Evaluation of Pre-service and In-service Teachers´ Digital Competence in Anhui Province, China

Ph.D. Thesis

Ph.D. Programme of Education in the Knowledge Society
University of Salamanca (https://ror.org/02f40zc51)
Salamanca, Spain

Candidate

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Supervisors

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April 2023

VNiVERSiDAD D SALAMANCA

Fernando Martínez Abad, Ph.D., Professor in the Department of Didactics, Organization and Research Methods at the University of Salamanca (Spain) and Alicia García Holgado, Ph.D., Associate Professor in the Department of Informatics and Automation, as supervisors of the Ph.D. thesis entitled "Evaluation of Pre-service and In-service Teachers´ Digital Competence in Anhui Province, China" developed by Li Yang

Hereby declare that:

This Ph.D. thesis, developed in the context of the Ph.D. Programme of Education in the Knowledge Society of the University of Salamanca (https://ror.org/02f40zc51), presents enough merits (theoretical and practical) evaluated through the proper assessment, publications, and original proposals to be presented and defended publicly.

Salamanca, Spain, April 2023.

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Abstract

With the integration of technologies in education, every country has proposed technology development plans in the educational field and increased investment. China has fully realized that ICT has played a significant role in promoting future educational development and has determined the status of technology development for education from a national strategy. Therefore, it has created great changes in the teachers´ teaching and learning environments. This changing process in education is creating and will continue to create new challenges for teachers' working methods in pedagogical, didactic, and administrative contexts and their specialized knowledge and basic skills.

The teacher is the key element in the whole educational process, particularly in educational action for transformation and improvement of education in fostering students' digital skills, specialized knowledge, and basic skills. Under these circumstances, the digital competence of teachers has received world attention that requires developing learning skills and receiving knowledge from various sources available in modern society, producing new demands for understanding and using digital learning opportunities in the educational field.

Serval concepts have been used to describe the teachers´ use of ICT, such as teachers´ information literacy, teachers´ digital literacy, teachers´ ICT skills, teachers´ information technology skills, teachers´ ICT competency, and teachers´ digital competence. There is a close connection between these commonly used concepts. However, based on the definition of digital competence, we concluded that digital competence is a boundary concept underpinned by digital literacy, media literacy, information, and data literacy. Hence, the concept of digital competence is used for describing the use of ICT in the present study because it offers a more comprehensive view of the use of technology.

Many nations and organizations have set considerable demands concerning teachers´ digital competence, and the theoretical framework related to teachers´ digital competence has been launched. This study provides a comprehensive

overview of the six main national and international frameworks published. There are various Europe-supported frameworks, one China-supported framework, one United States-supported framework, two UNESCO-supported frameworks, as well as A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 of the Sustainable Development Goals.

There is an overview of efforts and challenges on teachers' digital competence in China, which provides the starting points for a subject of reflection and analysis of the Chinese teachers' digital competence status. The overview mainly focuses on the main terms used to talk about teachers' use of technology for teaching and learning, the main purposes of the previous studies related to the digital competence of teachers, the main characteristics of the research methods, and the main proposals made to improve the digital competence.

This study proposed a diagnostic evaluation from a quantitative paradigm, which used a non-experimental-cross-sectional design. Thus, an ex-post-facto methodology based on survey studies was implemented to assess and analyze Chinese pre-service and in-service teachers' perception of digital competence in Anhui province. Moreover, this quantitative study explores the relationship between sociodemographic factors (age, educational degree level, ICT courses, years of teaching experience) and their digital competence level. The results of this study firstly demonstrated that both pre-service and in-service teachers in Anhui province have an excellent perception of digital competence in the three measured areas. Secondly, factors such as age, years of teaching, and educational background influence pre-and in-service teachers’ digital competence.

Finally, our primary recommendation for improving Chinese teachers´ digital competence is teachers’ training. After the theoretical support for pre-service and in-service K-12 teacher training was investigated, the training program was designed. Five clear strategies on excellence or best practice for teacher training integrated approach to improving Chinese teacher training: 1). teacher educators as role models; 2). scaffolding of authentic technology experiences; 3). learning instructional design with technology; 4). the reflection on the role of technology in

education; and 5). the training modality. The 3rd edition of the UNESCO ICT Competency Framework for Teachers was selected as the framework used. The training program is divided into five training modules depending on the different levels of digital competence of the population. The formative assessment with 12 practices was designed for the training program, as well as the summative assessment.

Keywords: Digital competence, China, Assessment, In-service teachers, Pre-service teachers, Teacher training.

Resumen

Con la integración de las tecnologías en la educación, todos los países han propuesto planes de desarrollo tecnológico en el ámbito educativo y han aumentado la inversión. China se ha dado cuenta plenamente de que las TIC desempeñan un papel importante en la promoción del futuro desarrollo educativo y ha determinado la situación del desarrollo tecnológico para la educación a partir de la estrategia nacional. Por lo tanto, se han creado profundos cambios en los entornos de enseñanza y aprendizaje del profesorado. Este proceso de cambio en la educación está creando y seguirá creando nuevos retos para los métodos de trabajo de los profesores en contextos pedagógicos, didácticos y administrativos, así como para sus conocimientos especializados y habilidades básicas.

El profesor es el elemento clave en todo el proceso educativo, en particular, en la acción educativa para la transformación y la mejora de la educación en el fomento de las competencias digitales, los conocimientos especializados y las competencias básicas de los estudiantes. En estas circunstancias, la competencia digital de los profesores ha recibido atención mundial que requiere desarrollar habilidades de aprendizaje y recibir conocimientos de diversas fuentes disponibles en la sociedad moderna, produciendo nuevas demandas para comprender y utilizar las oportunidades de aprendizaje digital en el ámbito educativo.

Se han utilizado varios conceptos para describir el uso de las TIC por parte del profesorado, como la alfabetización informacional del profesorado, la alfabetización digital del profesorado, las habilidades TIC del profesorado, las habilidades informáticas del profesorado, la competencia TIC del profesorado, la competencia digital del profesorado. Existe una estrecha relación entre estos conceptos de uso común. Sin embargo, basándonos en la definición de competencia digital, llegamos a la conclusión de que la competencia digital es un concepto fronterizo sustentado por la alfabetización digital, la alfabetización mediática, la alfabetización informacional y la alfabetización de datos. Por lo tanto, el concepto de competencia digital se utiliza para describir el uso de las TIC en el presente estudio porque ofrece una visión más completa del uso de la tecnología.

Muchas naciones y organizaciones han establecido exigencias considerables en relación con la competencia digital de los profesores, y se ha lanzado un marco teórico relacionado con la competencia digital de los profesores. Este estudio ofrece una visión global de los seis principales marcos nacionales e internacionales publicados. Hay varios marcos apoyados por Europa, un marco apoyado por China, un marco apoyado por Estados Unidos, dos marcos apoyados por la UNESCO, así como un Marco de Referencia Mundial sobre Competencias Digitales para el Indicador 4.4.2 de los Objetivos de Desarrollo Sostenible.

Se ofrece una visión general de los esfuerzos y retos en materia de competencia digital de los profesores en China, que proporciona los puntos de partida para un tema de reflexión y análisis de la situación de la competencia digital de los profesores chinos. La visión general se centra en los principales términos utilizados para hablar del uso que hacen los profesores de la tecnología para la enseñanza y el aprendizaje, los principales objetivos de los estudios previos relacionados con las competencias digitales de los profesores, las principales características de los métodos de investigación y las principales propuestas realizadas para mejorar la competencia digital.

Este estudio propuso una evaluación diagnóstica desde un paradigma cuantitativo, que utilizó un diseño no experimental-transversal. Así, se implementó una metodología ex-post-facto basada en estudios de encuestas para evaluar y analizar la percepción de la competencia digital de los profesores chinos en formación y en servicio en la provincia de Anhui. Además, este estudio cuantitativo explora la relación entre los factores sociodemográficos (edad, nivel de estudios, cursos de TIC, años de experiencia docente) y su nivel de competencia digital. Los resultados de este estudio demostraron, en primer lugar, que tanto los profesores en activo como los docentes en formación de la provincia de Anhui tienen una excelente percepción de la competencia digital en las tres áreas medidas. En segundo lugar, factores como la edad, los años de docencia y la formación académica influyen en la competencia digital de los profesores en activo y en formación.

Por último, como nuestra principal recomendación para mejorar la competencia digital de los profesores chinos es la formación de los profesores, después de investigar el apoyo teórico para la formación de los profesores K-12 antes y durante el servicio, se diseñó el programa de formación. Cinco estrategias claras sobre la excelencia o las mejores prácticas para la formación del profesorado integraron el enfoque para mejorar la formación del profesorado chino: 1). los formadores de profesores como modelos a seguir; 2). el andamiaje de experiencias tecnológicas auténticas; 3). el aprendizaje del diseño instruccional con tecnología; 4). la reflexión sobre el papel de la tecnología en la educación; y 5). la modalidad de formación. Además, se seleccionó como marco utilizado la 3ª edición del Marco de Competencias TIC para Profesores de la UNESCO. El programa de formación se dividió en cinco módulos formativos en función de los diferentes niveles de competencia digital de la población. La evaluación formativa con 12 prácticas fue diseñada para el programa de formación, así como la evaluación sumativa.

Palabras clave: Competencia digital, China, Evaluación, Profesores en activo, Profesores en formación, Formación del profesorado.

摘要

随着教育技术的整合，各国都提出了教育领域的技术发展计划，并加大投入。中国已经充分认识到 ICT 在促进未来教育发展中的重要作用，并从国家战略上确定了教育技术发展的地位。因此，教师的教学和学习环境发生了深刻的变化。教育的这一变化过程正在并将继续对教师在教学、授课和管理方面的工作方法，以及他们的专业知识和基本技能带来新的挑战。

教师是整个教育过程中的关键因素，特别是在培养学生的数字技能、专业知识和基本技能的教育改革和改善行动中。在这种情况下，教师的数字能力得到了世界的关注，这需要发展学习技能，即从现代社会的各种来源中接受知识，产生新的需求，在教育领域理解和使用数字学习机会。

有很多概念被用来描述教师对 ICT 的使用，如教师的信息素养、教师的数字素养、教师的 ICT 技能、教师的信息技术技能、教师的 ICT 能力、教师的数字能力等。这些常用的概念之间存在着密切的联系。然而，根据数字能力的定义，我们得出结论，数字能力是一个由数字素养、媒体素养、信息和数据素养支撑的边界概念，它对技术的使用提供了一个更全面的看法。因此，在本研究中，数字能力的概念被用来描述教师 ICT 的使用。

因为许多国家和组织机构对教师的数字能力提出了相当高的要求，与教师的数字能力相关的理论框架也随之推出。本研究对已发表的六个主要国家和国际框架进行了全面的概述。其中有各种欧洲支持的框架，一个中国支持的框架，一个美国支持的框架，两个联合国教科文组织支持的框架，以及《全球数字素养技能参考框架》的指标 4.4.2。

本研究对中国教师数字能力的努力和挑战进行了概述，为反思和分析中国教师的数字能力状况提供了课题的起点。概述主要集中五点:1).谈论教师使用技术进行教学的主要术语，2).以往与中国教师数字能力相关的研究的主要目的，4).中国教师数字能力相关研究方法的主要特点，5).以及为提高中国教师数字能力提出的主要建议。

本研究提出了一个定量范式的诊断性评价，它采用了非实验性的横断面设计。因此，基于调查研究的事后方法被实施，以评估和分析中国安徽省的职前和在职教师对其自身数字能力的感知。此外，这项定量研究还探讨了社会人口学因素（年龄、教育学位水平、ICT 课程、教学年限）与他们的数字能力水平之间的关系。本研究的结果首先表明，安徽省的职前教师和在职教师在三个测量领域的数字能力感知都很好。其次，年龄、教龄、教育背景等因素影响着职前和在职教师的数字能力。

最后，由于我们对提高中国教师数字能力的主要建议是教师的培训，在调查了 K-12 教师职前和在职培训的理论支持后，我们设计了培训方案。在教师培训中，有五项明确的策略，即：1).教师教育者作为榜样；2).真实技术经验的支架；3).用技术学习教学设计；4).对技术在教育中的作用的反思；以及 5).培训模式。联合国教科文组织第三版《教师信息通信技术能力框架》被选为使用的框架。培训计划根据人们不同的数字能力水平分为五个培训模块。为培训项目设计了包含 12 项实践的形成性评估，以及总结性评估。

关键词：数字能力，中国，评估，在职教师，职前教师，教师培训。

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Chapter 1. Introduction

This chapter describes the problem and the main ideas leading to this doctoral thesis. Firstly, the problems and justification of this thesis were presented, in which the concepts of teachers' digital competence and the government policy related to teachers´ digital competence in China were presented. Secondly, based on the problems detected, the main objective of this research is defined, in addition to a set of partial objectives that allow the main objective to be achieved. Then, the methodological framework for conducting the research is presented. Lastly, the following chapters of this thesis were described.

1.1. The conceptions related to digital technology

Information and communication technologies (ICT) have fueled advancements and growth in society, culture, and education in the 21st century. The changes in society and culture affect boundary conceptions related to digital skills and knowing what people should have in a knowledge society. This wide variety of conceptions reflects the rapid development of technologies and different areas of interest. According to the literature review of Ilomäki et al. (2016), these commonly used conceptions are digital literacy (incl. digital literacies or digital literacy skills), new literacies (incl. new literacy skills/practices), media literacy (incl. media literacies or media literacy skills), multiliteracies (incl. multiple literacies), and digital competence (incl. digital competence or digital competence).

As Koltay (2011) mentioned, the three most prevalent concepts that focus on a critical approach to media messages are media literacy, information literacy, and digital literacy. Over the last few decades, digital competence and digital literacy have been used more frequently and are increasingly discussed, particularly in policy documents and policy-related discussions (Spante et al., 2018). Ilomäki et al. (2016) and Spante et al. (2018) indicated that the term digital competence (incl.

digital competence or digital competence) is comparatively new in research articles in respect of the term digital literacy (incl. digital literacies or digital literacy skills).

The initial definition of digital literacy origins from Gilster (1997). As Spante et al. (2018) mentioned, digital literacy in primarily EU and OECD policy documents is defined as the individual's capabilities for living, learning, and working in a digital society; capabilities concerning communication and collaboration, studying and learning to use digital tools and media to make informed decisions and achieve goals. However, the concept of digital competence first caught attention due to the policy document "Key Competence for Lifelong Learning" (European Commission, 2006). In this document, digital competence is defined as "the confident and critical use of Information Society Technology (IST) for work, leisure and communication" (European Commission, 2006, p. 1). It is founded on fundamental ICT skills, such as using computers to retrieve, evaluate, store, produce, present, and exchange information and to communicate and participate in collaborative networks via the Internet.

1.1.1. Media literacy

Media literacy is defined as accessing, analyzing, evaluating, and creating messages across various contexts (Livingstone, 2004). The theoretical scheme of media literacy is based on a set of seven specific skills (analysis, evaluation, grouping, induction, deduction, synthesis, and abstraction) and five sets of knowledge structures (media effects, media content, media industries, real-world, and the self) (Potter, 2004, 2009).

According to Potter (2010), the media is concerned with all forms of media such as print, television, visual media of still and moving, computers, multimedia, digital media, and all technologies that deliver information. Literacy is considered an activity that requires developing skills and building knowledge. Critical thinking is the most frequently mentioned skill, contributing to the knowledge of media literacy (Brown, 1998; Koltay, 2011). This is because without a democratic and critical approach to media literacy, the public will be merely positioned as selective receivers and consumers of online information and communication (Livingstone, 2004).

1.1.2. Digital literacy

Digital literacy was first introduced by Gilster (1997), which is "the ability to understand and use information in multiple formats from a wide range of sources when it is presented via computers" (p. 1). Gilster (1997) also mentioned that compared to technical skills or competences, critical thinking is a core digital literacy skill. Digital literacy emphasizes the critical evaluation of what is found there rather than the technical skills required to access the Internet (Martin & Grudziecki, 2006).

In the DigEuLit project digital literacy, Martin (2005) defined digital literacy as: the awareness, attitude and ability of individuals to appropriately use digital tools and facilities to identify, access, manage, integrate, evaluate, analysis and synthesize digital resource, construct new knowledge, create media expression, and communicate with others, in the context of specific life situation, in order to enable constructive social action; and to reflect upon this process. Additionally, as Martin and Grudziecki (2006) and Bawden (2008) mentioned, this DigEuLit project digital literacy is as a response to a call for actions on "digital literacy" in the context of the eLearning Program of the European Commission.

1.1.3. Digital competence

The concept of digital competence has long been recognized as a core competency in policy documents. Such as the Recommendation of the European Parliament and of the Council of 18 December 2006 on key competence for lifelong learning (European Commission, 2006), the digital competence frameworks for citizens in Europe (Carretero et al., 2017; Ferrari et al., 2013; Vuorikari et al., 2016). However, the standardization of digital competence in educational research has only been rapidly developed in recent years (Ilomäki et al., 2016; Krumsvik, 2014)—for example, the European Framework for the Digital Competence of Educators (Punie, 2017).

Digital competence is “an evolving concept related to the development of digital technology and the political aims and expectations of citizenship in a knowledge society” (Ilomäki et al., 2016, p. 655). The definition of digital competence by the

European Union (EU) framework of key competence for all citizens (European Commission, 2018, p. 9):

> Digital competence involves the confident, critical and responsible use of, and engagement with, digital technologies for learning, at work, and participation in society. It includes information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), safety (including digital well-being and competences related to cybersecurity), intellectual property-related questions, problem-solving and critical thinking.

Based on the definition of digital competence, we concluded that digital competence is a boundary concept underpinned by digital literacy, media literacy, information, and data literacy. Except for the concept of digital competence, there are no existing concepts included more than a passing mention of personal dispositions/attitudes or understandings of wider issues or safety and wellbeing (etc.) considerations. Therefore, the concept of digital competence is used for describing the use of ICT in present study because it offers a more comprehensive view of the use of technology.

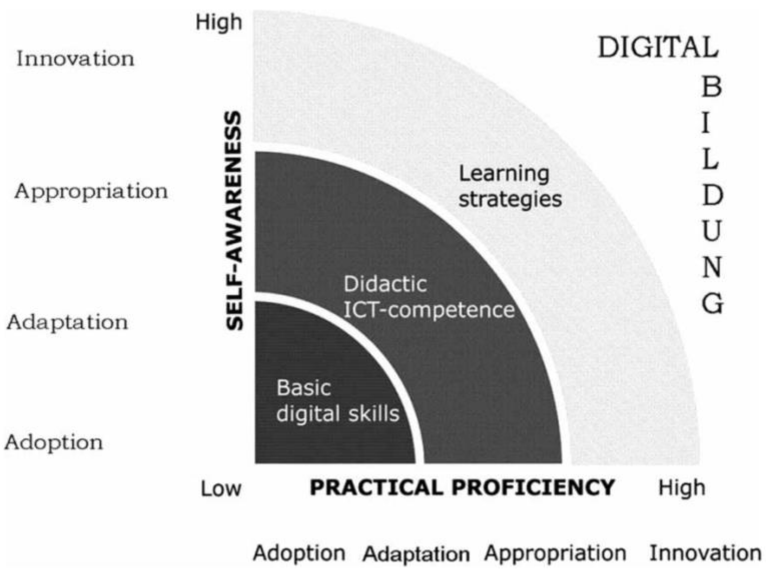
1.2. Problems and justification

1.2.1. Teachers´ Digital Competence

Technology affects the economic, social, and education fields (among others), and has changed how we learn, communicate, entertain ourselves, locate information, and acquire knowledge. This has created deep changes in the teaching and learning environments. This changing process in education is creating and will continue to create new challenges for teachers' working methods in pedagogical, didactic, and administrative contexts, developing students' digital skills and their specialized knowledge and basic skills (Kelentrić et al., 2017).

Teachers' digital competence conceptions are related to the teachers' professional development in the use of ICT with pedagogical judgment (Krumsvik, 2008), which "is considered regarding the individual teacher's ability to implement ICT into learning activities to improve students' development of knowledge and understanding" (Spante et al., 2018, p. 15). Figure 1 shows the visual model of the definition of digital competence in teachers' education, which gives abstractions of the variables thought to be most important for comprehending the phenomenon of digital competence in teacher education (Krumsvik, 2014). Instead of describing a phenomenon of digital competence in all its complexity, this theoretical foundation for the digital competence model was established to characterize digital competence phenomena for teacher educators using selected metrics.

Figure 1. Visual model of teachers´ digital competence definition



Source: (Krumsvik, 2014)

Teachers are crucial in fostering students' digital skills, specialized knowledge, and basic skills. Thus, their professional digital competence must be developed during their initial teacher education and continued during their teaching career through professional education and development. Therefore, several national and international initiatives have developed frameworks related to digital skills for teachers. These frameworks outline and detail the specific knowledge, competence, attitudes, and skills, such as the relevant project of UNESCO ICT Competence for Teachers (UNESCO, 2011, 2018), the Information and Communication Technology Standards for Teachers (NETS-T), or the European Framework for Digital Competence of Teachers (DigCompEdu) (Redecker & Punie, 2017). These national and international frameworks consisted of some differentiated competency areas that require teachers to promote effective, inclusive, and innovative learning strategies, using digital tools.

1.2.2. Digital Competence in Chinese Education

The changes brought by technology are increasingly affecting all levels of the education system in each country. Many governments, including China, have ambitious educational policies regarding digitalization. For example, Educational mobile applications in China are widely used by staff, students, and parents. These applications take education and learning as the main application scenarios, serving school teaching and management, student learning and life, and home-school interaction. Therefore, the Ministry of Education of China (2019a) attaches great importance to filing mobile educational applications through the "Educational Mobile Internet Application Filing Management Measures" to complete the filing of mobile educational applications in stages.

On the other hand, China's Ministry of Education considers online education an essential part of education services as a new type of education. The development of online education is conducive to constructing a networked, digital, personalized, and lifelong education system and building a learning society. The Ministry of Education started to promote integrating information technology and intelligent technology into education and teaching in 2019, both in online and offline education (Ministry of Education of People´s Republic of China, 2019b). Schools are encouraged to increase the development and sharing of online education resources through the national public service system of digital education resources and to expand teaching resources such as online classes of relevant schools and teachers. The notice requires universities to ensure that the quality of online courses incorporated into higher education is at least our original face-to-face courses.

The Notice of the Ministry of Education and Other Five Departments on the issuance of the "Teacher Education Revitalization Action Plan (2018-2022)" was launched by the Ministry of Education of People´s Republic of China (2018). This plan aims to accelerate the modernization of education and the construction of educational power, as well as to promote the development of education informatization in the new era and cultivate a new innovation-driven development engine. As Zhao (2018) mentioned, with the integration with big data and cloud computing technologies, China has fully realized the AI technology has played a significant role in promoting future intelligent development and has determined the status of AI technology development from national strategy. For example, the “Internet plus” artificial intelligence three-year action implementation has established in China. Therefore, this Teacher Education Revitalization Action Plan was formulated in conjunction with the task organization of major national strategies such as "Internet+": big data and next-generation artificial intelligence.

Immediately afterwards, With the objective to improve K-12 teachers’ digital competence, the Ministry of Education of People´s Republic of China (2019c) launched the Implementation of the National Primary and Secondary School Teachers' Information Technology Application Ability Improvement Project 2.0 for improving teachers' information technology application ability. Moreover, Ministry of Education of People´s Republic of China (2020b) also launched the Notice of the Finance Department of the Teacher Work Department of the Ministry of Education on Issuing the Implementation Guide for Online Training of Kindergarten Teachers in Primary and Secondary Schools. According to the Guidance on Promoting the Healthy Development of Online Education, Ministry of Education of People´s Republic of China (2019b) plans to train 10,000 principals of primary and secondary schools, 20,000 teachers of primary and secondary schools, 3,000 principals of vocational colleges, and 6,000 teachers of vocational colleges by 2022 through special training on "Internet learning space for all." So, all teachers and students will be covered by information-based teaching and learning applications.

1.3. Objectives

There is a consensus among researchers and policymakers that the teacher is a crucial element for the successful implementation of digital technologies in education. Previous reviews showed that for the time being, Spain is the country in the world most concerned with the digital competence of teachers in terms of the number of academic papers distributed (Basilotta-Gómez-Pablos et al., 2022; Rodríguez-García et al., 2019).

As mentioned before, China has initiated a political reform at all levels of education to lead the innovation of education digitalization with intelligent education in line with the digital drive. There are exist research related to China's K-12 pre-and in-service teachers' digital competence. For example, several Chinese scholars are interested in comparing the level of digital competence for K-12 in-service teachers between the east, middle, and west regions (Li et al., 2019; Liu et al., 2018; N. Zhang et al., 2019). Particularly, some of them have focused on in-service teachers' digital competence in a specific region, such as in Yunnan province (Zhou et al., 2016), Jiangxi province (Wang & Ren, 2020), and the city of Shanghai (Liang, 2020). Chinese scholars also did research on digital competence for pre-service teachers, such as Yan et al. (2018) validated self-measurement tools for pre-service teachers' ICT competency, and Wang and Wu (2018) analyzed Chinese pre-service teachers' TPACK level.

However, no studies have yet explored the digital competence levels of both pre-service and in-service teachers and attempted to find a link between the digital competence of these two populations, with a particular focus on Anhui Province. Therefore, there is a need of implement inclusive pedagogical practices by K-12 pre- and in-service teachers in Anhui province, China. Consequently, a series of objectives have been proposed in this doctoral thesis.

General objectives:

- Address the study of digital competence for K-12 pre-service teachers and in-service teachers in the Anhui region (China).
- Determine the digital competence level of K-12 pre-service teachers and in-service teachers in Anhui province.
- Formulate an educational proposal to improve the digital competence of in-service teachers and pre-service teachers in Anhui province.

Specific objectives:

- Identify frameworks related to digital competence and its key components for teachers in China, with particular attention to the Anhui region.
- Design and validate a questionnaire adapted to the Anhui region context that allows evaluating the digital competences of pre-service and in-service teachers.
- Determine the perception of digital competence for pre-service and in-service teachers in Anhui region.
- Design a training course for Chinese pre-service and in-service teachers to improve their digital competence level.

1.4. Presentation of the following chapters

This work is developed in the Ph.D. Programme Education in the Knowledge Society (García-Peñalvo, 2013, 2014) under the University Institute of Education Sciences, University of Salamanca. This Ph.D. program has been created with a clear vocation to present the teaching-learning processes as authentic motors of the so-called Knowledge Society to be able to discuss and generate new knowledge in this line and under a symbiosis with the most cutting-edge technological advances.

The focus of this program is interdisciplinary, supported mainly by the Recognized Research Groups of the University of Salamanca GRIAL (García-Peñalvo, 2016; García-Peñalvo et al., 2019) (http://grial.usal.es), GE2O (https://ge2o.usal.es/), GITE (https://gite.usal.es/), OCA (http://campus.usal.es/~oca/), VISUALMED (http://visualmed.usal.es/), Robotics and Society (http://gro.usal.es/), and E-LECTRA (http://electra.usal.es), of which GRIAL is a Consolidated Research Unit (UIC 081). These groups of researchers from the University of Salamanca are complemented by a wide range of national and international researchers, who make up the vanguard of the lines of research related to Education in the Knowledge Society, cover the following main descriptors or areas of research:

- Educational Assessment and Orientation.
- Interaction and eLearning.
- Research-Innovation in Educational Technology.

- Communication and Education.
- Medicine and Education.
- Artificial Intelligence and Robotics in Education.
- Engineering and Education.
- Education, Libraries and Scientific Culture.
- Education and Climate Change

The research work included in this document has been developed within the GRIAL research groups focused on educational assessment and orientation for K-12 pre- and in-service teachers in Anhui province, China. The thesis is divided into eight chapters with three primary phases:

1º Phase: research literature of teachers´ digital competence:

a. Comparative analysis of current impact frameworks of digital competence for teachers (Chapter 2).
b. Systematic literature review of teachers' digital competence in China (Chapter 3).

2º Phase: assessment of teachers´ digital competence:

a. Methodology of quantitative analysis (Chapter 4).
b. Quantitative analysis of teacher digital competence in the region of Anhui, China (Chapter 5).

3º Phase: development of proposals for improving teachers´ digital competence:

a. Theoretical support of K-12 pre-and in-service teacher training in digital competence (Chapter 6).
b. Design a training program in digital competence for Chinese K-12 pre- and in-service teachers (Chapter 7).

The current chapter is the first, which exposes the research's objectives, problems, and justification, presenting the development of digital competence in education and highlighting the Chinese government's policy support of digital competence in the educational field.

The second chapter compares the national and international frameworks of digital competence for teachers. Six important frameworks have been selected that focus on teachers' professional development. There are respectively framed by UNESCO, US, Europe, and the Chinese government. In this chapter, we explain each framework and then use a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to compare them.

The third chapter presents two systematic literature reviews on pre- and in-service teachers' digital competence in China. Two different search terms and selection criteria determined the articles left in each systematic literature review. Therefore, in this chapter, we compare these two systematic literature reviews.

The fourth chapter describes the method part of the observational research applied. It is presented the research design, the instrument used to measure teachers' digital competence, the status of sampling and population, and the data analysis method for this quantitative analysis.

The fifth chapter presents the findings of quantitative analysis. This includes statistical analysis of pre-and in-service teachers' levels of digital competence and the exploration of factors that influence pre-and in-service teachers' digital competence.

In chapter six, we provide a global overview of digital competence training for teachers through an SLR that is intended to provide theoretical support for K-12 pre- and in-service teacher training in digital competence.

Chapter seven proposes a training program in digital competence to improve Chinese teachers' digital competence. In this chapter, we focus on the program design, in which we present the characteristics, the used framework, competence, training objectives, course duration, resources required, and training content, including assessment methods for training activities.

The last chapter discusses the research findings first. Then, we summarize the research findings. The limitations and further research lines of the research are presented as well.

Chapter 2. Comparative Study of Teacher's Digital Competence Frameworks

This chapter includes a theoretical framework, which provides a comprehensive overview of the six main national and international frameworks published. There are various Europe-supported frameworks: DigComp, DigComp 2, and DigComp 2.1; one United States-supported framework: National Educational Technology Standards; and two UNESCO-supported frameworks: UNESCO ICT Competency Framework for Teachers, and A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 of the Sustainable Development Goals (SGDs). While this research studies Chinese teachers´ digital competence, the China-supported framework was also considered in this chapter.

The results of this work were published as a book chapter (Yang et al., 2021). Hence, in this chapter, we present the method used to analyze and compare the frameworks and conduct a SWOT comparative analysis. Meanwhile, through this comparative analysis, we seek to understand what current trends characterize Digital Competence acquisition and whether frameworks propose different Digital Competence approaches.

2.1. Background

ICT offers opportunities to develop knowledge, economies, societies, and education. In the educational field, “digital competence has been gradually introduced into school curricula, assessment tests, and classroom practice over the past decade” (Ottestad et al., 2014, p. 223). Hence, many countries’ education systems need teachers to be equipped with digital competence (UNESCO, 2011). Nowadays, digital competence is the fifth basic competence in all subjects at all levels, as well as in the new teacher education curriculum in a lot of countries (Krumsvik, 2014).

Teachers' digital competence is complex compared to other occupations and among average citizens, which requires an awareness of this complexity. As Krumsvik (2014) mentioned, how teachers carry out and experience the pedagogical use of ICT often depends on their digital competence. However, "many educators in the field believe that teachers are not adequately prepared to use technology for instruction" (Elstad & Christophersen, 2017, p. 1). Therefore, there is a need to develop both theoretical foundations and models for a more in-depth understanding of digital competence in teacher education (Krumsvik, 2014). Under these circumstances, various digital competence frameworks for educators aims to detail how digital technologies can enhance and innovate education and training, for example, the Digital Competence Framework for Educators (Cabero-Almenara & Palacios-Rodriguez, 2020).

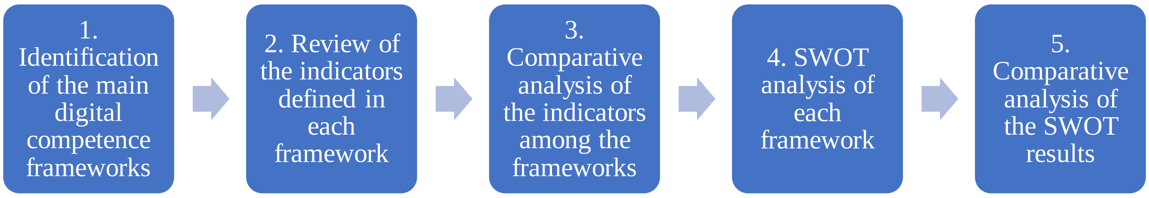
Moreover, the rapid digital competence framework development in the last decade has been concentrated on many countries and organizations, with the outstanding position of the European Union (EU), followed by UNESCO and the United States (US), among others. The global environment has changed so drastically that there are many different frameworks, but there is no a global standard. Each region or country has its own framework, and this makes it difficult to establish an assessment of digital competence at the international level, which the decision and operation processes of educational institutions become more volatile and dynamic than ever. Therefore, some studies comparing these frameworks have emerged in recent years (Caena & Redecker, 2019; Ferrari et al., 2012; Hazar, 2019), but there are no one Strengths-Weaknesses-Opportunities-Threats (SWOT) comparative analysis (Helms & Nixon, 2010) for teachers' digital competence frameworks.

This chapter analyzes six relevant frameworks for the development of teachers' Digital Competence. Based on the SWOT comparative analysis of the frameworks (Ghazinoory et al., 2011; Hill & Westbrook, 1997), we discuss the proficiency levels that are currently foreseen by these frameworks and propose comprehensive descriptors of Digital Competence. The general aim is to make it easier to integrate an assessment digital competence framework for teachers in other regions of the world that do not have their own framework.

2.2. Materials and methods

The study was focused on two main parts: (1) the digital competence framework's evolutionary character; and (2) the comparative analyzes between these identified frameworks. Therefore, the first objective of the work in this chapter is to analyze these frameworks' contributions to understanding the development of this competence. The second objective is to determine whether there are any differences between these frameworks through SWOT analysis. As Figure 2 shows, this research has five main steps of this research work.

Figure 2. The main phases of research work in the analysis



In the first step, six main digital competence frameworks were identified: Information technology application competency standards for primary and secondary school teachers (China) (Ministry of Education of People´s Republic of China, 2014), a series of DigComp frameworks (Carretero et al., 2017; Ferrari et al., 2013; Vuorikari et al., 2016), International Society for Technology in Education (ISTE Standards) (ISTE, 2008), UNESCO ICT competency frameworks for teachers (UNESCO, 2011, 2018), Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 of the SDGs (UNECSO, 2018) and TPACK framework (Koehler et al., 2013).

In the second step, we reviewed the indicators defined in each framework. We found that each framework has its own indicators. For example, the structure of the DigComp matrix comprises four basic elements (competence descriptors and titles; proficiency levels; knowledge, skills, and attitudes; and examples of use) in any of the competence areas or dimensions (Information; Communication; Content Creation; Safety, and Problem-Solving); or the structure of UNESCO ICT competency framework for teachers' matrix comprises three levels of domain (technology literacy; knowledge deepening; knowledge creation) in six aspects (Understanding

ICT in Education Policy; Curriculum and Assessment; Pedagogy; Application of Digital Skills; Organization and Administration; and Teacher Professional Learning). Then, as can be seen in the following link (https://tinyurl.com/y3q4ho3r), we tried to make a comparative analysis based on the indicators, but there was difficult to make such a comparison for several reasons, among others: in similar dimensions, indicators in one framework can be suitable for several dimensions of another framework; or there are dimensions that are mentioned in one framework but have no place in another.

As the comparison, the third step was very complex to make; we chose to perform a SWOT (Strengths-Weaknesses-Opportunities-Threats) analysis as a strategic management tool by reducing the quantity of information to improve decision-making. SWOT analysis is used as a teaching and academic tool by consultants, trainers, and educators (Helms & Nixon, 2010). In this work, we use SWOT analysis to identify the critical factors (table 1) of the situation focusing on two issues: the organizational analysis (Strengths and/or weaknesses), and the environmental analysis (Opportunities and/or Threats).

Table 1. SWOT analysis example

Strengths and/or weakness	**Opportunities and threats**	
Financial support Academic support Skills/experiences Leadership Technology Service Competitive advantage	Competitive environment: • Identify any product/service that may be a substitution. Demographic trends: • Changing population characteristic: age structure of China' population. • Geographic shifts in population.	Publics: • Financial publics (institutions providing capital). Technological trends: • The faster pace of technological change. • Presents unlimited opportunities. • High research and development budgets.

	• Better-educated population.	• Concentration on minor improvement.
	Political trends: • Changing government agency enforcement. • Growth of public-interest groups.	

2.3. SWOT analysis

Based on previous findings, these frameworks could have positive outcomes in providing guidance for technology-integrated learning. Like content standards, they provide a view of the *end* or what citizens should know and be able to do after engaging in technology-supported learning nowadays.

In this section, we present a comparative SWOT analysis regarding teachers' digital competence in three categories according to the government or organization that supports them.

2.3.1. SWOT analysis of DigComp

Strengths and/or Weaknesses:

A certain amount of experience has accumulated in the DigComp framework (Ala-Mutka, 2011; Ferrari et al., 2013), which has deep and extensive learning of other frames about digital competence. For example, version 1.0 of DigComp was based on the case studies analyzed from 15 impact frameworks around the world. The framework is a necessary guideline for: policy formulation and support; instructional planning for education, training and employment; assessment and certification. It is the basis for continued competent performance, including values, aspirations and priorities.

Opportunities and Threats:

Furthermore, from 2013 to 2017, the DigComp framework was developed step by step and coherently, which has continuously adjusted to meet the needs of social development (Carretero et al., 2017; Ferrari et al., 2013; Vuorikari et al., 2016). However, technology and innovation policy formulation in Europe is not fully integrated. There are various institutions dealing with policy formulation and different countries have different situations, which could make the framework difficult to be implemented.

2.3.2. SWOT analysis of ISTE Standards

Strengths and/or Weaknesses:

These standards put forward more clear requirements for the information technology level of different members of society, and the entire standard system is more specific and detailed (Ramírez Martinell et al., 2015). These series of ISTE standards have remarkable development experiences that have undergone several revisions since 1990 (Thomas, 1991) until today, which make corresponding adjustments every few years to meet the needs of social development (Handler & Strudler, 1997; Bucci et al., 2003; Trust, 2018). ISTE's Standards do not describe narrow, content-specific, performance objectives, such as those assessed by standardized tests. But there still has the issue of considering the adequacy of resources to support the implementation of the standards across courses, such as their financial support.

Opportunities and Threats:

ISTE's standards are used in the United States and at least 40 other countries, as well as a model for adapting curricula for different levels of education. These describe broader intellectual competence vital to productivity in a digital age (an age requiring more than mere proficiency with technology tools) and are concentrated on minor improvement.

However, from the point of changing government agency enforcement, some countries have an absence of transparent technology policy to cover the objectives, instruments, and institutions. The changing technologies require a careful review of the applications introduced and the pedagogical model for students.

2.3.3. SWOT analysis of UNESCO frameworks

Strengths and/or Weaknesses:

Because the ICT Competency Framework for Teachers was developed by a cross-sectoral working group and based on consultations with experts in the field from all world regions, it has an extensive base of support, working closely with its partners CISCO, INTEL, ISTE and Microsoft (Midoro, 2013). Thus, this framework has strong financial, technological, and academic support.

Both UNESCO frameworks conducted an extensive consultation to identify the competence that citizens should develop to use technology effectively, which enhanced the research area leadership.

Additionally, both frameworks offer a quite comprehensive service through UNESCO digital library website. Besides, they offer Guidelines on Adaptation of the UNESCO ITC competency Framework for Teachers.

As mentioned, UNESCO has made efforts to include examples and expert views from countries in the following regions: Asia, the European Union (UNESCO, 2018). But this project does not include the view from a lot of important Latin American countries, like Brazil, Peru, Bolivia, Argentina, neither includes China.

Opportunities and Threats:

For some citizens, perhaps for many citizens, these will be novel and challenging ideas, and it will take time for them to understand these new approaches, but these frameworks are a tool-oriented approach. It will also require strong leadership from the government, from those responsible for education and professional learning, and from school principals.

The UNESCO ICT competency framework for teachers is intended to inform educational policymakers, teacher-educators, providers of professional learning, and working teachers on the role of ICT in educational reform. Moreover, these publications are available in Open Access, which “help countries develop comprehensive national teacher ICT competency policies and standards for free and develop a methodology that can serve as the foundation for Sustainable Development Goal (SDG)” (UNESCO, 2018, p. 5).

Some challenges in the approach of both frameworks and their implementation are highlighted, as well as critical issues about the governmental o institutional support to teachers to promote the development of their digital competence. With the development of ICT practices in a lot of countries, DigComp 2.0 was selected as the reference digital literacy framework for this UNESCO 2018 project, which has played an extremely important role around the world, but basically, this framework did not develop so many new things.

2.3.4. SWOT analysis of Competency Standards for Teachers (China)

Strengths and/or Weaknesses:

This work has an extensive base of financial and governmental support. This "Competency Standard" is orientated to the development of ICT practices, to comprehensively enhance the information technology application capability of primary and secondary school teachers and promote the deep integration of information technology and education teaching (Ministry of Education of People´s Republic of China, 2014). On the other hand, it is based on the UNESCO ICT competency framework for teachers has played an extremely important role in China.

Since the actual conditions of informatization in primary and secondary schools in China are different and vary, this makes some regions lack in theoretical preparation, rational paradigm and strategic thinking, such as the framework in Anhui Province is typical of the lack of rational paradigm and strategic thinking. Furthermore, it has not been updated for many years since 2014. According to the Chinese scientific literature in recent years, China's progress in science and technology in the past six years is huge, but this theory has not been able to adapt to the current requirements of the development of technology education.

Opportunities and Threats:

These Competency Standards set out the basic and developmental requirements for teachers to apply information technology in education and teaching and professional development. The Chinese national government has paid significant attention to the teachers’ ability to apply information technology in primary and secondary schools, and its local governments have responded positively. The works undertaken as a new standard of teachers’ ability to apply information technology in primary and secondary schools (Trial) is intensifying for the implementation of the Education Informatization 2.0 Action Plan (Ministry of Education of People´s Republic of China, 2018), the implementation of the National Information Technology 2.0 Capacity Enhancement Project for Primary and Secondary School Teachers (Ministry of Education of People´s Republic of China, 2019c) and Action Plan for the Revitalization of Teacher Education (2018 – 2022) (Ministry of Education of People´s Republic of China, 2018). Therefore, this framework has a forceful political support.

However, today's theoretical frameworks are no longer adequate for the current development of education in China, and there is a lack of current research on theoretical frameworks for ICT in education in the Chinese context. As a result, the use of frameworks on teachers´ digital competence in China was mainly shaped through a combination of different frameworks from the international context. Therefore, current research on teachers' digital competence in China should first focus on developing a framework for teachers' digital competence in the current context. In this theoretical framework, the most important terms (e.g. digital competence, digital literacy, digital skills, ICT competency, etc.) in the current academic field should be explained and an appropriate term should be identified to apply the new theoretical framework.

A new digital theoretical framework that is in line with the current development of Chinese society will guide Chinese scholars in their research on teachers' digital competence in China and will also provide international scholars with a clearer understanding of Chinese teachers' digital competence research. Hence, this will gradually bring Chinese teachers' digital competence research into line with international research and provide an opportunity for more collaborative research on teachers' digital competence between China and the international community.

2.3.5. SWOT analysis of TPACK framework

Strengths and/or Weaknesses:

The conception of TPACK stems from Shulman (1986, 1987), which pedagogical content knowledge (PCK) used to explain how teachers' understanding of educational technologies and PCK interact with one another to produce effective teaching and learning. Over the years, many theories related to TPACK framework have been proposed and assessed, establishing practices and approaches toward developing knowledge of concepts, theories, ideas, organizational frameworks, knowledge of evidence and proof. Particularly, the descriptions of TPACK framework have been developed through a series of publications, which content, pedagogy, and technology are three main components of teachers' knowledge in TPACK model (Koehler, 2009; Koehler et al., 2013; Koehler et al., 2014). As Koehler (2009, p. 9) mentioned, "this is a framework of deep, flexible, pragmatic, and nuanced understanding of teaching with technology".

Nevertheless, this framework ignores the complexity inherent in each knowledge component; the complexities of the relationships among the components can lead to oversimplified solutions or failure. On the other hand, under the framework, teachers need to develop fluency and cognitive flexibility in each of the key domains, which means that teachers need to dedicate more time to their work not only in the content and pedagogy but also in knowledge of technology. It could cost them lot of time after work time.

Opportunities and Threats:

Because many personal and professional characteristics, including age and experience, are associated with higher levels of TPACK, the TPACK framework requires teachers to develop fluency and cognitive flexibility in technology, pedagogy and content, in the manner in which these domains and contextual parameters interrelate. On the other hand, “the TPACK framework offers several possibilities for promoting research in teacher education, teacher professional development, and teachers’ use of technology” (Koehler, 2009, p. 67). There is no single technological solution that applies to every teacher, every course, or every view of teaching. Therefore, this framework could develop the teacher’s ability to construct practical solutions, which changes the capabilities of classroom technology.

Furthermore, the TPACK framework, since its introduction in 2006, has had a significant impact on both theory and practice in educational technology, which leads to teachers having the ability to challenge students at the different levels of Substitution, Augmentation, Modification, and Redefinition (SAMR) model, and places educators in a better position to understand the variance in levels of technology integration occurring (Humes, 2017).

Even though the TPACK framework has a growth of public-interest groups, there still has a threat from government policy and norms: this framework may not get government financial or political support due to it is not a government project. Besides that, there may be resistance from teachers due to the need for highly skilled maintenance personnel required for its implementation. Moreover, the complexity of implementing this framework may make it difficult to convince teachers to use it.

2.4. Characterization of digital competence frameworks

This section presents how digital competence transcends the individual citizen’s use of ICT; meanwhile, the teachers’ digital competence requires the development of teaching practices that promote it in students.

Firstly, as Table 2 shows, the selected six frameworks were developed for different targets.

Table 2. Basic information about selected frameworks

	DIGCOMP	**A Global Framework of Reference**	**ISTE Standards**	**ICT Competency Framework for Teachers**	**Competency Standards for Teachers (China)**	**TPACK framework**
Target groups	European citizens	All citizens	All citizens	Global teachers	Teachers in China	All teachers/ educators
Country / Organization	EU	UNESCO	USA	UNESCO	CHINA	-
First version	2013	-	2008	2008	2014	2006
Last version	2017	2018	2017	2011	2014	-
Character	Political	Political	Political	Political	Governmental	Academic

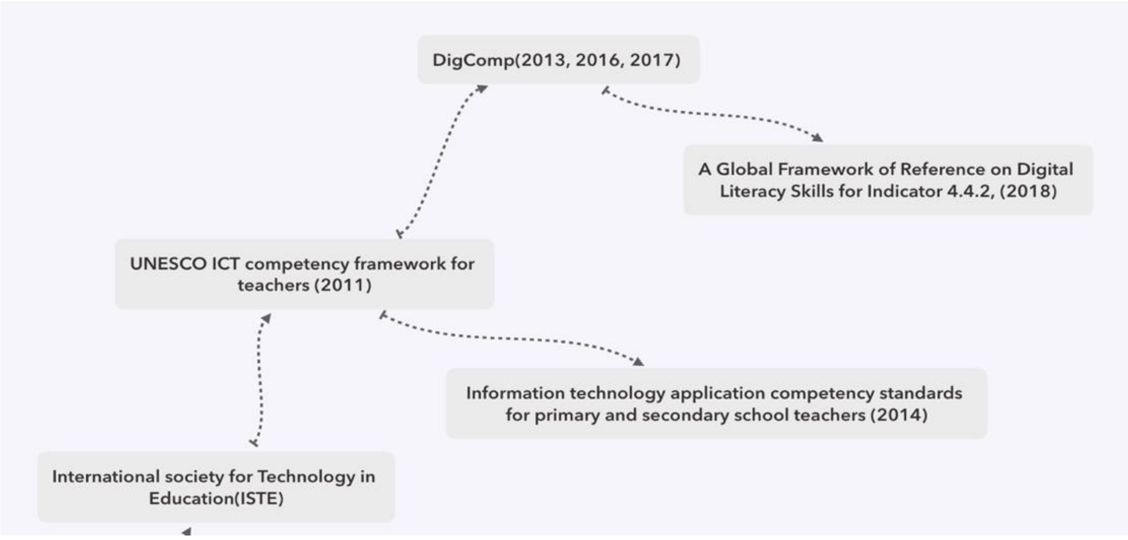
Secondly, besides the TPACK framework, the other frameworks seek the use of digital technologies critically and responsibly in terms of information, communication, content generation, well-being and problem-solving.

The ICT competency Framework (UNESCO) for Teachers were provided to help countries to develop comprehensive national teacher ICT competency policies and standards. Additionally, Competency Standards for Teachers (China) points the digital skills that teachers need based on the ICT competency Framework (UNESCO) for Teachers.

On the other side, the TPACK framework is a robust impact framework on both theory and practice in educational technology, which is given to teacher mediation to generate interactive practices with digital technologies to develop their students personally, professionally, and socially.

Thirdly, these frameworks have coincidences and nuances in understanding the development of digital competence. Even if some of these concepts identified in the competence dimensions differ in some way, the standards in the frameworks and the outcomes in the curriculum are closely related. There are generally five main elements: (1) purpose of the framework; (2) competence areas; (3) competence, learning domains (such as knowledge, skills, and attitudes); (4) how to perform the tasks; and (4) digital tools to be used. These descriptors summarize and bring together the competence areas as they are outlined in the selected frameworks.

Figure 3. The connection of selected frameworks



Finally, nations and organizations have developed different policies based on similar digital competence structures. However, the benefits of collaboration in the field of development of digital competences among countries o organizations have been well recognized. Figure 3 shows the temporal relationships and influences between the frameworks.

All selected frameworks were primary focused on competences, such as reflection, continuous practice, collaboration, citizens' social participation, or ICT. However, the highlighted challenge is the implementation of these frameworks, likewise critical issues about the institutional support to citizens to promote the development of their digital competence. As there are many different contextual and cultural factors influencing the implementation of curriculum frameworks, it is not possible to conclude that these frameworks are comparable in terms of their execution or impact.

On the other hand, we can notice that DigComp is subject to creating consensus only at the European level about the components of Digital Competence. However, it is more completely and well-developed and can serve as a conceptual reference model for other countries o educational institutions, like as the cornerstone of the development about Global Framework of Reference on Digital Literacy Skills.

Additionally, we concluded that the frameworks of digital competence development for teachers between Europe and UNESCO could be a particular impression for the future development of Chinese framework of teachers' digital competence.

Collaboration, the sharing of best practices and experiences in digital competence implementation, could bring considerable value to all countries worldwide. Therefore, another digital competence development opportunity exists between Europe and China to marry China's advanced renewable technologies and Europe's ability to explore the establishment of a digital competence framework and renovation of a digital competence framework for teachers in China. Cooperation between Europe and China has the potential to increase opportunities for China to improve their digital competence framework system.

Chapter 3. Systematic Literature Reviews of Chinese Teachers´ Digital Competence

The chapter 3 consists of two SLRs related to teachers´ digital competence in the context of China[1]. This is because we did not previously consider whether this literature review focused only on Chinese K-12 teachers or included higher education teachers. Hence, the first literature review findings included the current state of digitization of higher education teachers in China. However, once the final report was developed, we felt that our final study group was K-12 teachers rather than higher education teachers. Then, both SLRs were compared.

This work is organized as follows: First section presents conceptual frameworks related to teachers´ digital competence. Next section presents the method used in developing both SLRs, including its different issues and steps. In this part, we mainly compared research questions, the search terms, criteria, the quality assessment checklist. Then, the third section presents the results of the two SLRs regarding the content of the selected literature and discusses the findings in the process, reflecting on the different solutions and approaches found in the literature. Finally, there are presented the main findings in the conclusions section.

3.1. Conceptual frameworks related to teachers´ digital competence

Teachers’ digital competence has received international attention that requires developing learning skills and receiving knowledge from various sources available in modern society, producing new demands for understanding and using digital

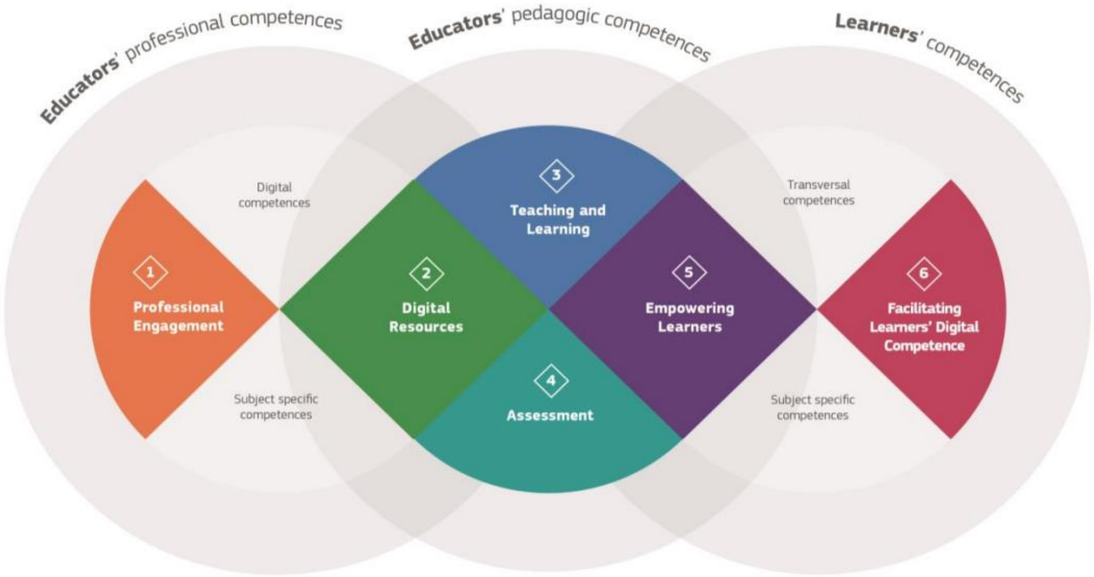
[1] To differentiate between the two SLRs, we will henceforth refer to the first SLR as 'SLR1' and the second SLR as 'SLR2'.

learning opportunities in the educational field. Digital competence is regarded as an opportunity and a solution for the future needs in the economic competition, so is considered a transversal key competence related to many 21st Century skills (e.g., language, mathematics, learning to learn, cultural awareness) (Ferrari et al., 2013). As a result, teachers' digital competence in their professional practice is one of the key components to ensure the learner's equity and quality of learning in society and the economy (UNESCO, 2018).

Based on the concept of digital competence, this review emphasizes that teachers' digital competence is related to the skills in using ICT with pedagogic-didactic judgment and awareness of its impact on learning strategies and students' digital education. This definition implies that teachers not only use ICT to improve the learning environment, foster ICT awareness, knowledge deepening, and knowledge creation (UNESCO, 2011), but also role models for learners' use of ICT in some way. However, recent studies still indicate some confusion regarding the digital competence and digital literacy of teachers. The articles selected in the SLRs by Spante et al. (2018) explained that digital competence is based on digital literacy. So, teachers' digital competence is more complex than teachers' digital literacy.

The outstanding impact of ICT in Education and its potential are transforming national education systems (UNESCO, 2011). Policymakers from different countries have made great efforts to establish ICT-related frameworks for educators. For example, the EU's DigCompEdu project (Redecker & Punie, 2017) sets outs guidance towards educators at all levels of education by determining six areas of digital competence (Figure 4). These six areas respectively focus on: (1) The professional environment; (2) Scouring, creating, and sharing digital resources; (3) Managing and orchestrating the use of digital tools in teaching and learning; (4) Enhancing assessment by digital tools and strategies; (5) Use of digital tools to empower learners; and (6) Facilitating learners' digital competence.

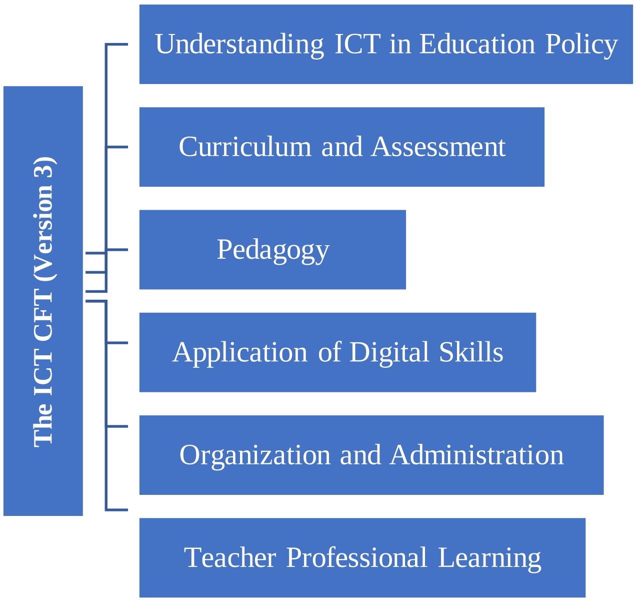
Figure 4. Framework of educators' digital competence



Source: (Redecker & Punie, 2017)

On the other hand, UNESCO (2011) ICT Competency Framework for Teachers has a comprehensive set of competence including six areas (Figure 5), which respectively focus on: (1) Awareness of ICT in Education policies; (2) Using digital tools to enhance curriculum and assessment; (3) Acquirement of ICT skills to support effective teaching and learning methods; (4) Prerequisites of basic ICT skills for integrating technology into a teacher's duties; (5) Manage the school's digital assets in physical and virtual environment; and (6) Ways for using ICT to empower teachers' lifelong professional development.

Figure 5. ICT Competency Framework for Teachers



In the China context, the Ministry of Education formulated various official documents with the purposes of accelerating the modern education by promoting the development of education informatization in the new era and cultivating a new engine of innovation-driven development, such as the "Teacher Education Revitalization Action Plan (2018-2022)" (2018) and the Implementation of the National Information Technology 2.0 Capacity Enhancement, Project for Primary and Secondary School Teachers (2019c). Particularly, "Information Technology Application Ability Standards for Primary and Secondary School Teachers (Trial)" (2014) as a competency standard was formulated to guide Chinese K-12 teachers' ICT training and assessment. This framework mainly has five areas: (1) Technology Literacy; (2) Planning and Preparation; (3) Organization and Administration; (4) Assessment and Diagnosis; and (5) Teacher Professional Learning. These areas are focused on five issues: (1) Acquirement of ICT skills to support effective teaching and learning methods; (2) Using digital tools to enhance curriculum preparation; (3) Using digital tools to enhance teaching process; (4) Using digital tools to enhance assessment; (5) Using ICT to empower teachers' lifelong professional development.

Apart from achievements from policymakers, researchers, and educators, school managements also have a conscious of making such big efforts in this related area. For example, Durán-Cuartero et al. (2016) made important contributions towards the conception of digital competence in the educational field. Internationally, a number of research pay attention on digital competence of K-12 education in different social context, in which some focus on in-service teachers (Badran et al., 2021; Fernández Cruz et al., 2018; Orosco-Fabian et al., 2021; Záhorec, Hašková, & Munk, 2021) and others focus on pre-service teachers (Cabero-Almenara et al., 2020; Calderón-Garrido et al., 2020; Jiménez-Hernández et al., 2020; Melash et al., 2020). A large number of reviews about teachers' digital competence emerged, such as Spante et al. (2018), focused on the relationship between digital competence and digital literacy. Uerz et al. (2018) and Røkenes and Krumsvik (2014) focused on the specific competences of teacher educators in teaching and learning with technology.

However, there is no SLR related to Chinese digital competence in the K-12 education field. Therefore, this paper aims to provide an overview of the research on K-12 pre-service and in-service teachers' digital competence in China. Firstly, we discover the main terms and dimensions used in the Chinese educational context. The used terms to describe the teachers' skills in using digital technologies change between regions, as well as the concept of teacher digital competence has different meanings depending on academic, cultural, historical, social, and educational contexts. Then, we identify the research trends in the assessment of pre-service and in-service teachers' digital competence by summarizing the main methodological characteristics and describing the main achievement. Finally, we highlight the research limitations and the future research directions for developing digital competence.

3.2. Research questions

In fact, both SLRs tried to discover the main terms and dimensions used for describing teachers´ digital competence in China, and the main proposals, methodological characteristics, and outcomes of the published research, including the research limitations and the future research directions. Hence, following these ideas, both SLRs focuses on the following research questions (RQ) respectively:

The first review was around these research questions:

◊ RQ 1.1. What are the main terms used to talk about teachers' use of technology for teaching and learning in the Chinese context?
◊ RQ 1.2. What are the main purposes of the studies related to the digital competence of teachers in China, and what are their relevant findings?
◊ RQ 1.3. What are the main characteristics of the research methods used in the selected studies?
◊ RQ 1.4. What are the main proposals made to improve the digital competence of Chinese teachers? And which of these proposals have been tested with people?

The second review was around these research questions:

◊ RQ 2.1. What are the major terms commonly used for describing and dimension contents have been laid out for assessing the skills competence of using digital technologies in China’s K-12 educational field?
◊ RQ 2.2. What are the main research streams, methodological characteristics, and outcomes of China teachers’ digital competence?
◊ RQ 2.3. What are the main proposals presented to improve China's K-12 pre-service and in-service teachers’ digital competence?
◊ RQ 2.4. What kinds of limitations and future directions of research are mentioned for accessing China teachers’ digital competence?

According to the research questions, we noticed that the purpose of the SLR1 were to describe the current state of digital competence of Chinese teachers, identify existing issues related to pre-service and in-service teachers, and map out a development framework for improving the digital competence of Chinese teachers. However, the SLR2 aimed to provide an overview of the research only in K-12 pre-service and in-service teachers’ digital competence in China.

3.3. Method

The main purpose of both SLRs is to identify, evaluate and interpret the available studies in the literature that consider the research questions proposed by the authors. Both studies used the PRISMA method (Moher, Liberati, Tetzlaff, & Altman,

2009) to conduct an SLR on publications related to teachers' digital competence in the context of China. Both SLRs execution process consists of five phases: (1) preliminary; (2) identification; (3) screening; (4) eligibility; and (5) analysis.

3.3.1. Inclusion and exclusion criteria

The databases selected are Web of Science (WoS), Scopus, and CNKI (China National Knowledge Infrastructure), which is a key national research and information publishing institution in China. Although WoS and Scopus cover the most relevant works published in the field Anglo-Saxon and European sources, they do not contain a significant amount of works related to the Chinese context. For this reason, we included the CNKI database as one of the main scientific databases available for both SLRs in China.

Both SLRs required the topic focused on digital competence, and the selected articles written in English or Chinese. Furthermore, the full version of the publications should have been available to consult via university library systems or the author's China National Knowledge Infrastructure account. Regarding the differences between the SLRs, the first one focused on the Asian educational context, particularly China. In contrast, the second one only focused on China K-12 in-or pre-service teachers. Then, the first selected studies were from a journal article, book chapters, or conference paper. In contrast, the SLR2 only selected original empirical studies published in journals with a peer-review process.

The inclusion and exclusion criteria of the SLR1 were organized into five inclusion criteria (IC) to ensure the works selected can provide answers to the research questions:

- IC 1.1: The work includes the following topics "digital competence" OR "digital competence" OR "digital competences" OR "digital competencies" OR "digital literacy" OR "digital abilities" OR "digital skills" AND
- IC 1.2: The work is focused on the Asian context with particular attention to China AND
- IC 1.3: The work is written in English or Chinese AND

- IC 1.4: The work is a Journal Article OR Book OR Book Chapter OR Conference Paper AND
- IC 1.5: The publication is the most recent and complete of the related publications on the same study.

The exclusion criteria (EC) were defined as the opposite of the IC. If any of the works retrieved do not meet IC, they will be excluded.

In the SLR1, we established the following EC:

- EC 1.1: The work does not include the following topics "digital competence" OR "digital competence" OR "digital competences" OR "digital competencies" OR "digital literacy" OR "digital abilities" OR "digital skills" AND
- EC 1.2: The work does not focus on the Asian context with particular attention to China AND
- EC 1.3: The work does not write in English or Chinese AND
- EC 1.4: The work does not a Journal Article OR Book OR Book Chapter OR Conference Paper AND
- EC 1.5: The publication does not the most recent and complete of the related publications on the same study.

On the other hand, the following inclusion and exclusion criteria of the SLR2 were used to ensure that the works selected can provide answers to the research questions described above. The different criteria used to include or exclude a paper were organized into six inclusion criteria (IC):

- IC 2.1: The work includes the following topics “digital competence” OR “digital competence” OR “digital competences” OR “digital competencies” OR “digital literacy” OR “digital abilities” OR “digital skills” AND
- IC 2.2: The work is focused on China K-12 in-service or pre-service teachers AND
- IC 2.3: The work is written in English or Chinese AND

- IC 2.4: The work is a Journal Article submitted to a peer review process AND
- IC 2.5: The article reports an original empirical study AND
- IC 2.6: The full version of the publication is available to consult via university library systems or the author's China National Knowledge Infrastructure account.

Finally, the EC proposed in the SLR2 were:

- EC 2.1: The work includes the following topics of teachers' digital competence OR
- EC 2.2: The work does not focus on China K-12 in-service or pre-service teachers, or the work just focuses on the status of regional digitization level OR
- EC 2.3: The work is written in other languages OR
- EC 2.4: The work is not a Journal Article OR
- EC 2.5: The secondary data analyzes, meta-analyzes, theoretical papers, and simulated results will be excluded OR
- EC 2.6: The full version of the publication is not available to consult via university library systems or the author's China National Knowledge Infrastructure account.

3.3.2. Search terms

We identified the main terms from the research questions and the possible alternative spellings and synonyms to create the search string using the PICOC method (Petticrew & Roberts, 2006). The different parts between these two SLR were the search strings used, including the potential kind of documents selected. Table 3 and Table 4 show search terms in titles, abstracts, and keywords of both SLRs respectively.

Table 3. The search terms in titles, abstracts, and keywords of the SLR1

Source	Search string
Web of science & Scopus	(“teacher” OR “teachers” OR “educator” OR “educators” OR “professor” OR “professors”) AND (“China” OR “Chinese” OR “Asia” OR “Asian”) AND ("digital competence" OR "digital competence" OR "digital competences" OR "digital competencies" OR "digital literacy" OR "digital abilities" OR "digital skills").
CNKI	教师及师范生信息技术/数字化能力
Types of documents	Article OR Book OR Book Chapter OR Conference Paper
Time period	2010-2021

Table 4. The search terms in titles, abstracts, and keywords of the SLR2

Source	Search string
Web of science & Scopus	((“teacher*” OR “educator*” OR “pre-service teacher*” OR “student teacher*”) AND (“China” OR “Chinese”) AND (“digital competenc*” OR “digital literac*” OR “digital abilit*” OR “digital skill*” OR “ICT competenc*” OR “IT competenc*” OR “ICT skill*”) AND (“kindergar*” OR “primar*” OR “secondar*” OR “K-12” OR “K12”)).
CNKI	教师及师范生信息技术/数字化能力
Types of documents	Article
Time period	2010-2021

3.3.3. Review process

In this review process, as mentioned before, we applied different search terms, IC, and EC. Moreover, the quality assessment checklists for both SLRs were different. The quality was evaluated using different quality assessment checklists, presented in Table 5.

Table 5. Quality Assessment Checklist for the Two SLRs

Indicators for the SLR1	Indicators for the SLR2	Score
Are the research objectives related to teachers' digital competence clearly described?	Are the research objectives related to teachers' digital competence clearly described?	Y/N/Partial
Was the study designed to achieve these objectives?	Is the study designed to achieve the objectives?	Y/N/Partial
Does the work describe the situation of teachers' digital competence in China?	Is the concept of digital competence clearly defined (terms used, dimensions)?	Y/N/Partial
Does the work access the teacher's digital competence?	Does the study clearly describe the instrument and research design?	Y/N/Partial
Does the study have a proposal to work on the digital competence of the teacher?	Is the sample and population of the study clearly described?	Y/N/Partial
Has the proposal been tested with teachers?	Has the research used a validated instrument related to digital competence?	Y/N/Partial
Has the research used a validated instrument related to digital competence?	Are the results or conclusions clearly describing teachers' digital competence in China (status of teachers' digital competence, influencing factors)?	Y/N/Partial
Is there any problem associated with the proposed situation described?	Does the study have proposals for improving China teachers' digital competence?	Y/N/Partial
Do the work answer all the research questions accurately?	Are there some limitations or problems clearly described?	Y/N/Partial

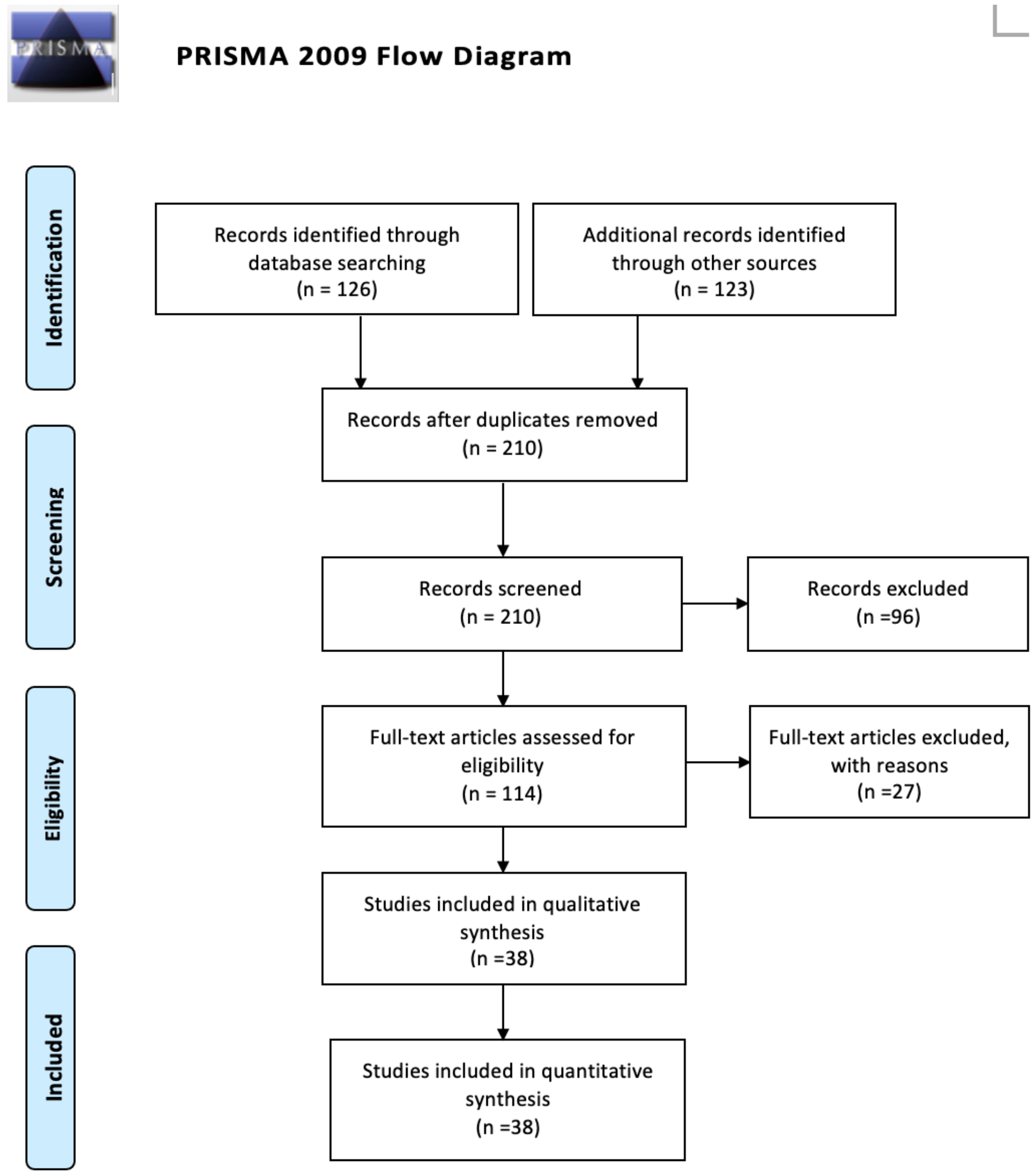
____	Are future lines of research presented?	Y/N/Partial

The answer for each one of the indicators could be scored with 1 point if the answer is "Yes", 0.5 points if the answer is "Partial" and 0 if the answer is "No". According to the checklist for the SLR1, each paper could obtain a score from 0 to 9 points. The first quartile mark (Q1 = 5 points) was used as the cutoff score for a paper to be included. If a paper scored less than 5, we excluded it from our final list to avoid low-quality works according to the assessment checklist. According to the checklist for the SLR2, each paper could obtain a score from 0 to 10 points. If a paper scored less than 8, we excluded it from our final list to avoid low-quality works according to the assessment checklist.

In this case, we noticed that the first four indicators in two SLR were the same, which focused on a clear description of the study goals, research design and teachers' digital competence conceptualization, and a use of a validated instrument. After the analysis of the rest of checklist, we concluded on the one hand that the indicators for quality assessment of the SLR1 were general. On the other hand, the indicators included in the SLR2 were more detailed, paying more attention on the quality of the selected articles by focusing on the clear description the instrument and research design, sample and population, results, conclusions, and limitations, including future lines of research. Therefore, the final selected articles were different.

For this, we present the review process for both SLRs separately. For the SLR1, searching the databases (identification phase), 249 papers were retrieved (50 from Web of Science, 76 from SCOPUS, and 123 from China National Knowledge Infrastructure limited to China Social Science Citation Index). All the raw results were collected in a repository (https://zenodo.org/record/7782201) Additionally, the analysis performed to achieve this number of papers was only based on their content, and without concerning bibliometric measurements (number of citations, journal source) or other issues.

Figure 6. Steps and Results of the Review Process in SLR1. PRISMA Statement (Moher, Liberati, Tetzlaff, Altman, et al., 2009)



The next step was the selection of papers used for the SLR1, as shown in Figure 6. It was performed following all these steps in SLR1 form (https://zenodo.org/record/7782292):

1. Phase one: The spreadsheet without the duplicates across the databases.
2. Phase two: The resultant 210 candidate papers were added to another sheet of the spreadsheet document, which were analyzed based on the title, abstract and keywords according to the inclusion/exclusion criteria

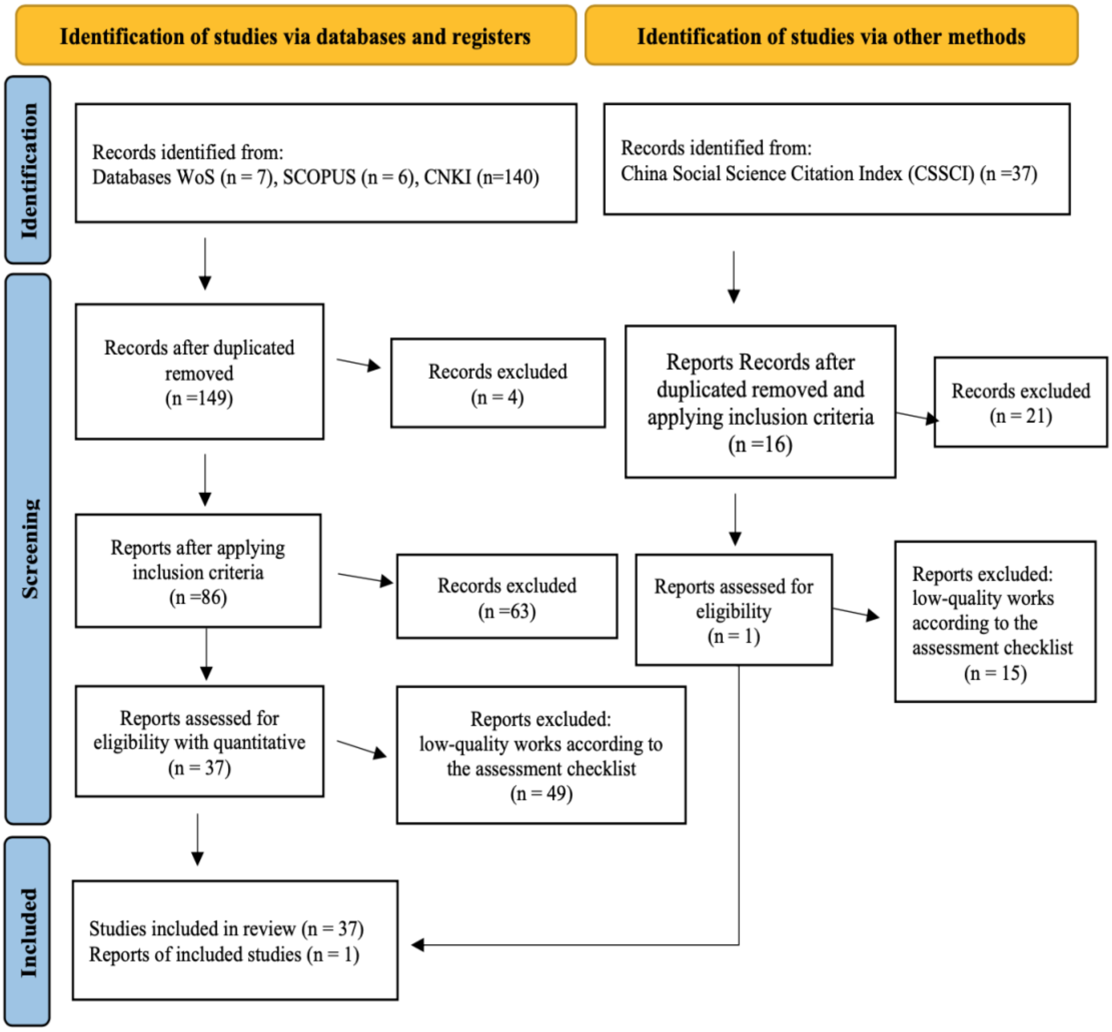
(screening phase). So, 54% of the papers (114) were retrieved. In those cases where the title and abstract were not sufficient to decide, the authors quickly assessed the entire content of the papers.

3. Phase three: These 114 selected papers in the previous phase were read in detail and analyzed following the previously posed research questions, which were subjected to a quality assessment checklist (see Table 5). The information was collected in another spreadsheet (eligibility phase).
4. Analysis phase: Papers selected after reading the full text (phase of final papers inclusion): 38 (18% of the total papers considered, 33% of the papers read). In this fourth step of the review, the papers were read in full as well, and it was analyzed in a last two spreadsheet for responding to research questions.

On the other hand, for the SLR2, the data extraction process follows PRISMA (Page et al., 2021). First, in the identification phase we retrieved 191 papers (7 from Web of Science, 6 from SCOPUS, 140 from CNKI limited to China Social Science Citation Index (CSSCI), and other 37 related papers from CSSCI). Additionally, the analysis performed to achieve this number of papers was only based on their content and without bibliometric measurements (number of citations, journal source) or other aspects.

As shown in Figure 7, it was performed following these steps to select papers. First, all the raw results were collected in SLR2 form (https://doi.org/10.5281/zenodo.7782201) which has already removed 4 duplicates across the databases and 5 duplicates across the CSSCI.

Figure 7. Steps and Results of the Review Process in SLR2. PRISMA Statement (Page et al., 2021)



The resultant 182 candidate papers were added to another sheet of the spreadsheet document (Second phase), which were analyzed based on the title, abstract, and keywords according to the inclusion/exclusion criteria (screening phase). A total of 102 papers (56 %) were retrieved, which 86 papers were retrieved from databases and 16 papers were retrieved from CSSCI. In those cases where the title and abstract were not sufficient to decide, the authors quickly assessed the entire content of the papers.

The third step was the eligibility phase. These 102 selected papers in the previous phase were read in detail and analyzed following the previously posed research questions, which were subjected to a quality assessment checklist (see Table 1), and the information was collected in another spreadsheet (Third phase). In this third step of the review, the papers were read in full to decide if they fulfilled a set of characteristics or quality criteria. The quality criteria focused on the description of digital competence (terms, dimensions), research objectives, methodological characteristics (research design, instrument, sample), research limitations, proposals for improving K-12 teachers' digital competence, and future research directions in the context of China. The quality was evaluated using the quality assessment checklist presented in Table 5. All the analysis step follows the identificatory in the Table 6.

Table 6. Analysis steps for selected papers based on research questions (SLR1 and SLR2).

Identificatory	Issues
RQ 1	• Terms • Dimensions
RQ 2	• Purposes • Methodological characteristics ◊ Population/sample (who, where, and how) ◊ Type of methodology (quantitative, qualitative, mixed) ◊ Type of instrument (questionnaire, interview, survey, etc.) ◊ Validation of the instrument (Content validation; EFA; CFA; EFA & CFA; Content validation & EFA; Content validation & CFA; Content validation, EFA & CFA; None) • Outcomes ◊ Status of teachers' digital competence level ◊ Difference in teachers' digital competence level ◊ Influencing factors
RQ 3	• Proposals
RQ 4	• Limitations of the research

3.4. Results

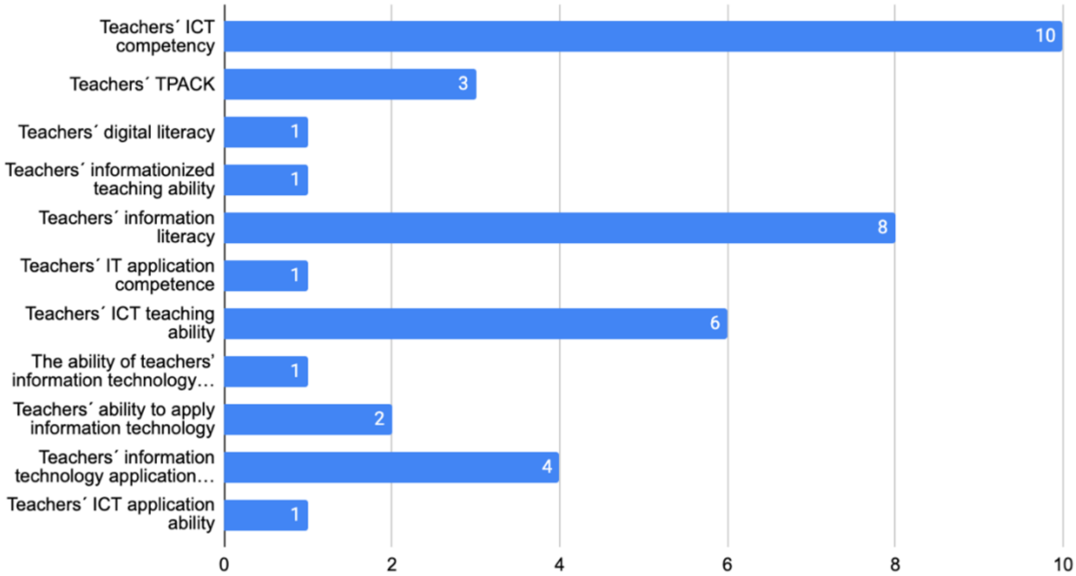
For the SLR1, 38 relevant studies that meet the rigorous applied screening criteria have been identified. Then these articles have been gathered, evaluated, and analyzed. This SLR provided evidence on research methods, influencing factors and proposals in teachers' digital competence in educational field, in addition to its terms used.

For the SLR2, we firstly explored the terms and dimensions commonly used to clarify the progress that has been made in the research on K-12 teachers’ digital competence in the context of China over the past ten years. Then we examined the purposes, methodological characteristics, and outcomes of selected research to gather the related information.

3.4.1. Main terms used

In the SLR1, as mentioned by Llomäki et al.(2011, p. 1), "several terms have been used to describe the skills and competence of using digital technologies, such as ICT skills, technology skills, information technology skills, 21st-century skills, information literacy, digital literacy, and digital skills". Table 73 (Appendix 1) and Figure 8 shows the findings of the digital competence terms used for describing teachers' digital competence. "Teachers' ICT competency" was the most used term (10/38 papers, 26.3%), followed by the term "Teachers' information literacy" (8/38 papers, 21%), the term "Teachers' ICT teaching ability "(6/38, 16%) and the term "Teachers' information technology application" (3/38, 7.9%).

Figure 8. Terms used for describing digital competence of teachers of 1ºSLR

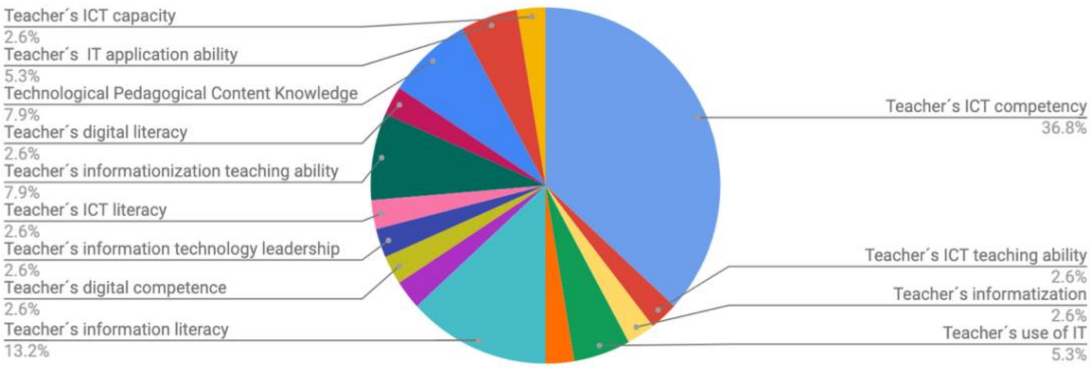


The term "Teachers' ICT competency" and the term "Teachers' information literacy" are the concepts initially based on ICT Competency Framework for Teachers from UNESCO (2011) framework. This framework emphasizes that having ICT competence is not enough for teachers to be able to teach their students. They need to be able to use ICT to assist students in being collaborative, problem-solving, and innovative learners.

According to these results, a mixture of terms is used around the keyword "information". From this we might infer that the concept of digital competence has not penetrated deeply into the Chinese educational landscape. Therefore, we concluded that the term "Teachers' ICT competency", as the primary term used in China, may be similar to the term "Teachers' digital competence". On the other hand, the reason why Chinese scholars continue to cite theoretical frameworks from various foreign countries or regions and use a mixture of these frameworks in the same article is that the current theoretical frameworks are insufficient to support the current state of development of digital theoretical frameworks in education. It is therefore urgent to update a theoretical framework that is suitable for the current stage of the country, which will facilitate the adaptation of the education system to the digital age to ecological China's policy of the 14th Five-Year Plan.

For the SLR2, Table 74 (Appendix 1) and Figure 9 show 13 technology-based and technology-oriented terms used to describe teachers' digital competence in China. 14 of 38 articles used the term "Teacher's ICT competency" which is the most common term used. It is followed by the term "Teacher's information literacy" (5/38 articles), the term "Teacher's informatization teaching ability" (3/38 articles), and the term "Technological pedagogical content knowledge" (3/38 articles). The other seven terms have been used in seven different articles, respectively. Several terms have been used to describe the competence of using digital technologies, which is in line with the phenomenon mentioned in the studies of Ilomäki et al. (2011) and Ilomäki et al. (2016).

Figure 9. The terms used related to teachers' digital competence of SLR2.



Based on the results, the term "Teacher's ICT competency" has been used in 14 research articles during the ten years. For example, Zhang et al. (2017), Zhang et al. (2014) and Wang and Ren (2020) used this term, which is based on national framework for K-12 teachers' digital competence (2014). On the opposite, the term "Digital competence" is rarely used in China's K-12 education, and only the article of Li et al. (2021) used it. Furthermore, only two articles (Zhao et al., 2018; Zhu & Wang, 2019) described their used terms. For instance, Zhu and Wang (2019), wrote that the term "ICT literacy" is a comprehensive ability, which is intrinsically manifested as ICT awareness attitudes and thinking habits, and external performance mainly refers to the ability to apply information technology. The rest of the articles used the term without any description, and some of them used terms as a synonym for some other terms, for instance, "Teacher's ICT capacity" in Li et al. (2018b) and "Teacher's informatization teaching ability" in Tang et al. (2019) are synonyms for the term of "Teacher's ICT competency".

Dimensions analysis for SLR2

Table 74 (Appendix 1) shows various instruments with different dimensions to evaluate teachers' digital competence. Five articles used the UTAUT model, seven articles adapted the technology acceptance model (TAM) to explore teachers' ICT use behavior, and three articles used TPACK to assess teachers' pedagogical knowledge of technology. Besides, five articles used dimensions from ICT Competency Framework for Teachers of UNESCO (2011). Four articles used dimensions from China national framework for K-12 teachers' digital competence (2014). The rest of the papers established their instruments with measured dimensions from different aspects to access K-12 teachers' digital competence.

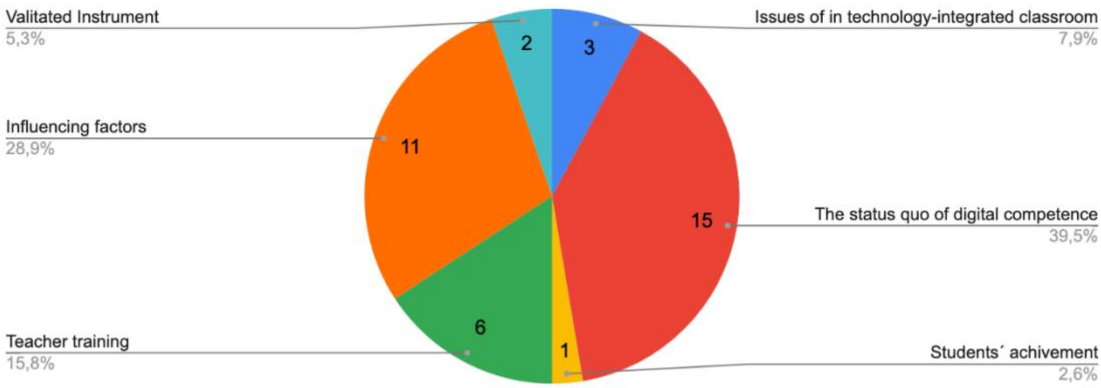
By analyzing the descriptors of dimensions, we found that the measured areas of teachers' digital competence define competences as proficiency in using technology in general or in using specific kinds of technologies. For example, the definition of competences in using technology in China national framework is general, which includes five dimensions: Technology literacy; Planning and preparation; Organization and administration; Assessment and diagnosis; and Teacher professional learning. In this framework, technology literacy refers to understanding ICT in education, accessing digital education resources, and having an awareness of ethics and security, which correspond to the conceptualization as Ala-Mutka (2011) mentioned: the first step in acquiring other knowledge, skills, and attitudes for building upon usage in a continuum from instrumental skills to productive competence and efficiency. In addition, we found that this framework is originally based on the ICT Competency Framework for Teachers of UNESCO. However, eight research articles define competence areas by using specific kinds of technologies (Huang et al., 2021; Liang, 2020; Liu et al., 2018; Yu & Zhang, 2020; Zhang et al., 2021; Qi Zhang et al., 2015; Zhou et al., 2018; Zhu & Wang, 2019). These focus on the practical abilities to use digital technologies in daily work, which are oriented at accessing the most-used software or tools, more than future development skills. For instance, Liu et al. (2018) specifically make clear access to use Office, platforms, and other tools (such as Word or PowerPoint), but do not mention any competence area related to teachers´ professional development skills for teaching and learning.

After examining and analyzing all these articles, we concluded that the common dimensions used for evaluating China K-12 teachers' digital competence revolve around three themes: (1) awareness of using digital technologies; (2) technical skills and practices of using digital technologies (preparing, implementing, and assessing); and (3) using digital technologies for professional learning, in which technical skills and practices of using digital technologies is the main research direction. Secondly, after approaching the narrower content of digital competence, we found that though China national and UNESCO teacher's ICT competence frameworks are comprehensive frameworks, both have excluded two important dimensions: teacher's use of digital resources in scouring, creating, and sharing; and learner's learning effectiveness.

3.4.2. Main research streams in SLR1

Figure 10 shows the six primary research proposals of all selected studies. There are 15 studies (39%) that investigated the status quo of digital competence level, 11 studies (30%) explored factors that influence teachers' digital competence, and six studies (16%) explored the issues related to teacher training in digital competence. Three studies focused on the issues in the technology-integrated classroom, and two studies built validated instruments for assessing pre-service and in-service teachers' digital competence. Only one study investigated K-12 students' achievement after using technology tools by teachers.

Figure 10. Research streams in SLR1



Based on the results of research proposals, we finally focused on three main themes of study outcomes: (1) the status quo of digital competence; (2) influencing factors; and (3) pre-service and in-service teachers' training. Regarding the status quo of digital competence in China, there are two main findings: pre-service and in-service teachers' digital competence level and the status of informatization level in different regions. Regarding influencing factors, we found that the main factors investigated in the selected studies were natural, external, internal, and factors from the technology acceptance model. The teachers' training effectiveness, user behavior, and influencing factors were investigated for the outcomes of teacher training.

3.4.2.1. The status quo of digital competence in the context of China

Regarding teachers' digital competence level, Kong and Zhao (2017), Ma et al. (2019b) and Tang et al. (2019) indicated that in-service teachers have a high level of awareness of the use of ICT in planning and preparing teaching sessions and in learning development, but they lack high ability to use ICT tools for teaching and learning practice. For example, in the study of Ma et al. (2019b), though teachers have a high level of recognition of the use of ICT for teaching and learning, their practical use of ICT in online communication tools and educational resources is not innovative. For pre-service teachers, Zhou et al. (2017) indicated that pre-service teachers have the willingness to change teaching methods. However, their willingness to optimize teaching and learning with ICT tools is not strong, and their ability to integrate technology with teaching is weak. For teachers of higher education, Yang and Hu (2019) and Liang et al. (2016) indicated that university teachers have consciously good awareness and responsibility of using ICT. They have good theory and design of information-based teaching and learning. However, university teachers' proficiency in using information technology to design and develop digital lessons and to use teaching resources is low.

On the other side, five studies demonstrated the status quo of the informatization level in Chinese regions (Kuang et al., 2018; Liu et al., 2018; Rao et al., 2019; N. Zhang et al., 2019; Zhou et al., 2016). Rao et al. (2019) and Kuang et al. (2018) indicated that there is no longer a significant difference in the configuration of classrooms in the East, Central, and Western regions, as well as the overall gap in the allocation of resources for informatization of primary education in counties is narrowing. However, from the study of N. Zhang et al. (2019) we find that the problem of unbalanced information technology resources in basic education has not been completely solved. As it has been shown in this study, in the mountainous areas of western Yunnan still exist poor information technology hardware environments and lack of network resources and access channels. Besides, Kuang et al. (2018) suggested that there is still room for innovation in using information technology to promote educational balance. The gap between the quality of education in the eastern and western regions of China is narrowing as the practice of informatization in education gradually progresses. However, many provinces in the western region are disadvantaged in terms of education. This finding validates previous research findings that China's level of informatization of regional status is uneven between its eastern, central, and western regions, where the eastern and central regions are more developed than the western regions (Fan & Song, 2017; Zhao & Qian, 2018). Furthermore, Liu et al. (2018) and N. Zhang et al. (2019) noted that teachers in the central and western regions generally have lower levels of digital competence than those in the eastern regions, especially in terms of using ICT tools for teaching and learning purposes.

3.4.2.2. Factors influencing teachers' digital competence

For the outcomes of studies related to the influencing factors, studies demonstrated that several factors have a significant direct and indirect impact on the teachers' digital competence. Research finds significant factors such as gender, age, years of teaching experience, teaching subjects, educational background, teachers' training experience, technological environment, or self-efficacy etc. For instance, Zhang et al. (2016) indicated a significant relation between gender and teachers' digital competence levels. This finding is opposite to the findings from Li et al. (2017) and Liang (2020). Moreover, Li et al. (2017), Zhang et al. (2018), and Zhou et al. (2018) indicated that age, years of teaching experience, and hours of training accepted by teachers have an impact on teachers' digital competence in teaching and learning. For example, Li et al. (2017) demonstrated that the teaching experience significantly impacts teachers' digital competence, which teachers with six months to three years of teaching experience have relatively better digital competence than others. Besides, teachers' educational background as another influencing factor was investigated by Liang (2020), indicating that there were no significant differences in ICT application skills between teachers from different educational backgrounds.

On the other hand, several kinds of research are based on the technology acceptance model. Li, Liao, et al. (2016), Zhang et al. (2016) and Zhang et al. (2018) indicated that some factors have a significant and positive effect on teachers' behavior in using technology for teaching and learning, such as social influence, performance expectancy, facilitating conditions, perceived usefulness, perceived ease of use, etc. Besides, student interaction feedback also affects teachers' information technology application behavior (Li, Wu, et al., 2016b; Li et al., 2017; Xu & Hu, 2017; Y. Zhang et al., 2015).

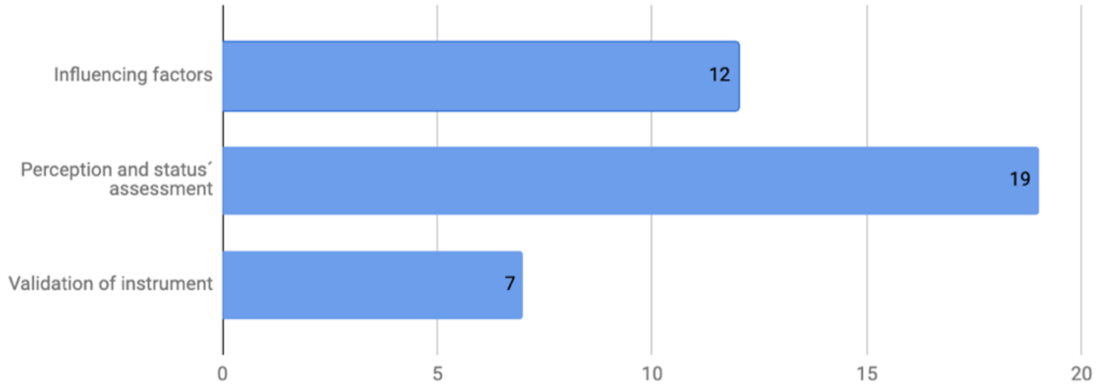
3.4.2.3. For teacher training

Among the studies related to teachers' training, we have found that the online format conducted all these training programs. For example, Li and Huang (2018) and Huang et al. (2016) investigated teachers' online discussions in workshops. Both indicated that participants could not identify and analyze the relevance of issues, and a large proportion of the discussions were ineffective. In this case, Li and Huang (2018) suggested that the facilitator's guidance is the most critical aspect of the online discussion. Therefore, the facilitator in the workshop needs to take specific measures to guide the online discussion process at different stages of the workshop. Concerning the two studies related to the effectiveness of teacher training, Wu et al. (2016) indicated that after Web 2.0-based training for teachers' educational technology skills, most teachers have a higher level of educational technology awareness and responsibility, knowledge and skills, teaching design, implementation and evaluation, and innovation with educational technology. Besides that, X. M. Zhang et al. (2019) indicated that the use of mind mapping in teacher training facilitates learners' mastery of the content, and content on practical teaching software is preferred by learners after training. Furthermore, based on the technology acceptance model, Wang and Guo (2017) indicated that job performance, objective use, external support conditions, computer efficacy, and social needs influence teachers' behavioral intentions to use web-based workshops.

3.4.3. Main research streams in SLR2

In the SLR2, after analyzing the research streams of selected articles, we classified them into three main categories (Figure 11): (1) Perception and status assessment, which include articles assessing and evaluating participants' perception or their digital competence level; (2) Influencing factors, which include articles exploring the factors that could influence and made differences in participant's digital competence; and (3) Validation of instruments, which include articles constructing digital competence-related models and using their corresponding instrument to measure the reliability and validity of the questionnaire.

Figure 11. Research streams in SLR2.



Based on the research proposals, the outcomes of the 38 articles will be analyzed by two aspects: (1) status of teachers' digital competence, which articles assessed and evaluated participants' perception; and (2) factors influencing teachers' digital competence, which articles investigated factors from technology acceptance model or sociodemographic factors of participants.

3.4.3.1. Status of teachers' digital competence

First of all, three articles reported the general status of participants' digital competence in the eastern, central, and western regions of China. Chen, Zhou, Wang, et al. (2020), Ma et al. (2019a) and Liu et al. (2018) concluded that the digital competence of participants in the eastern region is generally higher than in the central and western regions, and the digital competence of participants in urban areas is higher than in rural areas. These results correspond to the findings of previous studies. The informatization level of the status of regions is unbalanced in China among their eastern, middle, and western regions, which the eastern area has a higher level of informatization than the central and western areas (Fan & Song, 2017; Zhao & Qian, 2018).

At least ten articles measured dimensions which were underpinned by China national and UNESCO (2011) frameworks, assuming that teachers demonstrated a good awareness of technology literacy goals, and preliminary technology literacy level of educational practice. Regarding the awareness of technology literacy, Chen, Zhou and Wu (2020) and Tang et al. (2019) mentioned that participants' digital competence in the areas of awareness and ethics of using IT was high. Secondly, in terms of the educational practice, participants have basic knowledge of using ICT resources to support the curriculum, but they are weak in the organization and administration, assessment and diagnosis, and teacher professional learning. Liu and Kong (2017), Zhao et al. (2017), Zhang et al. (2014) and Tang et al. (2019) reported that participants' digital competence in the area of assessment and diagnosis is weak. In the works of Liu and Kong (2017) and Tang et al. (2019), participants lack of specific strategies to organize and manage a standard classroom. Besides, Ma et al. (2019a) and Zhao et al. (2021) suggested that participants lack awareness of using digital tools to enhance professional learning.

3.4.3.2. Influencing factors

Seven studies investigated the factors influencing teachers' technology use behaviors based on the technology acceptance model. These factors are basically divided into two aspects: internal factors and external factors. Three articles (Li, Liao, et al., 2016; Liu et al., 2012; Zhang & Wu, 2018) examined internal factors such as self-efficacy, perceived ease of use, or perceived usefulness. Subjective criteria have a significant direct or indirect impact on the teachers' digital competence, in which self-efficacy is the vital factor. On the other hand, four articles investigated that the external factors such as facilitating conditions, social influence, technical foundation, school system, teacher training, and technology environments have likewise significant direct or indirect impact on the teachers' digital competence (Li et al., 2018b; Li, Wu, et al., 2016b; Wan & Zhao, 2016; Zhang et al., 2016).

There are significant relations between the Chinese in-service teacher's level of digital competence and sociodemographic factors, which are mainly reflected in three aspects: age, educational background, and career stage. First, three articles found significant relations between teachers' age and digital competence levels, where young teachers have an obviously higher level of integrated information technology for teaching and learning (Chen & Lu, 2020; Ma et al., 2019a; Tang et al., 2019). For instance, Ma et al. (2019a) suggested that teachers over the age of 50 are significantly lower than others in digital competence in terms of awareness of using ICT and professional teaching and learning. Secondly, five articles (Chen & Lu, 2020;

Liang, 2020; Sun et al., 2021; Tang et al., 2019; Zhao et al., 2021) demonstrated that there are significant differences between teachers' digital competence and the years of teaching experience, However, there is significant disagreement in the findings as to how many years of teaching experience have higher digital competence. For example, Tang et al. (2019) and Chen and Lu (2020) indicated that teachers with less than 10 years of teaching experience have a higher level of digital competence. In Zhao et al. (2021), teachers with 11-15 years of teaching experience have a higher level of digital competence. However, Liang (2020) found that teachers with longer years of teaching experience have stronger digital educational practices, which the digital competence levels of teachers with more than 15 years of teaching experience is significantly higher than that of teachers of other teaching experiences. Finally, two articles indicated that teachers' digital competence level is consistent with their educational background; teachers with higher educational levels have a higher digital competence level (Chen & Lu, 2020; Zhao et al., 2021).

3.4.3.3. Validation of instruments

Seven articles have the goal of building new validated instruments through constructed new digital competence-related models, such as Li et al. (2019) constructed assessment model for pre-service teachers. Zhu and Wang (2019) built new validated instruments for access to kindergarten teachers. Yu and Zhang (2020) built new validated instruments for measuring teachers IT leadership on teaching efficacy.

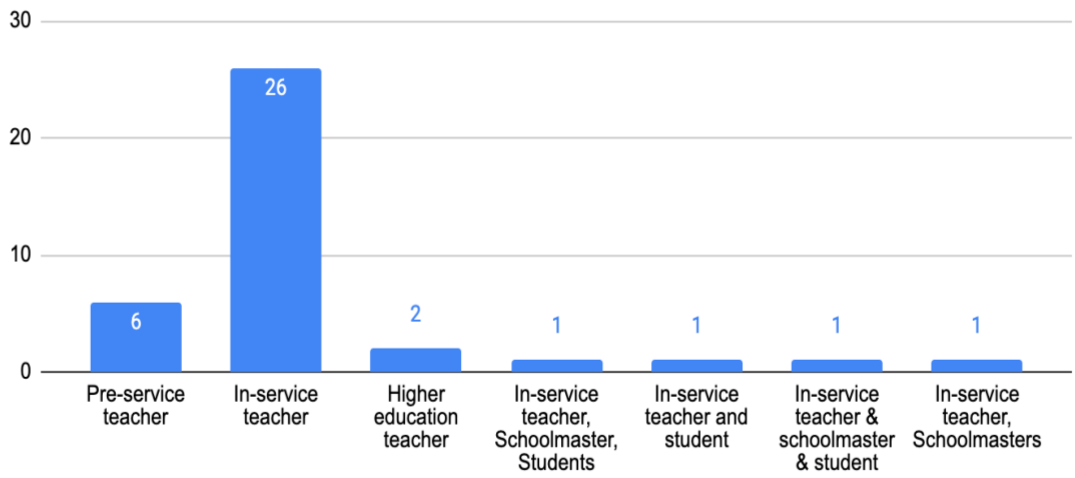
3.4.4. Main characteristics of the research methods used

3.4.4.1. Research methods in SLR1

Concerning the main characteristics of research methods of the SLR1, we investigated the population and sample, study regions, methodology, collected data method, and instruments.

Figure 12 shows that the in-service teachers is the main population studied in the selected papers. 30/38 papers (78.9%) studied the in-service teachers, in which three studies also investigated the schoolmasters' digital competence. However, 6/38 papers (16.2%) studied the pre-service teachers. Finally, two studies investigated higher education teachers' digital competence.

Figure 12. Study populations in SLR1.



On the other side, Table 7 shows the sample sizes of the selected 38 studies: 10 studies (63.2%) had small sample sizes, including between 1-200 participants; five studies included sample sizes 501-1,000 participants; 7 studies sampled middle size samples between 1,001-2,000 participants; and five studies (13%) had large samples, with more than 5,000 participants.

Table 7. Sample Size (Number) of the SLR1

Sample size	1-200	201-500	501-1,000	1,001-2,000	2,001-5,000	> 5,000	No mention
Nº papers	10	4	5	7	4	5	3

Regarding the Chinese region, where the study was conducted, 18 articles (47%) did not report or unclearly report their studying region, and the other 20 articles mentioned that their study was conducted in different regions of China. Figure 13 shows that Henan (n=7), Shanghai (n=6), Guangxi (n=7), and Zhejiang (n=7) provinces have been studied more frequently, followed by Anhui (n=5), Sichuan (n=5), Chongqing (n=5), and Jiangsu (n=5) provinces. From this we can conclude that most studies were conducted in the eastern and southern provinces of China. Less research has been done on teachers' digital competence in the central, western, and northern regions.

Figure 13. Frequency of Chinese provinces studied

Figure 14 shows the type of methodology, in which quantitative research (24/38 papers, 63%) is the most common, followed by mixed methods (9/38 papers, 24%) and, finally, qualitative approaches (5/38 papers, 13%).

Figure 14. Type of the methodology in SLR1

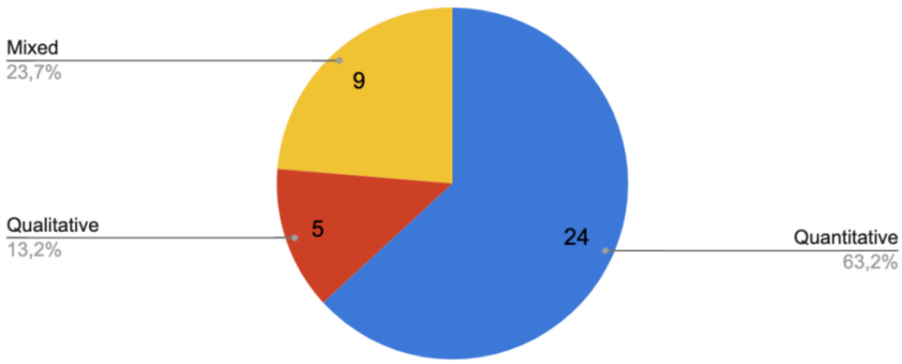
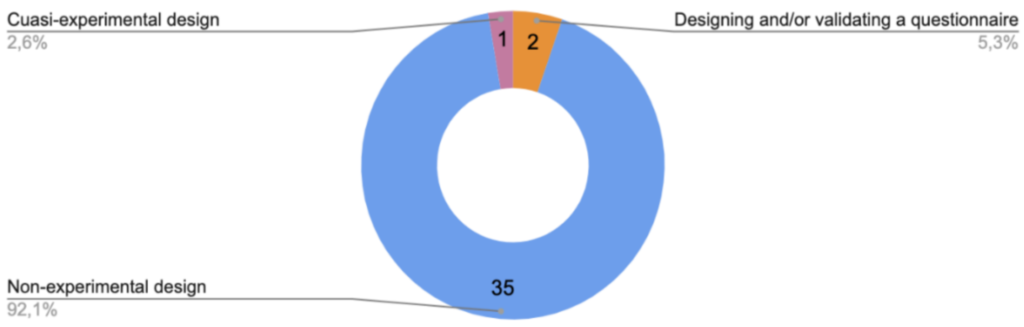


Figure 15 shows the main findings on the design-validation provided by these papers, including 35 (84.2%) studies focused on the diagnostic evaluation of the level of digital competence with non-experimental design. On the other hand, two studies focused on the fundamental intention of design and/o validating a questionnaire, and only one study used quasi-experimental research design.

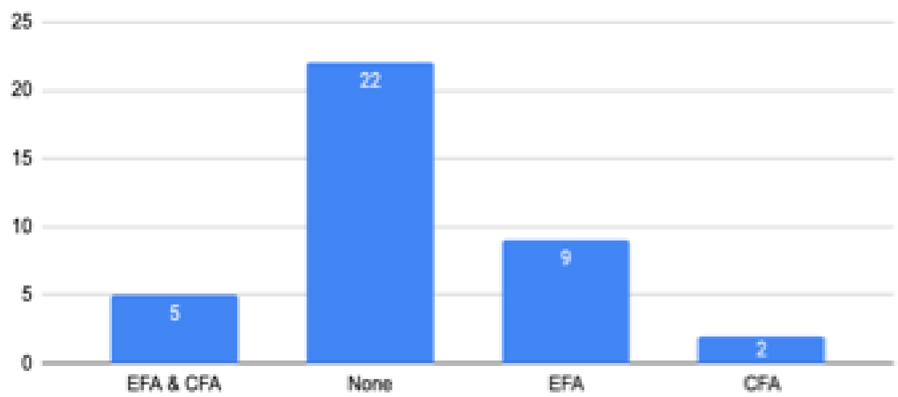
Concerning the methods used for collecting data, questionnaires, interviews, observation, and surveys were the main methods used. Among these studies, 21 of 38 used questionnaires, the most common instrument used for collecting data, followed by a combination of questionnaires and interviews (8/38 papers, 21.1%).

Figure 15. The design-validation in SLR1



For the instrument used, Figure 16 shows that most of the selected papers didn't include any reference to the validation of the instruments used (n =22). In contrast, nine studies included an exploratory factor analysis (EFA), and two studies applied both exploratory and confirmatory factor analysis for validating the instruments.

Figure 16. Validation of the instruments used in SLR1



3.4.4.2. Research methods in SLR2

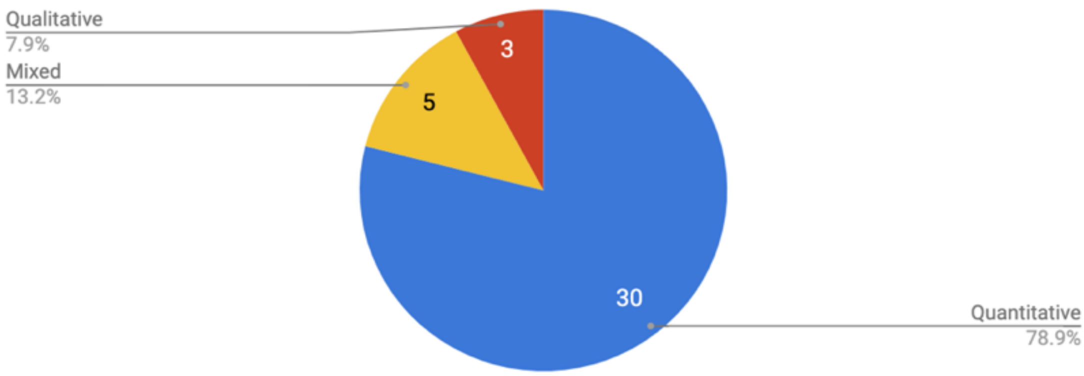
For the SLR2, the main population has been studied in the selected papers, of which 35 of 38 works (92%) studied in-service teachers, and 3 research (8%) studied pre-service teachers. Regarding the sample sizes, Table 8 demonstrates that 16 of 38 research (42%) included a sample size of less than 500 participants, seven articles had a sample size of 500-1,000 teachers, five articles had sample sizes of 1,000-1,500 teachers, one paper had between 2,000-2,500 participants, five between 3,000-10,000 teachers, and finally two articles had a sample size higher than 10,000 participants.

Table 8. Sample size of research papers in SLR2

Sample size	<500	500-1,000	1,001-1,500	1,501-2,000	2,001-2,500	2,501-3,000	3,001-10,000	>10,000
Nº papers	16	7	5	2	1	0	5	2

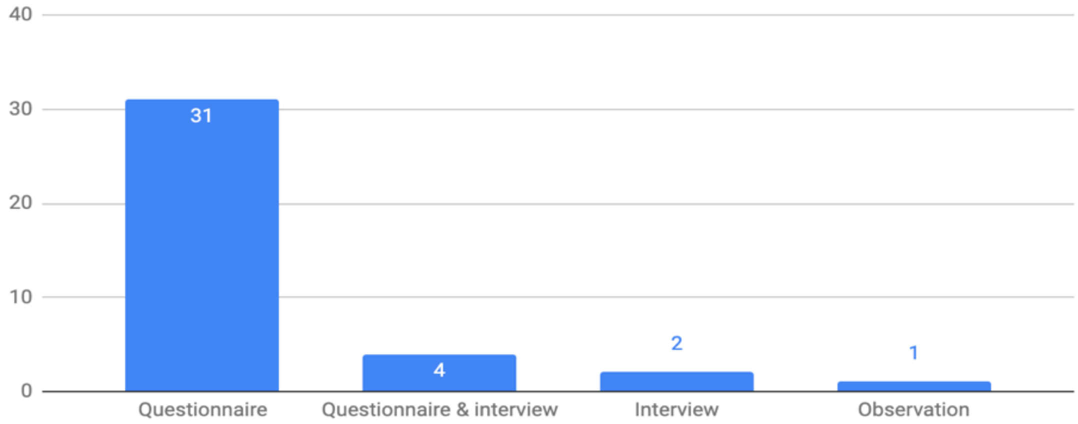
Regarding the research design, all selected articles used a non-experimental design. Figure 17 shows the types of the methodologies. 30 of 38 research (78.9%) used quantitative methodology, followed by 5 papers (13.2%) with mixed methodology and 3 papers with qualitative approaches. Besides, for investigating complex and intricate multivariate relationships that previously could not be easily untangled and examined, structural equation modeling (SEM) is an adequate methodology in social sciences rsearch. Thus, we found that 8 works used SEM methods, in which five research applied covariance-based models (CB-SEM) and three researchs applied variance-based models (PLE-SEM).

Figure 17. Type of research designs in SLR2



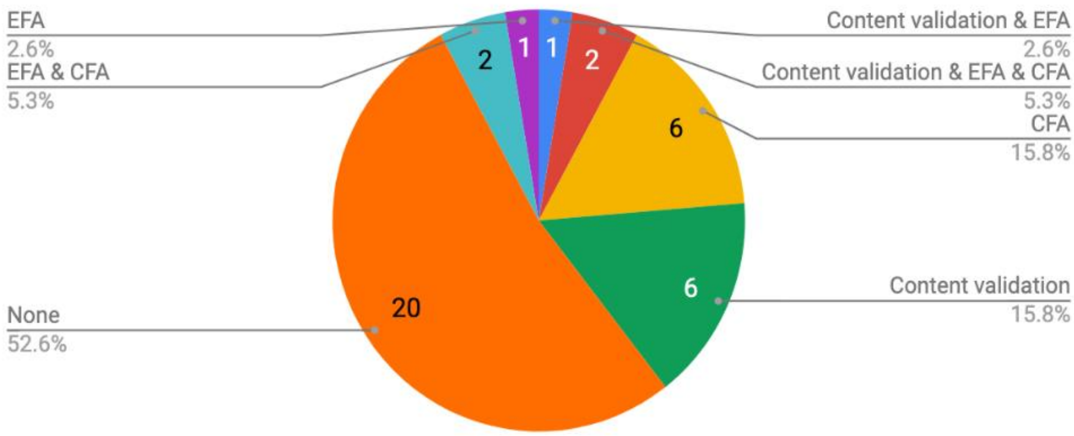
On the other hand, attending to the instrumentation, Figure 18 shows that 31 of 38 research articles (81.6 %) used questionnaires, which are the most used instrument in selected papers. Therefore, four research articles used both questionnaires & interviews, two articles used only interviews, and one article used observation.

Figure 18. Instruments used in SLR2



Moreover, 20 of 38 selected papers (Figure 19) have no reference to the validation of the instruments used. On the other hand, while 6 research articles (15.8%) used confirmatory factor analysis (CFA), one research applied exploratory factor analysis (EFA), and six (15.8%) studies included a content validation. Finally, two papers (5.3%) used both EFA and CFA, 2 research used content validation & EFA &CFA, and one article used content validation & EFA.

Figure 19. Validation of the instrument used in SLR2.



Based on these results, we conclude first that the sample sizes are generally large, but the need for more studies on pre-service teachers' digital competence is detected. Secondly, the quantitative methodology with questionnaires is the most common methodology for Chinese educational researchers and, while all research applied non-experimental design, more experimental research is needed. Lastly, although CFA and content validation are the most frequent validation methods, more than 50 % of articles doesn’t apply any instrument validation. Thus, it is important to make educational researchers in China aware of the importance of using valid and reliable instruments.

3.4.5. Main proposals presented

3.4.5.1. Proposals presented in SLR1

Among all the selected articles in the SLR1, Table 4 (Appendix 1) shows that 34 of 38 articles gave proposals for improving pre-service and in-service teachers' digital competence, in which 26 studies (47.4%) presented some theoretical proposals and 8 studies (21%) included practical proposals. Establishing a good atmosphere of ICT, conducting teacher training (20 of 34 articles), and making good pedagogical strategies were three main aspects of proposals put forward by the authors. However, we found only one article (X. M. Zhang et al., 2019) implementing and assessing an online teacher training program with in-service teachers.

Establishing a good atmosphere for ICT. We concluded that the studies recommend creating a good ICT atmosphere, in which government and schools are seen as important supporters who can make an effort to create a good ICT culture. Focusing on the figure of the government, six studies indicated that the government should provide support in terms of policy protection, resource allocation and mechanism development for information technology in basic education (Li, Liao, et al., 2016; Liang et al., 2016; Rao et al., 2019; Tang et al., 2019; Wang & Ren, 2020; Zhou et al., 2016). For example, Tang et al. (2019) indicated that the government needs to upgrade the support service system in all aspects and establish a continuous guarantee mechanism regarding technology, personnel and materials. In particular, Li, Liao, et al. (2016) mentioned that government should accelerate the transformation of China's education information technology from hardware to software construction.

Conducting teacher training. For professional teacher development, training approach, training content, and pedagogical strategies were three main aspects of training. In terms of the training approach, online training is the main way to improve in-service teachers' digital competence, such as, Li, Wu, et al. (2016b) and Z.

Zhang et al. (2019) recommended centralized training in an online format. Regarding the training content, Li et al. (2018a) and Xu and Hu (2017) recommended developing complete training course standards and building a highly adaptable 'precision' training model to promote the training content system. Moreover, the training content should be constantly updated by means of increasing the proportion of practical technology, such as teaching app applications, audio and video creation and editing. Besides, Teachers' skills in finding and classifying materials should be improved to keep up with the development of the real world of technology and make teachers feel effective (Yang & Hu, 2019). Because of pedagogical strategies for in-service teachers' training, first of all, it is necessary to enhance teachers' motivation and thinking about using technology for learning and teaching in post-service training (Li et al., 2017; Yang & Hu, 2019). Then, in order to explore more dynamic teacher professional development activities and offer more hands-on learning opportunities for teachers, five studies (Li, Liao, et al., 2016; Liang, 2020; Tang et al., 2019; Yang & Hu, 2019; Zhao et al., 2015) indicated that the training should focus on the characteristics of different categories and grouped according to the age, subject category and level of education of teachers, so that each training session is conducted from a different starting point and is focused. Lastly, Wu et al. (2016) and Tang et al. (2019) suggested establishing an evaluation system in teacher training process, such as establishing two-way evaluation of subject and object, combining quantitative and qualitative evaluations to optimize the evaluation criteria, and optimizing the input and output of the use of ICT for teachers by means of performance evaluation.

Regarding digital competence education for pre-service teachers, Zhou et al. (2017) demonstrate that there is lack of systematic curriculum system and the organized support means (hardware and software resources) for the practice of IT application, particularly in the lack of systematic support platform and high-quality case resources generally. This led to low awareness of professional development, and a low willingness to apply technology to optimize teaching, to design and organize applications ability. In this case, our study found three studies proposing the recommendations for pre-service training (Li et al., 2019; Mu et al., 2019; Zhou et al., 2017). They thought that universities or teacher training institutions need to build a systematic curriculum system to enhance the digital competence of pre-service teachers. In terms of the teaching contents, Mu et al. (2019) suggested teaching and evaluating theoretical and basic courses in education and psychology, to improve the effectiveness of theoretical learning.

On the other hand, two studies recommended strengthening pre-service teachers' individual and community practice (Mu et al., 2019; Zhou et al., 2017). Mu et al. (2019) and Li et al. (2019) particularly highlighted encouraging pre-service teachers to apply what they have learned in practice and promote the integration of theory and practice through constructing digital competence evaluation system. However, Zhou et al. (2017) suggested building practice support platform and quality case resources to effectively link information-based teaching theory and practice, by building quality case resources for information-based teaching based on the TPACK framework, and creating a tripartite cooperation mechanism between teacher training universities, local governments and primary and secondary schools to promote collaborative development and innovation among pre-service teachers. Besides, Li et al. (2019) suggested promoting the deep integration of technology and education teaching through the construction of an information technology environment.

Making good pedagogical strategies. As Kelentrić et al. (2017) mentioned, teachers' digital competence not only means the skill of using ICT to improve the learning environment, but it also requires teachers to develop students' ability to identify credible information, quote sources, protects their intellectual property, apply ethical values and attitudes in communication and interaction, produce their digital resources, and develop a reflective relationship concerning their own and others' actions, cultural differences, values and rights. The pedagogical strategy in this study refers to some methods to integrate ICT in teachers' teaching and learning process.

3.4.5.2. Proposals presented in SLR2

In the SLR2, based on the explored influencing factors and the assessment results of teachers’ digital competence, four main aspects of interventions have been recommended for improving teachers' digital competence level: (1) establish a good technology environment and atmosphere; (2) re-design a refined multi-evaluation system; (3) teacher's ICT training; and (4) targeted investment in hardware and software facilities. All these interventions rely on the will and skill of several key contributors such as researchers, policymakers, school leaders, including teacher educators. All interventions are resumed in Table 9, showing al papers which proposed any intervention. Only 6 works doesn't include any intervention proposal (Kong & Zhao, 2017; Liu & Kong, 2017; Liu et al., 2018; Zhang et al., 2016; Zhang et al., 2021; Zhu & Wang, 2019).

Table 9. Interventions purposed in SLR2

Articles selected	Interventions
(Chen & Lu, 2020)	1. Strengthen the construction of rural education informatization 2. Accurate training for teachers to integrate ICT into teaching practice 3. Play the coordinating role of the government and establish cooperative relations with universities
(Chen, Zhou, & Wu, 2020)	1. Conduct individualized training 2. Active teaching optimization and innovation activities 3. Enhance teachers' ability to analyze learning conditions and communicate information.
(Chen, Zhou, Wang, et al., 2020)	1. Cultivate the awareness of information innovation and build a team of high-quality innovative teachers. 2. Improve the modernization of teaching management. 3. Improve the construction of information application security. 4. Promote the balanced development of rural and urban teachers' information literacy.
(Huang et al., 2021)	1. Focus on improving the technical mastery of teachers after training. 2. Create an optimized section atmosphere to promote transformation.

	3. Promote transformation.
(Li et al., 2018b)	1. Emphasize the role of teachers' self-efficacy and awaken the internal drive for self-improvement. 2. Improve the training content system and build a “precise” training model. 3. Focus on teachers' technical concepts to lay the ideological foundation for effective integration
(Li et al., 2019)	For pre-service teachers, the state should increase the financial investment and policy inclination.
(Li et al., 2021)	1. Improving teachers’ digital competence to meet the requirements of online teaching. 2.Cultivating teachers’ intention to use online teaching to promote online teaching behaviors.
(Li, 2020)	1. Re-revise teachers' ICT application competency standards to expand the scope of their training. 2. Establish and improve the incentive mechanism for teachers' work. 3. Cultivating teachers' interpersonal relationships to enhance teachers' self-regulation ability.
(Li, Liao, et al., 2016)	1. Enhance teachers' awareness of perceived usefulness and perceived ease of use of ICT through training. 2. Education informatization should be transformed from hardware to software. 3. Create a good ICT cultural atmosphere.
(Li, Wu, et al., 2016a)	1. The training content should be different (knowledge skills, emotional attitude). 2. Change the way of training with one-to-one guidance, cooperative learning and hands-on teaching.
(Li, Wu, et al., 2016b)	1. Targeted teacher ICT training. 2. Develop an educational informatization performance evaluation system. 3. Improve the atmosphere of using ICT 4. Invest in hardware facilities.

(Liang, 2020)	1. Deepening the practical orientation of ICT training. 2. Promote the participation of multiple subjects. 3. Build a systematic ICT learning path. 4. Cooperate and interact, and to value the guiding role of experienced teachers.
(Liu et al., 2012)	1. Focus on the usefulness of ICT. 2. Strengthen training and practice to make teachers understand the role of ICT in teaching and learning. 3. Schools provide clear evaluation criteria, develop appropriate management measures, and form a good working atmosphere. In particular, school leaders should pay attention to ICT.
(Ma et al., 2019a)	1. Provide teachers with direction of effort and self-assessment means 2. Build an integrated teacher information literacy training system. 3. Pay attention to the factors that affect teachers' ICT professional development.
(Mu et al., 2019)	1. Universities should adjust the requirements and evaluation methods of teaching to encourage pre-service students to practice. 2. Instructing teachers to use technology to change teaching and learning methods based on their theories and methods. 3. Teachers should understand, recognize, and use ICT to improve their teaching needs.
(Qi Zhang et al., 2015)	1. Develop a self-assessment tool before and after teacher training 2. Develop a training curriculum system 3. Carry out a diversified evaluation system after understanding the effects of pre-service and post-tests
(Sun et al., 2021)	1. To train teachers to use ICT for teaching practice. 2. To provide effective ICT resources for rural teachers.

	3. To provide targeted training for teachers according to their teaching level and age group
(Tang et al., 2019)	Precise training strategies for teachers.
(Wan & Zhao, 2016)	1. Strengthen the construction of ICT hardware and software. 2. Implement on-demand training and school-based training. 3. Innovate management mechanism.
(Wang & Guo, 2017)	1. Focus on the construction of incentive mechanism. 2. Pay attention to the construction of training content and resources. 3. Strengthen the organizational leadership and support services of workshop leaders. 4. “Precise training” for teachers' ICT practice
(Wang & Ren, 2020)	1. Investigate students and teachers’ literacy in the ICT environment. 2. Digital literacy between music and visual arts teachers should be investigated. 3. Focus on older arts teachers’ digital literacy development.
(Wang & Wu, 2018)	1. Add TPACK ability training courses combined with disciplines. 2. Build a modern educational technology laboratory and TPACK evaluation system. 3. Build the educational practice and incentive mechanism for pre-service teachers of various majors.
(Yu & Zhang, 2020)	1. Create a positive atmosphere and play a technology-led role. 2. Strive for technological advancement and disciplinary integration 3. Focus on the radiation effect and fix the collaboration model. 4. Focus on teaching leadership, digging deeper into digital resources.

	5. Focus on extracurricular guidance, online and offline combination
(Zhang & Wu, 2018)	1. Restructure the training content. 2. Enhance teachers' work efficacy. 3. Create a good atmosphere for use. 4. Create a balanced informatization condition.
(Zhang et al., 2014)	1. Develop a self-assessment tool before and after teacher training 2. Develop a training curriculum system 3. Carry out a diversified evaluation system after understanding the effects of pre-service and post-tests
(Zhang et al., 2017)	1. Promote the construction of ICT application environment 2. Improve teachers' ability of teaching evaluation and diagnosis, and develop a diversified evaluation system
(Zhang et al., 2018)	1. A good technical environment consisting of school administrators and expert teachers, etc. 2. Systematic reform of the curriculum related to teacher education.
(Zhao et al., 2015)	1. According to the characteristics of teachers' TPACK knowledge in different subjects, optimize the training courses. 2. According to the differences of teachers' TPACK knowledge, encourage teachers to participate in MOOCs related courses and improve the teacher training mechanism. 3. Explore a hybrid training model based on flipped classroom.
(Zhao et al., 2017)	1. Adapt to the concept and content of teaching and learning innovation with technology. 2. Be problem-oriented and focus on teachers' teaching practice process with technology. 3. Integrate information-based leadership into teachers' ICT competence.

(Zhao et al., 2018)	1. Students and teachers' literacy in the ICT environment will be a key research area in future. 2. Digital literacy between music and visual arts teacher should be investigated. 3. Focus on older arts teachers' digital literacy development.
(Zhao et al., 2021)	1. Rational design of ICT training contents. 2. Strengthen the practice of school-based training model. 3. Strengthen the organization and guarantee mechanism to promote innovation in ICT practice.
(Zhou et al., 2018)	1. Targeted digital teaching resources construction. 2. Deepen the training of teachers' IT practice.

According to Table 9, six articles mentioned that school administrators should establish a good technology environment and atmosphere to strengthen teachers' motivation for digital educational practice (Chen & Lu, 2020; Huang et al., 2021; Li, Liao, et al., 2016; Liu et al., 2012; Yu & Zhang, 2020; Zhang et al., 2018). Three of these six articles suggested that the government can play a coordinating role to allow primary and secondary schools and universities to establish a new type of cooperative relationship characterized by a "development community" (Chen & Lu, 2020; Tang et al., 2019; Zhao et al., 2021). Moreover, Chen, Zhou and Wu (2020) mentioned that the outstanding teachers could take the lead in exploring to stimulate other teachers to carry out teaching innovation with ICT; young teachers and older teachers form teaching innovation teams to complement each other's skills and experience.

Second, five authors recommended to re-design reasonable incentive mechanisms and matching a refined multi-evaluation system, which plays an important role in helping the overall technological teaching atmosphere (Li, Wu, et al., 2016b; Liu et al., 2012; Wang & Ren, 2020; Zhang et al., 2017; Zhang et al., 2018). For example, Zhang et al. (2018) indicated that a multi-evaluation system should be improved and optimized to stimulate teachers' desire to learn and use digital tools in the class, which will help the overall information-based teaching atmosphere. Then, 18 of 38 articles (47.3%) put forward the intervention of the ICT training course, in which nine articles proposed to improve the ICT training content system by developing content stratification to meet teachers' personal needs, such as their teaching subjects, teaching periods and years of teaching experience. Moreover, the other two recommended purposes are to develop a self-assessment tool for teachers' ICT before and after training and to design an evaluation system during the teachers' ICT training process (Zhang et al., 2014; Qi Zhang et al., 2015).

Finally, seven articles proposed to invest hardware and software facilities, such as Chen and Lu (2020) and Wan and Zhao (2016), which suggested improving the construction level of educational informatization hardware facilities in rural and underdeveloped areas. Li et al. (2016) indicated that education informatization in current China should be transformed from hardware construction to software construction. Additionally, Zhao et al. (2015) implied that researchers should seek out more training ways like a combination of online and offline models to improve in-service teachers' digital competence.

For pre-service teachers, Li et al. (2019) indicated that government should provide more financial support, technical support, and policy support for building an information-based environment and carrying out information literacy education for student teachers. Then, four articles suggested that a systematic curriculum reform for pre-service teachers using ICT should be completed, which is one of the effective measures to improve teachers' pedagogical use of ICT (Li et al., 2019; Mu et al., 2019; Wang & Wu, 2018; Zhang et al., 2018). These imply that the application of new technologies and high-quality resources in high education is in urgent need of expansion, as well as an innovative model of the curriculum to promote pre-service teachers' digital competence.

3.5. Conclusion

The different search terms and selected criteria conduct different selection results. In each of the SLRs 38 articles were screened and 17 of them were duplicates. All selected articles are shown in the Table 10.

Table 10. Finally selected articles for both SLR

Number	Selected articles for SLR1	Selected articles for SLR2
1.	Zhao et al. (2018)	Zhao et al. (2018)
2.	Liu et al. (2018)	Liu et al. (2018)
3.	Zhou et al. (2018)	Zhou et al. (2018)
4.	Zhao et al. (2015)	Zhao et al. (2015)
5.	Wang and Wu (2018)	Wang and Wu (2018)
6.	Mu et al. (2019)	Mu et al. (2019)
7.	Liang (2020)	Liang (2020)
8.	Zhao et al. (2018)	Zhao et al. (2018)
9.	Liu et al. (2018)	Liu et al. (2018)
10.	Li et al. (2019)	Li et al. (2019)
11.	Li, Wu, et al. (2016a)	Li, Wu, et al. (2016a)
12.	Li, Liao, et al. (2016)	Li, Liao, et al. (2016)
13.	Tang et al. (2019)	Tang et al. (2019)
14.	Kong and Zhao (2017)	Kong and Zhao (2017)
15.	Wang and Ren (2020)	Wang and Ren (2020)
16.	Ma et al. (2019a)	Ma et al. (2019a)
17.	Wang and Guo (2017)	Wang and Guo (2017)
18.	Yao et al. (2019)	Wan and Zhao (2016)
19.	Z. Zhang et al. (2019)	Li et al. (2018b)
20.	Xia et al. (2017)	Zhang et al. (2017)
21.	Yan et al. (2018)	Zhang et al. (2014)
22.	Li, Wu, et al. (2016a)	Zhao et al. (2021)
23.	Zhou et al. (2017)	Zhao et al. (2017)
24.	Li et al. (2017)	Liu and Kong (2017)

25.	Li and Huang (2018)	Chen, Zhou, Wang, et al. (2020)
26.	X. M. Zhang et al. (2019)	Chen, Zhou and Wu (2020)
27.	He et al. (2018)	Liu et al. (2012)
28.	Li et al. (2018a)	Zhang et al. (2018)
29.	Xu and Hu (2017)	Zhang and Wu (2018)
30.	Yang and Hu (2019)	Li et al. (2021)
31.	Kuang et al. (2018)	Sun et al. (2021)
32.	Rao et al. (2019)	Li (2020)
33.	Zhou et al. (2016)	Chen and Lu (2020)
34.	Huang et al. (2016)	Yu and Zhang (2020)
35.	N. Zhang et al. (2019)	Qi Zhang et al. (2015)
36.	Qi Zhang et al. (2015)	Huang et al. (2021)
37.	Liang et al. (2016)	Zhu and Wang (2019)
38.	Wu et al. (2016)	Zhang et al. (2021)

These two reviews were focused on different issues in the last research questions, where the first review focused on the type of limitations and further direction of research of selected articles, and the SLR2 focused on the specific proposals mentioned in the selected article. However, related to the same research questions, we still found that both literature reviews show similar findings.

Firstly, both reviews showed that "Teacher's ICT competency" is the most common term used to describe the competences of using digital technologies. China's national framework is based on UNESCO teachers' ICT competence framework (2nd edition). Their dimensions revolve around three themes: awareness of using digital technologies, technical skills, and practices of using digital technologies (preparing, implementing, and assessing), and using digital technologies for professional learning.

Secondly, the SLR2 classified three main categories: perception and status assessment, influencing factors, and instrument validation. Except for these three categories, the first review classified the other three primary research proposals of all selected studies: the issues related to teacher training, the issues in the technology-integrated classroom, and K-12 students' achievements after using technology tools by teachers. Concerning research outcomes, both literature reviews showed similar results. First, the informatization level of the status of regions is unbalanced in China among their eastern, middle, and western regions. The eastern area has a higher informatization level than the central and western areas. Teachers have higher levels of awareness and ethics of using IT, but their professional practice for teaching and learning is weak. Then, both reviews demonstrated that several factors have a significant direct and indirect impact on the teachers' digital competence, such as gender, years of teaching experience, teaching subjects, educational background, teachers' training experience, technological environment, and self-efficacy. Lastly, the first review also demonstrated the outcomes related to teacher training in digital competence, in which the online training format and the effectiveness of teacher training are the main study focus.

Chapter 4. Methodology

The theoretical framework presented in Chapter 2 and Chapter 3 allow to observe some of the most relevant aspects of teachers' digital competence in China by focusing on the status of teachers' professional development in digital competence for teaching and learning. The findings of SLR indicated that teachers' digital competence is an important research topic in Chinese education. The informatization level of the status of regions needs to be more balanced in China among their eastern, middle, and western regions. Factors (such as gender/sex, years of teaching experience, teaching subjects, educational background, teachers' training experience, technological environment, and self-efficacy) significantly impact Chinese teachers' digital competence.

However, as seen, there is no one study for Anhui province specifically, nor comparing pre-service and in-service teachers. Thus, the objectives of this empirical study are to assess and analyze Chinese pre-service and in-service teachers' perception of digital competence and to explore the relationship between sociodemographic factors (age, educational degree level, ICT courses, years of teaching experience) and their digital competence level in Anhui province. In this regard, we propose the following research questions:

1. What is the status of the perception of digital competence for Chinese pre-service and in-service teachers?
2. Which analyzed factors influence the level of digital competence of pre-service/in-service teachers? Furthermore, which are the stronger factors that can influence the level of digital competence of pre-service/in-service teachers?

This chapter includes the methodology definition of this empirical research. Firstly, the research design is presented. Secondly, the sample and population of the research are described, including an initial exploration of the research sample sociodemographic distribution adjustment to the target population. Then, the variables, instruments and research procedures are defined. Lastly, we explain the data analysis methods used.

4.1. Research design

With the aim to achieve the objective and validate the instrument for assessing pre- and in-service teachers' digital competences in the context of China, this study proposed a diagnostic evaluation from a quantitative paradigm, which used a non-experimental-cross-sectional design. Thus, an ex-post-facto methodology based on survey studies were implemented.

Attending to the main goals and the research design, the results section will show the main scores of pre-service and in-service teachers perceived digital competence in the Anhui (China) region, and its relationship with the measured sociodemographic variables.

4.2. Sample and population

4.2.1. Target population

According to the Communiqué of the Seventh National Census of Anhui Province (2021), the whole population among the permanent residents of the province is 61,027,171. The population of ethnic Han is 60,594,623, and the other ethnic minority population is 432,548, which account for 99.29% and 0.71%, respectively, in the whole population.

Table 11 shows 2019 numbers of full-time teachers from 2005-2019, based on Anhui Provincial Statistical Yearbook (National Bureau of Statistics of China, 2020). The number of teachers working in elementary schools is the highest, remaining at about 255,000 people annually. Regarding regular secondary school, about 150,00 teachers are working in junior school and about 70,000 in senior school. However, the number of people working in vocational secondary schools has changed significantly over the past fifteen years. Although in 2005, there were more than

17,000 teachers in vocational secondary schools, by 2019, only 4,500 teachers were working in vocational secondary education in the context of Anhui province of China.

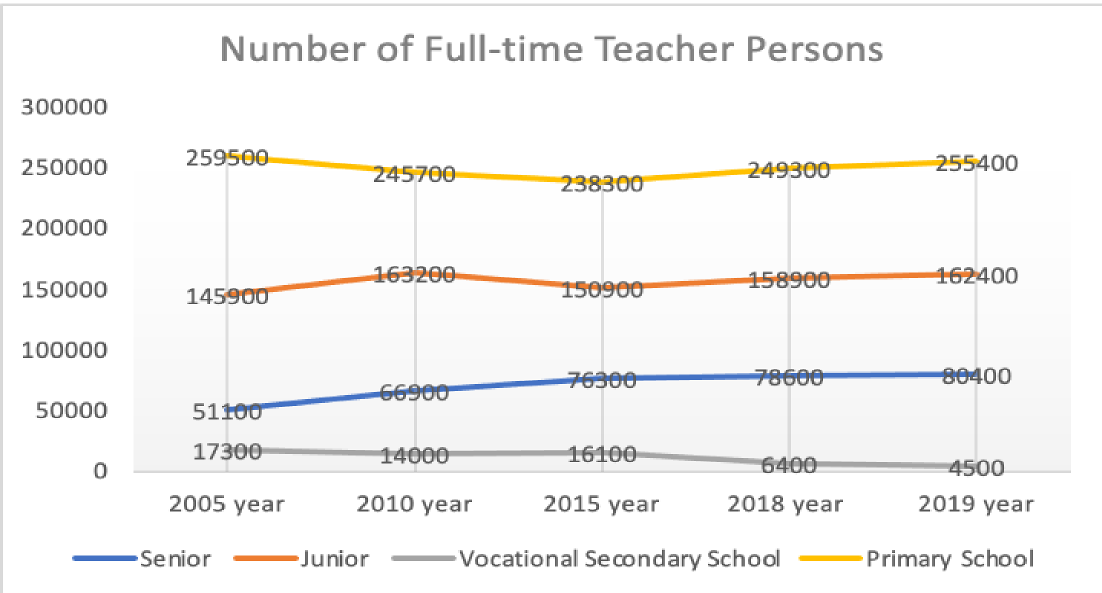
Table 11. Number of Full-time Teacher in Anhui province

Teachers / Years	Regular Secondary Schools		Vocational Secondary School	Primary School
	Senior	Junior		
2005	51,100	145,900	17,300	259,500
2010	66,900	163,200	14,000	245,700
2015	76,300	150,900	16,100	238,300
2018	78,600	158,900	6,400	249,300
2019	80,400	162,400	4,500	255,400

Source: National Bureau of Statistics of China (2020)

Figure 20 shows the evolution of the full-time teacher population from 2005-2019. Primary school teachers are the largest group from 2005 to 2019, with more than 23,000 people. Then, teachers at junior schools have the second largest number of employees, followed by the teachers working in senior schools. Apart from that, the number of vocational secondary school teachers has dropped sharply, especially since 2008. By contrast, the number of teachers engaged in regular secondary school (junior and senior school) has increased slightly.

Figure 20. Number of Full-time Teacher Persons in Anhui province.



Source: National Bureau of Statistics of China (2020)

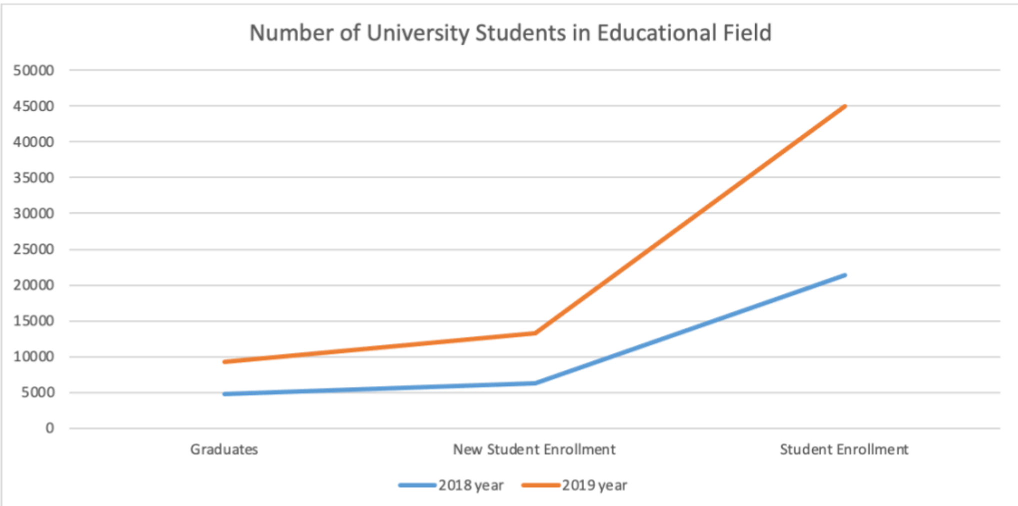
The Anhui Provincial Statistical Yearbook (2020) also demonstrated the number of undergraduate students in educational field in 2018 and 2019. Table 12 shows the number of university students in the educational field. Apart from the 4,760 graduated student teachers, there were 6,319 new and 21,392 enrollment student teachers in 2018. In 2019, there were 4,574 graduated student teachers, 6,933 new enrollment students, and 23,519 enrollment teachers.

Table 12. Number of University Students in Educational Field

Educational field / Years	Graduates	New Student Enrollment	Student Enrollment
2018	4760	6319	21392
2019	4574	6933	23519

Figure 21 shows the evolution of the number of students in Educational Field, divided in three groups (graduates, new student enrollment and student enrollment) from 2018 to 2019. The number of these types of pre-service teachers have increased, especially the student enrollment.

Figure 21. The number of students in Educational Field



4.2.2. Sample of the research

The sample of this research was retrieved online from both pre-service and in-service teachers between February and May 2021 in Anhui province of China. A non-probabilistic sampling procedure (voluntary response sample) was applied.

All the analyzes were applied separately based on both samples: pre-service and in-service teachers. Figure 22 shows the initial samples obtained (n=498). Most participants (116) were from Hefei (the capital of Anhui province). Finally, n=496 participants were included in the final sample since two questionnaires were not filled in completely.

Figure 22. Geographical distribution of the sample

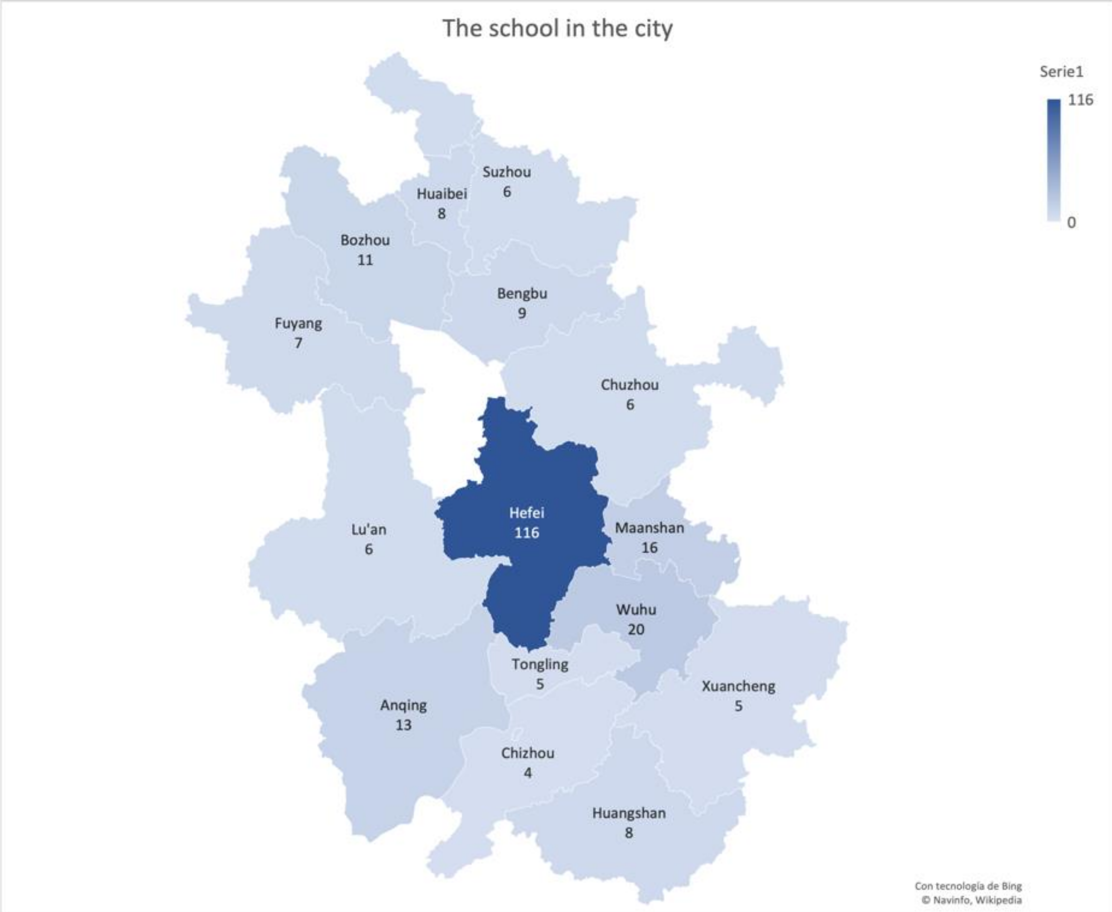


Table 13 shows that 248 in-service teacher and 250 pre-service teachers were included in the final sample. Among 248 in-service teacher participants, 136 (55%) were female and 112 (45%) were male. On the other hand, among 250 pre-service teacher participants 122 (49%) were female and 128 (51%) were male.

Table 13. Distribution sample of sex for pre-service and in-service teachers

Sex	In-service teacher		Pre-service teacher	
	Frequency	Percentage	Frequency	Percentage

Female	136	55%	122	49%
Male	112	45%	128	51%
Total	248	100%	250	100%

Figure 23 shows the sex distribution of pre-service and in-service teacher samples. It shows that the sex distribution was balanced between both groups.

Figure 23. Distribution sample of sex for pre-service and in-service teachers

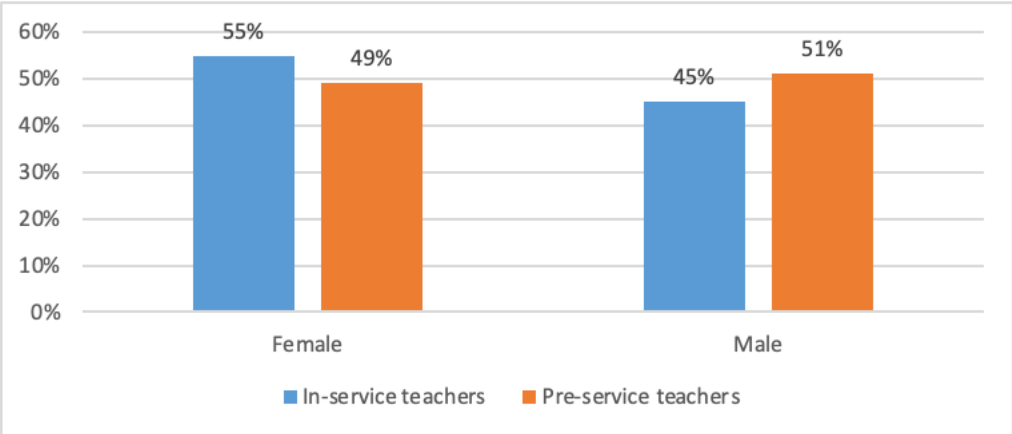


Table 14 presents the descriptive statistics for pre-service and in-service teachers´ age and years of teaching experience. According to these results, the mean of in-service teacher teaching experience was 7.92 years. The values of P_{25}, P_{50}, and P_{75} were 3, 5, and 10, respectively, so most in-service teachers had a teaching experience between 3 and 10 years. Regarding the pre-service and in-service teachers' age, the mean value of the pre-service teacher sample was 21.55, and of the in-service teachers was 31.82.

Table 14. Descriptive statistics of in-service and pre-service teachers´ age / teaching experience

	Mean	S_X	Min	P_{25}	Mdn-P_{50}	P_{75}	Max
Age (Pre-service)	21.55	2.70	16	20	21	23	36
Age (In-service)	31.82	6.84	17	28	30	35	55
Teaching Exp.	7.92	7.84	0	3	5	10	34

Based on the descriptive statistics from Table 14, Figure 24 shows the distribution of both groups' age and in-service teachers' teaching experience.

Figure 24. Distribution of sample´s age and teaching experience

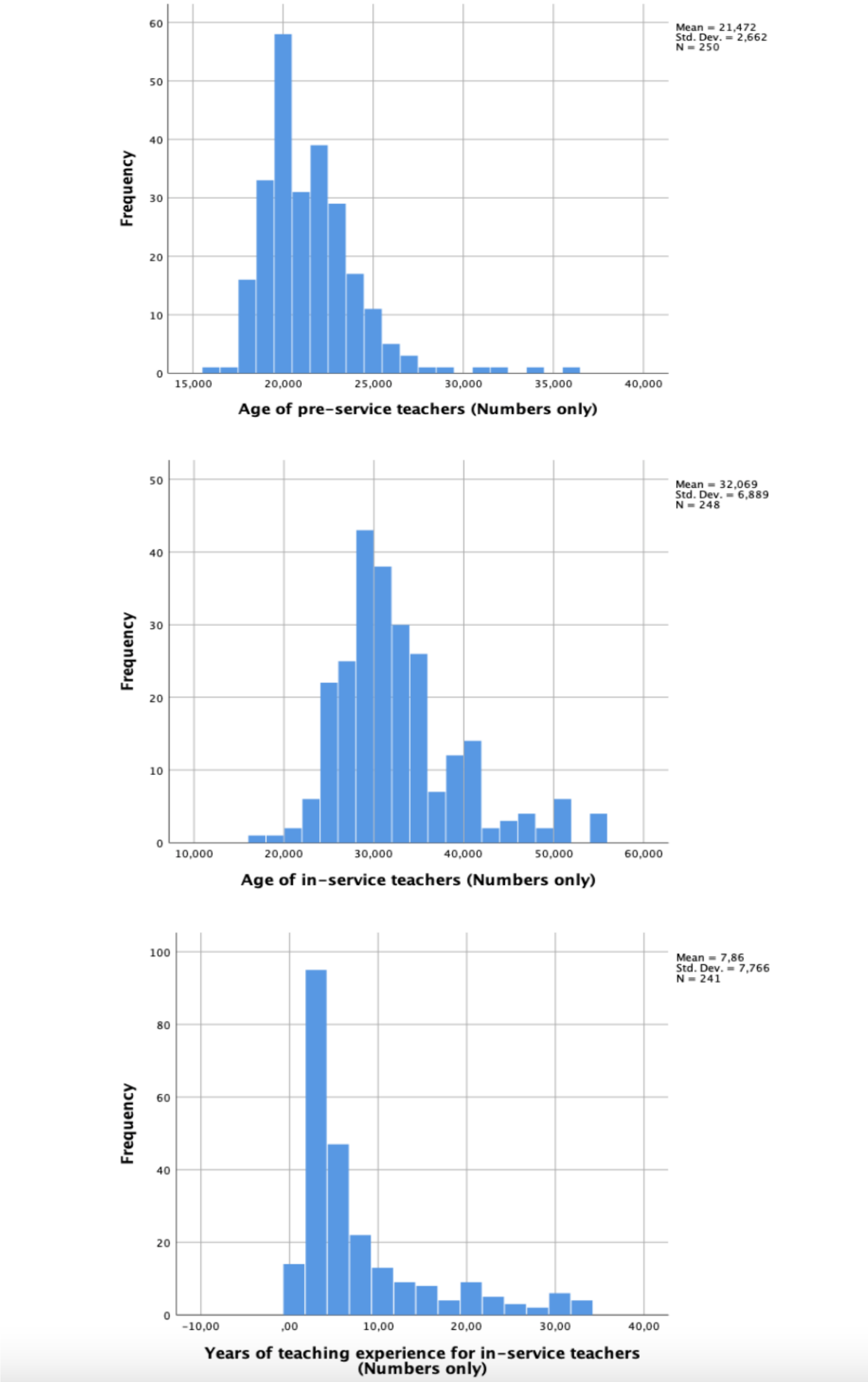


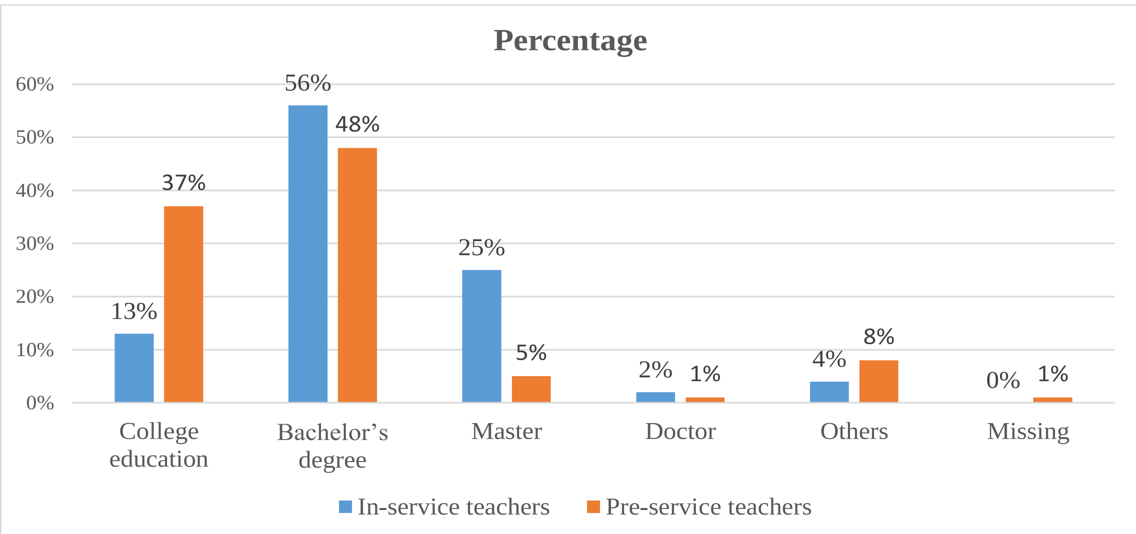
Table 15 shows the educational background status of pre-service and in-service teachers. Most participants had a bachelor's degree, with 56% of in-service teachers and 48% of pre-service teachers. Very few participants had doctoral degrees, including 2% of in-service teachers and 1% of in-service teachers.

Table 15. Distribution of pre-service and in-service teachers´ educational background

Educational background	In-service teachers		Pre-service teachers	
	Frequency	Percentage	Frequency	Percentage
College education	33	13%	93	37%
Bachelor's degree	138	56%	119	48%
Master	63	25%	12	5%
Doctor	5	2%	3	1%
Others	9	4%	21	8%
Missing	0	0%	2	1%
Total	248	100%	250	100%

Figure 25 shows distribution of pre-service and in-service teachers' education backgrounds. In both groups, most of the participants had bachelor's degrees.

Figure 25. Distribution of pre-service and in-service teachers´ educational background



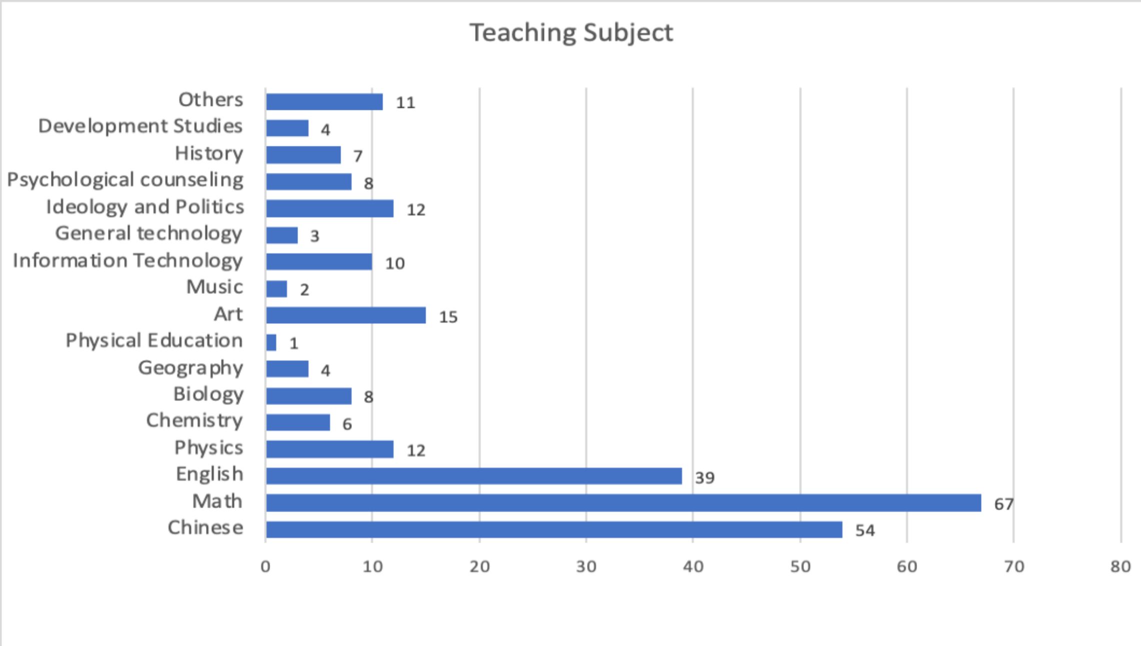
On the other side, Table 16 shows the distribution of in-service teachers' job titles, where 175 (68%) people were subject teachers, 31 (12%) teachers were grade leaders, followed by 23 (9%) research leaders. It is worth noting that these job titles can overlap.

Table 16. Distribution of in-service teacher´s job title

Job Title	Frequency	Percentage
Principal or Deputy Principal	4	2%
Middle school	20	8%
Research leader	23	9%
Grade leader	31	12%
Subject teacher	175	68%
Others	6	2%
Total	259	100%

Figure 26 shows the distribution of in-service teachers´ teaching subjects. The most significant number of teachers engaged in teaching mathematics was 67. Then, 54 teachers engaged in teaching Chinese subjects, followed by 39 teachers teaching English subjects. Moreover, 15 art teachers, 12 physics teachers, and 12 other teachers were engaged in teaching ideology and politics classes.

Figure 26. Distribution of in-service teachers´ teaching subject



4.3. Variables and instrument

4.3.1. Variables

The variables included in the study are separated into explanatory variables, predictor variables, and criterion variables. The criterion variables are the self-perceived digital competence, which are divided into the dimensions of the questionnaire. The explanatory and predictor variables included in the questionnaire were analyzed in the results about the self-perceived digital competence (the criteria variables).

In addition, other explanatory variables were obtained, such as the teachers' working school types, the teaching years, the available hardware (desktop computer, laptop or tablet, smartboard interactive), and the available research project. In this case, all predictor and explanatory variables used are shown in Table 17.

Table 17. Predictor y explicative variables for pre-and in-service teachers

Variables	Name	Type
Sociodemographic variables	Sex	Nominal
	Age	Ordinal
	Educational background	Ordinal
	Profession	Nominal
Explanatory variables	ICT training courses experience	Nominal
	The working school types	Nominal
	The available hardwires	Nominal
	The available research project	Nominal

4.3.2. Instrument

Thanks to the SLR of teachers´ digital competence in the context of China, we found an instrument which fits perfectly with our research. Therefore, the actual questionnaire of this research comes from the instrument designed by Yan et al. (2018).

Since there is no suitable ICT assessment tool for current pre-service teachers in China, it is challenging to evaluate pre-service teachers´ digital competence and training units to improve their digital competence level. In this context, to provide a scientific basis for pre-service teacher digital competence training, Yan et al. (2018) designed and validated this instrument to effectively diagnose pre-service teachers´ self-perceived digital competence. As Figure 27 shows, this instrument was formed by three fundamental factors: (1) Basic Technology Literacy (divided in three dimensions: Ideologist; Technical Environment; and Information Security); (2) Technical Support Learning (divided in three dimensions: Self-learning; Communication and Collaboration; and Research and Innovation); and (3) Technical Support Teaching (divided in three dimensions: Resource preparation; Process Design; and Practice Reserve).

Figure 27. Dimensional structure of the instrument

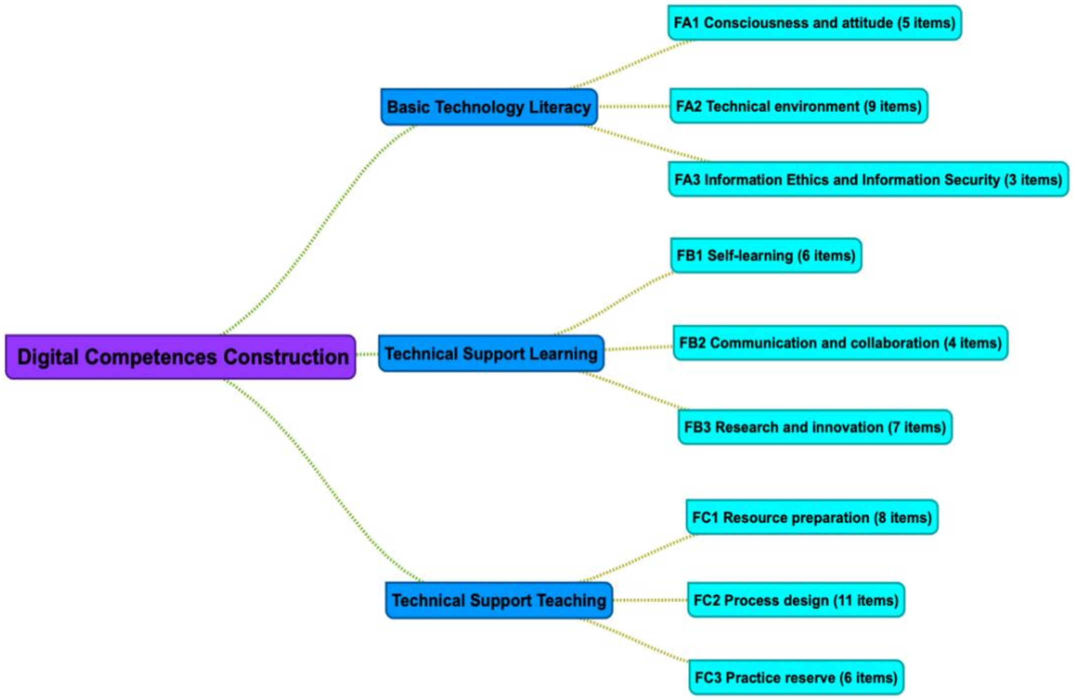


Table 18 presents the standard description of each factor-dimension of the Digital Competence and its performance indicators.

Table 18. Factors, dimensions, and its standard description with performance indicators

Factor	Dimension	Focus point	Standard description with performance indicators
Basic technical literacy	Ideologist	Active learning	1. Understand the role of information technology in teaching and learning and have an awareness of active learning of information technology. ---Concern about the application and progress of information technology in education and teaching. ---Share and exchange experiences and new discoveries in the application of information technology with others.
		Active application	2. Nave an awareness of the need to actively explore and use information technology to support lifelong learning and promote their own development. ---Focuses on quality educational resources

			and continuous learning for their own development. ---Be conscious of learning anytime and anywhere with the help of information technology tools.
	Technical environment	Deceives	3. Proficiency in the common operation of information technology teaching equipment and ability to solve common problems. ---Skillful operation of information technology teaching equipment. ---Solve common problems in the application of information-based teaching equipment.
		Software	4. Proficiency in the use of common and subject-specific software related to teaching and learning. ---Proficiency in the operation of common general-purpose software. ---Proficiency in the operation of common software applicable to the teaching and learning of the discipline.
		Platform	5. Proficiency in the use of e-learning platforms and social software. ---Proficiency in the use of common social software. ---Proficiency in the use of common web storage tools. ---Proficiency in the use of common e-learning platforms (e.g., thematic learning sites, Moodle, Sakai, etc.).
	Information Security	Self-discipline	6. Applying common sense to information security in everyday situations and consciously following legal and ethical norms. ---Have an awareness of information security and understand the security risks and appropriate disposal methods in the application of information technology. ---Respect intellectual property rights and always give clear and standardized references to the source of the material cited in their own results. ---Screen online information, do not illegally obtain information from others, and do not

			disseminate false, violent or other undesirable information.
		Influencing others	7. Promote the safe, legal and responsible use of information and technology to influence others positively by example. ---Remind others promptly and kindly when their behaviour is contrary to information ethics or information security. ---In the online environment, guide actively communication trends and create a healthy and civilized social environment.
Technical support learning	Self-learning	Access to resources	1. Proactively access valuable resources to broaden professional horizons in an information-based environment. ---Screening and acquiring the required resources to address learning needs. ---Track the frontiers of professional development and accumulate key clues to broaden professional horizons (e.g., key people in the profession, key conferences, key communities, key journals, etc.).
		Process management	2. Use information technology to support goal management, time management, information management, etc., to improve the quality and efficiency of self-directed learning. ---Avoiding or eliminating the distractions of irrelevant information or communication in the learning or task completion process. ---Use information technology tools (e.g., small software for time management, information management) to enhance self-regulation. ---Use technology tools (e.g., cloud notes, e-portfolios, and other tools that facilitate knowledge management) to plan and document learning processes and store learning outcomes.

		self-reflection	3. Consciously plan and document their learning paths and outcomes to develop self-reflective habits for self-growth. ---Use technology tools (e.g., blogs, cloud notes, e-portfolios, and other tools that aid in knowledge management) to plan and record information such as learning products, process data, or learning reflections. ---Habit of self-reflection, able to rationally analyze their learning and life situations, identify potential and problems, and adjust personal development plans accordingly.
	Communication and collaboration	Interpersonal interaction	4. Understand and respect different points of view and take the initiative to use information technology to communicate and share effectively with peers, teachers, and experts. ---In the information technology environment, be able to tolerate and understand other people's viewpoints and communicate and share smoothly. ---Use information technology proactively to communicate effectively with peers, teachers, experts, etc.
		Effective collaboration	5. Be able to collaborate effectively with others in an information-based environment in response to specific learning tasks and real-world problems. ---Agree on clear collaboration rules (e.g., respective responsibilities, communication time, application of tools, collaboration strategies, etc.) with relevant participants. ---Consciously follow collaboration rules and use information technology tools to facilitate effective collaboration. ---Uses technology tools to conduct peer review and enhance collaboration.
	Research and innovation	Critical thinking	6. Use critical thinking and appropriate technological tools to identify and analyze problems in learning and life. ---Be selective in receiving knowledge and experience from multiple sources and use thinking tools to identify valuable issues in an information-based environment.

			---Dare to question existing theories or opinions and be able to analyze things rationally and comprehensively with the help of technological tools.
		Data Awareness	7. Good at collecting and analyzing data, interpreting results, making sound judgements, and formulating solutions to problems. ---Use information technology tools (e.g., online questionnaire systems, survey systems) to collect data. ---Process and analyze data with reasonable use of data processing software for specific problems. ---Make reasonable judgments, summaries, and predictions based on the results of data analysis.
		Innovative capacity	8. Use information technology tools to construct knowledge, stimulate ideas, design and develop original works, and solve problems creatively. ---Creatively design solutions in conjunction with specific information technology environments. ---Design and produce high-quality original works (e.g., posters, promotional videos, digital stories, three-dimensional models, etc.) using technology tools based on project needs.
Technical support teaching	Resource preparation	Design & Production	1. Knowledge of tools and methods for processing and producing digital educational resources in a variety of formats, and the ability to adapt them scientifically and logically to predetermined educational contexts. Design and production of digital educational resources. ---Design carefully from the perspective of effectively supporting teaching and learning before producing digital educational resources. ---Access quality materials from a variety of sources. ---Use appropriate software tools to edit and manipulate materials.

		Evaluation and optimization	2. Evaluate scientifically the merits and demerits of digital educational resources in relation to specific application situations and propose strategies for improvement. ---Judge the merits and demerits of digital educational resources according to certain criteria. ---Propose targeted improvement suggestions for existing digital educational resources.
		Resource management	3. Have a holistic awareness of resource building and plan and manage digital education resources appropriately. ---Consciously plan and enrich personal digital education resource pools. ---Manage digital educational resources based on the need for backup, sharing, and collaboration with a reasonable selection of technology tools.
		Resource integration	4. Select and integrate technology resources to provide learners with rich learning opportunities and personalized learning experiences. ---Know the role of different types of technology resources (including learning websites, apps, etc.) in providing learning opportunities and learning experiences for learners. ---Select and integrate technology resources appropriately for the individual learning needs of the learner.
	Process design	Pattern understandin g	5. Understand the principles and methods of commonly used teaching modes and identify the advantages of applying information technology in different modes. ---Know the commonly used IT teaching modes (e.g., project-based learning, resource-based learning, WebQuest, MiniQuest, blended learning, etc.) ---Understand the scenarios and roles of different teaching models

		Pattern application	6. Choice of pertinent teaching modes to complete the process design According to the pre-set information-based teaching context, . ---Choose a reasonable choice of teaching mode based on the conditions of curriculum standards, learning objectives, and teaching content. ---Know how to use technology resources to support different aspects of teaching and learning.
		Event design	7. Scientific design of diverse learning activities and instructional strategies that promote learner autonomy, cooperation and inquiry. ---Understand the positive role of information technology in autonomous, cooperative, and inquiry learning. ---Take into account possible differences in learners (e.g., level, style, etc.) and provide tailored learning suggestions when designing information technology instruction. ---Provide valuable support tools for learners' autonomous, collaborative, and inquiry activities (e.g., study guides, learning flow charts, thinking templates, etc.).
		Evaluation Design	8. Scientifically design information-based teaching evaluation programs, and rationally select, adapt and apply information-based teaching evaluation tools. ---Give examples to illustrate the concepts, principles and methods of process-based assessment. --Design an assessment scheme that can balance process and individualization in accordance with curriculum standards, learning objectives, student characteristics and technical conditions. -Choose, adapt or develop appropriate assessment tools (e.g. assessment scales, observation sheets, questionnaires, etc.) according to the content or process to be assessed.

		Organizational implementation	9. Understand teaching implementation strategies in an information-based teaching environment and understand the basic principles and methods of teaching interventions. -- Understand the principles and methods of teaching interventions such as questioning, encouraging, aiding, monitoring, and managing in an information-based teaching environment, and try to use them in real or simulated teaching situations. ---Analyze pedagogical interventions and their effectiveness objectively and rationally when observing lessons.
	Practice reserve	Analytical improvements	10. Effectively use of technology to track and analyze the learning process and recommend targeted improvements. ---Master common methods of analyzing classroom instruction (both live and transcribed). ---Collect process data from targeted observations and use of technology in the teaching and learning of others (e.g., lead teachers). ---Provide insights and improvements based on the data collected when analyzing the classrooms of others.
		Practical experience	11. Make appropriate use of information technology to support teaching and learning practices in real or simulated teaching and learning contexts. ---Smoothly connect the various teaching and learning processes in real or simulated IT teaching and learning situations. ---Provide timely and effective instruction to common problems that arise when guiding students in the use of information technology for learning.

Thus, the scale of measure of the Digital Competence used in this study was translated and validated from Yan et al. (2018). Therefore, the final online questionnaire included sixty Likert-type response items (Appendix 2_Table 75), in addition to the questions related to the sociodemographic and explanatory variables shown above (Table 17).

The sixty Likert-type response items related to the assessment of digital competence level had a five-level Likert scale, with the following labels: totally agree [5], agree [4], no agree neither disagree [3], disagree [2], and strongly disagree [1].

4.4. Procedures

Before sending the online questionnaire to the educational sciences' undergraduate students (pre-service teachers), the institutional board conducted a review of the privacy and security levels of the questionnaire. Meanwhile, this questionnaire was also sent to in-service teachers who engaged in primary school, junior school, and senior school within the Anhui province. We implemented the online questionnaire in Qualtrics platform, which was used with the USAL license to make it accessible in China.

For data collection, the questionnaire was administered during the participants' free time so that its application would not interfere with the usual rhythm of the classes. The objective of the research project objective was explained, and the students' collaboration was requested by encouraging them to participate in the study. Finally, the surveys were completed by 625 participants. After identifying and cleaning the uncompleted or low credibility questionnaires data, 498 anonymous participants remained for inclusion in the study.

4.5. Data Analysis

All the data obtained for this study were analyzed with SPSS version 26 (USAL license) and JASP version 0.14.1 (open-source software).

Concerning the reliability of the questionnaire, Cronbach's Alpha coefficient was used to determine the internal consistency of the dimensions of the scale firstly.

While the instrument has a robust initial hypothesis about the latent structure of determined construct, confirmatory factor analysis (CFA) with robust error calculation and DWLS estimator were applied (the results are presented above).

So, Chi-square test was utilized for assessing model fit initially. The chi-square test is the most used absolute fit index, which measure the global recovery of empirical observations without considering the mean and covariance structure. For assessing model adequacy, we used the chi-square statistic to prove the adequacy between the hypothesized model and data from a set of measurement items. As Alavi et al. (2020, p. 2010) mentioned, "given the chi-square fit statistic is affected by large samples, the ratio of the chi-square statistic to the respective degrees of freedom (χ^2/df) is preferred. Excepting the chi-square test, the other absolute fit indexes determine the extent to which the model predicts the observed covariance matrix from the estimated parameters. Main absolute fit indexes included in this analysis were the Goodness of fit index (GFI) and the Standardized root mean square residual (SRMR).

Other important fit statistics are the incremental fit indexes, which compare the fit of the empty (or null) model with the empirical model. In this study we included these incremental fit indexes: Bentler-Bonett Normed Fit Index (NFI), Bollen's Relative Fit Index (RFI) and Comparative Fit Index (CFI). In addition to these measures, we computed the general explained variance and the internal consistency of the final factors and dimensions in the CFA with the use of the average variance extracted (AVE) and composite reliability (CR). Both indicators are interpreted, respectively, in the same way than the scores computed usually in EFA: % of variance explained in each factor (R^2); and Cronbach's Alpha.

Table 19 shows the general interpretation of all these fit indices.

Table 19. Interpretation of fit indices.

Chi-square	The p-value of the statistic test Chi-square ranges from 0 to 1. A p-value=1 indicates perfect fit, and p-values>α indicates adequate fit.
Chi/d.f.	Ratio between statistic chi-square an the degrees of freedom of the test (Cole, 1987). Values below 5 show acceptable fit, and below 2 good fit.

SRMR	Its value ranges from 0 to 1. A value of 0 indicates perfect fit, values below .05 good, and below .08 acceptable (Byrne, 1998).
GFI	Its value ranges from 0 to 1, with a value of 1 indicating perfect fit. Values above .9 indicates acceptable fit, and above .95 good fit.
CFI, NFI, RFI	
AVE	Its value ranges from 0 to 1, with a value of 1 indicating maximum variance extracted. Values above .4 indicates acceptable fit, and above .5 good fit.
CR	Its value ranges from 0 to 1, with a value of 1 indicating perfect internal consistency. Values above .7 indicates good reliability.

After the validation of the general scale, we initially used descriptive statistics to analyze the univariate distributions of sociodemographic variables, and the factors-dimensions of the Digital Competence construct. Subsequently, we used correlational and inferential statistics to analyze the Digital Competence scores by sociodemographic variables, and to relate the Digital Competence factors-dimensions to each other. In the descriptive analysis we used some statistics like frequency tables, means, standard deviations, percentile, or coefficient of variation.

The generalization of sample statistics to population was performed by statistical inference, based on a significance level (α) of 5%. Before the application of inferential analyzes, the normality and homoscedasticity assumptions of criterion variables were confirmed.

On the one hand, Shapiro-Wilk test was applied for assessing the normality of variables. The null hypothesis for the Shapiro-Wilk test is that the variable distribution is a random sample from a normal distribution. So, we reject the null hypothesis if p-value is lower than 5%. Before, Skewness and Kurtosis were obtained to descriptively analyze the normality assumption. If skewness = 0, the variable distribution is absolutely symmetrical, and if kurtosis = 0, the variable distribution is neither peaked nor flattened. Additionally, the density distributions with the shape of variables were presented. Non-parametric inferential tests were computed when the normality was rejected, On the other hand, the Levene test was computed to assess the equality of variances of criterion variables in the group comparisons. The null hypothesis for the Levene test is that the variances are equal in both groups Therefore, if p-value (Sig.) $<\alpha$ H0 is rejected. In these cases, the relevant homoscedasticity adjustment (Welch or Games-Howell) was applied.

Correlational and inferential statistics used were:

- Pearson correlation coefficient to compare scale variables.
- Parametric (t-test or one-way ANOVA) or non-parametric (Mann-Whitney or Kruskal-Wallis) tests, based on compliance with the previous assumptions of normality and homoscedasticity, to compare demographic groups of the research.

Al inferential tests included the appropriate effect size statistic (Cohen's d, eta squared or rank-biserial correlation).

4.6. Conclusion

This chapter presents the research method applied in the empirical diagnostic evaluation, which used a non-experimental-cross-sectional design with an ex-post-facto methodology based in a quantitative paradigm. Then, the initial exploration of Anhui province (China) has been presented. The exploration of the research sample show that there were 248 in-service teacher participants and 250 pre-service teacher participants, and essentially the sex distribution was balanced between the pre-and in-service teachers. Thirdly, the variables included in the study have been presented, differentiating between explanatory, predictor, and criterion variables. The explanatory and predictor variables included in the questionnaire were analyzed concerning the self-perceived digital competence. Based on the study of Yan et al. (2018), these self-perceived digital competence have three primary areas: basic technological literacy, technical support learning skills, and technical support teaching skills. Lastly, we explain the procedure and the data analysis applied.

Chapter 5. Results of Data Analysis

This chapter presents the results obtained from the study described in the previous chapter. It includes three main parts: the reliability and validity analysis of the digital competence scale in the obtained sample, the descriptive analysis of the level of digital competence of pre-service and in-service teachers and the factors related to the level of digital competence of pre-service teachers and in-service teachers.

5.1. Reliability and validity of digital competence scale

To ensure the quality of the questionnaire and the accuracy of measurement, it is necessary to test the reliability and validity of the digital competence scale included in the questionnaire.

Table 20 present the absolute and incremental fit indices of the CFA model, showing good scores in all three factors. The values of ratio $\chi 2$/df were below 2, SRMR were below .05, and the values of GFI, CFI, NFI and RFI were above .95. So, the global fit of the model in all factors included was good.

Table 20. Statistics of several fit indices of the hypothetical model.

	Value		
	FA Consciousness and attitude	**FB Technical environment**	**FC Information Ethics and Information Security**
chi^2	78.876	26.184	113.693
df	116	116	296
p	.997	<.999	<.999
Ratio (x^2/df)	.668	.226	.384

Absolute fit index	**GFI**	.991	.998	.996
	SRMR	.047	.029	.036
Incremental fit index	**CFI**	<.999	<.999	<.999
	NFI	.986	.997	.995
	RFI	.984	.996	.994

On the other hand, Table 21 demonstrates the item factor loadings in the CFA model, the reliability scores (Cronbach's Alpha and CR), and the AVE of the dimensions. First, Cronbach's alpha of all dimensions and factors are above .7, indicating that factor reliabilities are acceptable. However, CR in the factors is below .6, indicating good internal consistency in dimensions but a lower consistency in the second order factors. Regarding the AVE, it reaches values close to (and even higher than) 40% in most of the dimensions, which values around 35%-40% in the second order factors. Concerning the factor loadings, all values are higher than .40, indicating that the items included in the dimensions are suitable.

Table 21. Results of CFA, their factor loadings, and reliabilities of the model.

	Item	**Factor loadings**	**Cronbach's Alpha**	**CR**	**AVE**
FA1 Consciousness and Attitude	IT 1	.597	.818	.760	39.16%
	IT 2	.622			
	IT 3	.641			
	IT 4	.639			
	IT 5	.629			
FA2 Technical Environment	IT 6	.741	.881	.879	44.81%
	IT 7	.628			
	IT 8	.696			
	IT 9	.661			
	IT 10	.672			
	IT 11	.576			
	IT 12	.690			
	IT 13	.700			

	IT 14	.647			
FA3 Information Ethics and Information Security	IT 15	.669	.803	.786	55.19%
	IT 16	.809			
	IT 17	.744			
FB1 Self-learning	IT 1	.495	.857	.744	32.75%
	IT 2	.552			
	IT 3	.550			
	IT 4	.603			
	IT 5	.637			
	IT 6	.586			
FB2 Communication and Collaboration	IT 7	.635	.846	.729	40.20%
	IT 8	.646			
	IT 9	.606			
	IT 10	.650			
FB3 Research and Innovation	IT 11	.612	.916	.850	44.85%
	IT 12	.670			
	IT 13	.705			
	IT 14	.662			
	IT 15	.676			
	IT 16	.648			
	IT 17	.710			
FC1 Resource Preparation	IT 1	.600	.894	.802	33.63%
	IT 2	.548			
	IT 3	.557			
	IT 4	.589			
	IT 5	.630			
	IT 6	.582			
	IT 7	.589			
	IT 8	.539			
FC2 Process Design	IT 9	.692	.935	.881	38.31%

	IT 10	.619			
	IT 11	.631			
	IT 12	.621			
	IT 13	.585			
	IT 14	.562			
	IT 15	.627			
	IT 16	.639			
	IT 17	.620			
	IT 18	.612			
	IT 19	.596			
	IT 20	.615			
FC3 Practice Reserve	IT 21	.656	.884	.788	38.31%
	IT 22	.568			
	IT 23	.628			
	IT 24	.654			
	IT 25	.596			
	IT 26	.607			
F1 Basic Technology Literacy	FA1	.591	.880	.661	39.48%
	FA2	.662			
	FA3	.630			
F2 Technical Support Learning	FB1	.560	.925	.631	36.33%
	FB2	.615			
	FB3	.631			
F3 Technical Support Teaching	FC1	.562	.944	.612	34.49%
	FC2	.605			
	FC3	.594			

5.2. Descriptive analysis

The following results were obtained from the pre-service and in-service teachers who completed the questionnaire (Appendix 2). As mentioned in the methods section, the digital competence scale was composed of three core factors: Basic

Technology Literacy with three dimensions (17 items), Technical Support Learning with three dimensions (17 items), and Technical Support Teaching with three dimensions (26 items). It is important to remember that all items had a Likert-type response scale with five levels.

5.2.1. Descriptive analysis of items in each dimension

In this section, tables show the frequency, means, and standard deviations of all items in each dimension. These data were carried out by both pre-service and in-service teachers from Anhui province.

First, Table 22 shows the descriptive analysis by item in Consciousness and Attitude. The first significant option was "agree," with more than 43% of participants selecting it for all items, and "totally agree" was the second primary option. Especially in item A1, 53.5% of people chose "agree," and 30 % chose "totally agree," indicating that 83.5% of participants are interested in learning some new applications of information technology. In contrast, only 43.8% of people chose "agree," and 31.3 % chose "totally agree" for item A5, indicating that 75.1% of participants consciously use information technology to learn anytime, anywhere. The mean for each item is above 3.90, while item A1 reached a mean of 4.05.

Table 22. Descriptive analysis by item in FA1 Consciousness and Attitude

FA1	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item A1	3.4	1.3	11.8	53.5	30.0	4.05	0.880
Item A2	3.1	3.9	19.0	44.5	29.5	3.94	0.968
Item A3	3.4	3.7	15.9	44.9	32.0	3.98	0.968
Item A4	3.6	6.5	14.9	46.8	28.2	3.90	1.002
Item A5	3.4	4.9	16.6	43.8	31.3	3.95	0.990

Then, Table 23 shows participants´ use of ICT for teaching activities in a Technical Environment. The option “agree” was the most considerable option chosen in the items of the dimension, followed by “totally agree.” However, for the item (A12), “totally agree” (46.3 %) was the preferred election, followed by “agree” with 35.4% of participants. This indicated that participants are confident in proficiently using at least one messaging tool (e.g., QQ, Weibo, blog, WeChat, etc.). The mean of all items is higher than 3.7, mainly the mean of item A12 (4.17) and item A13 (4.02).

Table 23. Descriptive analysis by items in FA2 Technical Environment

FA2	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item A6	4.7	7.7	20.9	38.9	27.8	3.77	1.082
Item A7	3.3	11.7	27.9	38.0	19.1	3.58	1.029
Item A8	2.8	6.5	15.0	45.3	29.8	3.93	0.976
Item A9	3.2	4.5	20.0	46.9	25.3	3.87	0.954
Item A10	3.6	8.1	24.7	39.8	23.7	3.72	1.027
Item A11	3.6	10.8	22.8	38.8	24.0	3.69	1.061
Item A12	3.3	4.1	10.9	35.4	46.3	4.17	1.000
Item A13	2.8	4.6	15.0	43.6	34.0	4.02	0.961
Item A14	3.6	5.5	22.6	42.3	26.0	3.85	0.999

Table 24 presents the descriptive analysis results for Information Ethics and Information Security. “Totally agree” was the most extensive option for each item in this dimension. Additionally, 37.35 % of people chose “agree” for item A (15). Each mean value of all items in the dimension was above 4. So, participants have a high sense of self-discipline in applying common sense to information security in everyday situations and consciously following legal and ethical codes but also promote the safe, legal, and responsible use of information and technology and positively influence others by example.

Table 24. Descriptive analysis by items in FA3 Information Ethics and Information Security

FA3	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item A15	2.8	5.4	16.4	37.3	38.1	4.03	1.005
Item A16	3.3	3.8	13.7	31.5	47.7	4.17	1.016
Item A17	3.1	1.8	14.0	32.6	48.5	4.22	0,965

For the dimension of *Self-learning*, Table 25 shows that “agree” was chosen by more than 55% of participants for all items, followed by “totally agree”. This means that participants have a high level of self-learning regarding access to resources, process management, and self-reflection.

Table 25. Descriptive analysis by items in FB1 Self-learning

FB1	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item B1	1.8	3.6	9.1	60.3	25.2	4.00	0.804
Item B2	1.3	6.5	15.1	59.6	17.5	3.86	0.827
Item B3	1.5	9.8	13.2	58.6	17.0	3.80	0.886
Item B4	1.6	7.5	16.4	57.3	17.2	3.81	0.865
Item B5	1.3	8.8	14.9	53.9	21.1	3.85	0.899
Item B6	1.6	6.4	16.4	58.2	17.3	3.83	0.845

Table 26 shows the level of participants´ digital competence in *Communication and Collaboration* dimension, where “agree” was chosen by more than 55% of participants for each item, and “totally agree” was the second most prominent option for each item in this dimension. It means that the participants can collaborate effectively with others in an information-based environment in response to specific learning tasks and real-world problems, including taking the initiative to use information technology to communicate and share effectively with peers, teachers, and experts. The mean of each item was below 4 in this dimension.

Table 26. Descriptive analysis by items in FB2 Communication and Collaboration

FB2	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item B7	2.2	5.8	13.6	59.5	18.9	3.87	0,859
Item B8	1.8	6.9	16.2	55.3	19.8	3.84	0.880
Item B9	1.6	5.4	12.3	56.6	24.1	3.96	0.852
Item B10	1.8	6.6	12.9	58.6	20.1	3.89	0,863

Table 27 reveals the level of competence of the participants in terms of *Research and innovation*, showing that more than 55% of the participants selected "agree" for each item, followed by the options of "neither agree nor disagree" and "totally agree." The means were below 4 in all items.

Table 27. Descriptive analysis by items in FB3 Research and Innovation

FB3	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item B11	1.5	7.2	13.7	58.0	19.7	3.87	0.860
Item B12	2.1	6.1	15.0	56.6	20.1	3.86	0.878
Item B13	2.5	7.1	16.4	53.6	20.4	3.82	0.919
Item B14	1.6	6.7	15.6	58.3	17.7	3.84	0.852
Item B15	1.6	7.1	17.2	56.8	17.2	3.81	0.860
Item B16	1.8	5.8	18.8	56.7	17.0	3.81	0.847
Item B17	2.3	10.1	14.7	56.2	16.7	3.75	0.929

Table 28 shows the level of participants´ digital competence in the *Process preparation* dimension, where “agree” was the most selected choice by participants, followed by “totally agree”. It means the participants have a considerably high digital process preparation level for teaching. The mean in each item of this dimension was below 4.

Table 28. Descriptive analysis by items in FC1 Process Preparation

FC1	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item C1	1.8	5.4	14.3	58.2	20.2	3.90	0.846
Item C2	1.3	6.3	14.2	61.4	16.7	3.86	0.813
Item C3	1.7	6.0	15.0	58.5	18.8	3.87	0.842
Item C4	1.8	6.6	16.3	58.4	16.9	3.82	0.854
Item C5	1.2	6.3	15.4	55.6	21.5	3.90	0.846
Item C6	1.0	7.1	14.9	57.5	19.5	3.87	0.838
Item C7	1.0	8.1	13.0	56.8	21.1	3.89	0.861
Item C8	0.8	5.6	14.3	58.6	20.6	3.93	0.802

Table 29 shows the level of digital competence for participants in *Process design*, where “agree” was chosen by more than 55% of participants for all items, following by “totally agree”. The means of each item were below 4.0.

Table 29. Descriptive analysis by items in FC2 Process design

FC2	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.

Item C9	1.3	9.9	17.0	53.2	18.5	3.78	0.907
Item C10	1.2	7.8	15.6	57.5	17.9	3.83	0.852
Item C11	1.5	8.0	14.2	58.4	17.9	3.83	0.866
Item C12	1.6	7.6	14.0	57.7	19.7	3.87	0.846
Item C13	1.2	7.3	12.6	56.5	22.5	3.92	0.860
Item C14	1.0	6.3	14.2	58.5	20.0	3.90	0.822
Item C15	1.5	6.5	12.4	58.6	21.5	3.93	0.827
Item C16	1.2	8.4	13.9	56.9	19.7	3.85	0.870
Item C17	1.0	6.1	14.4	59.1	19.5	3.90	0.814
Item C18	1.3	7.5	14.9	56.5	19.9	3.86	0.864
Item C19	1.2	7.1	15.0	56.5	20.2	3.87	0.852
Item C20	1.0	9.1	17.1	55.7	17.1	3.79	0.867

Table 30 shows the level of digital competence of participants in the *Practice reserve* dimension. “Agree” was chosen by more than 55% of participants for each item, while “totally agree” was the second most prominent option. The means in all items were below 3.90 in this dimension.

Table 30. Descriptive analysis by items in FC3 Practice reserve

FC3	TD (%)	D (%)	NA-D (%)	A (%)	TA (%)	Mean	S.D.
Item C21	1.0	8.1	15.3	56.4	19.2	3.85	0.859
Item C22	1.0	5.8	17.3	56.6	19.3	3.87	0.820
Item C23	1.5	6.8	13.5	57.4	20.8	3.89	0.859
Item C24	1.5	7.6	16.7	55.0	19.3	3.83	0.877
Item C25	1.3	5.5	15.1	58.8	19.4	3.89	0.820
Item C26	1.2	6.8	15.0	59.4	17.7	3.86	0.826

5.2.2. Descriptive analysis of dimensions and factors

Regarding the results of the descriptive analysis of the dimensions and factors, the mean and standard deviation of each dimension and factor were highlighted. Their minimum and maximum values were then also reported, as well as the percentages of P_{25}, P_{50}, and P_{75}.

First, Table 31 shows the descriptive analysis results of three dimensions in the factor of *Basic Technology Literacy*. The minimum mean score was 3.86 for *FA2 Technical environment,* and the maximum mean value was 4.14 for *FA3 Information Ethics and Information Security*. Besides, the P_{25} percentile for three dimensions ranged between 3.56 and 3.67, and the P_{75} percentile ranged between 4.22 and 5.

Table 31. Descriptive analysis by dimensions. Basic Technology Literacy

F1	Mean	S.D.	Min	P_{25}	P_{50}	P_{75}	Max
FA1	3.96	0.753	1	3.60	4.00	4.40	5
FA2	3.86	0.689	1	3.56	4.00	4.22	5
FA3	4.14	0.850	1	3.67	4.33	5.00	5

Second, Table 32 shows the descriptive analysis results of three dimensions in the factor of *Technical Support Learning*, where the mean values of the three dimensions were between 3.82 and 3.88. Apart from the three dimensions having the same P_{50} percentile value of 4.00, the P_{25} percentile of the three dimensions ranged between 3.43 and 3.50, and their P_{75} percentile ranged between 4.25 and 4.29.

Table 32. Descriptive analysis by dimensions. Technical Support Learning

F2	Mean	S.D.	Min	P_{25}	P_{50}	P_{75}	Max
FB1	3.86	0.67	1	3.50	4.00	4.27	5
FB2	3.88	0.72	1	3.50	4.00	4.25	5
FB3	3.82	0.71	1	3.43	4.00	4.29	5

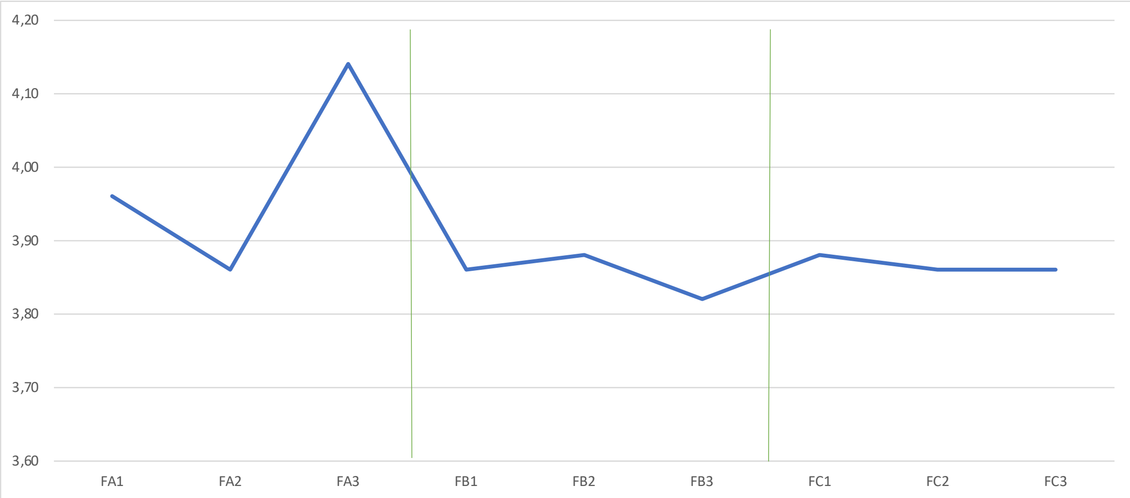
Third, Table 33 shows the descriptive analysis results of three dimensions in the factor of *Technical Support Teaching*, where the means of three dimensions were 3.88, 3.86, and 3.86, respectively. While all dimensions obtained the same P_{25} and P_{50} values, the P_{75} percentile ranged between 4.25 and 4.33.

Table 33. Descriptive analysis by dimensions. Technical Support Teaching

F3	Mean	S.D.	Min	P_{25}	P_{50}	P_{75}	Max
FC1	3.88	0.64	1	3.50	4.00	4.25	5
FC2	3.86	0.65	1	3.50	4.00	4.25	5
FC3	3.86	0.68	1	3.50	4.00	4.33	5

In the meantime, Figure 28 shows the trend of the nine dimensions in three factors for both pre-service and in-service teachers, based on their mean value. This figure shows that the overall trend of the dimensions declined, and the *FA3 Information Ethics and Information Security* dimension had a higher mean than other dimensions.

Figure 28. Trend chart for nine dimensions. Mean score.



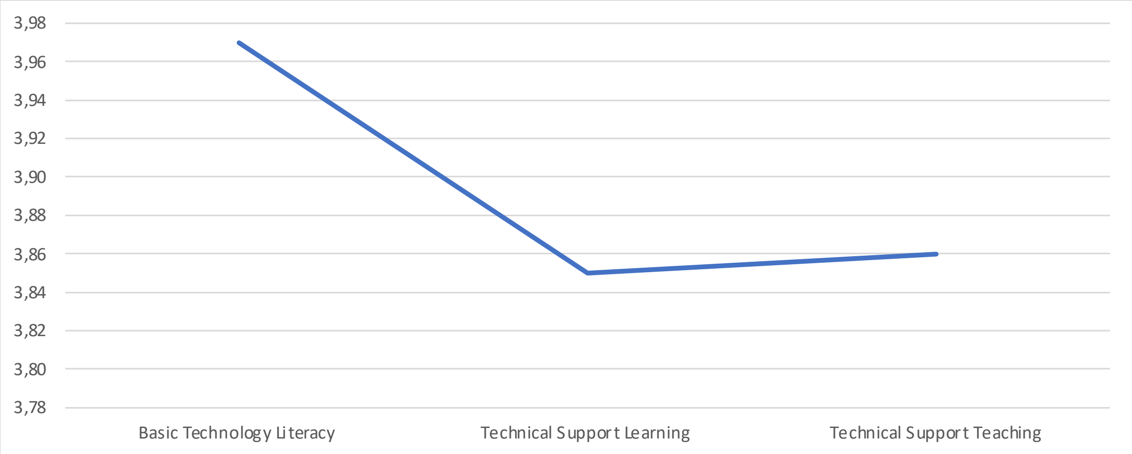
On the other hand, Table 34 shows that the means of three factors (F1 - *Basic Technology Literacy*, F2 - *Technical Support Teaching*, and F3 - *Technical Support Learning*) were 3.97, 3.85, and 3.86. All their 25th percentiles were 3.65, while their 75th percentiles were 4,24, 2,25, and 4,44, respectively.

Table 34. Descriptive analysis of three measured factors

	Mean	D.T.	Min	P_{25}	P_{50}	P_{75}	Max
F1	3.97	0.72	1	3.65	4.08	4.44	5
F2	3.85	0.66	1	3.65	4.00	4.24	5
F3	3.86	0.63	1	3.65	3.97	4.25	5

In the meantime, Figure 29 shows the trend of the mean for three factors. *Basic Technology Literacy* was higher than *Technical Support learning* and *Technical Support Teaching.* In addition, the mean of *Technical Support Teaching* was slightly higher than that of *Technical Support learning*.

Figure 29. Trend chart for three measured factors. Mean score.



5.3. Correlation analysis between dimensions or factors

Table 35 shows the results of the Pearson correlation coefficient test, which determine whether significant relationships exist between the pairs of dimensions in the factor. The values of R_{xy} between all the pairs of dimensions were above .7, and all their p-values were <.001. This indicates direct and very high significant correlations between all dimensions in three factors: *Basic Technology Literacy, Technical Support Learning, and Technical Support Teaching*.

On the other hand, Table 35 also shows the results of the Pearson correlation coefficient for each pair of factors. Since all the values of R_{xy} were above .6, their p-values<.001, there are direct and high significant correlations between each factor.

Table 35. Pearson correlation coefficient between dimensions in each factor

Factor	Dimension	R_{xy}	Sig.
F1 Basic Technology Literacy	FA1 Consciousness and attitude – FA2 Technical environment	.791	<.001
	FA1 Consciousness and attitude – FA3 Information Ethics and Information Security	.706	<.001
	FA2 Technical environment – FA3 Information Ethics and Information Security	.725	<.001

F2 Technical Support Learning	FB1 Self-learning – FB2 Communication and collaboration	.817	<.001
	FB1 Self-learning – FB3 Research and innovation	.826	<.001
	FB2 Communication and collaboration – FB3 Research and innovation	.810	<.001
F3 Technical Support Teaching	FC1 Resource preparation – FC2 Process design	.874	<.001
	FC1 Resource preparation – FC3 Practice reserve	.816	<.001
	FC2 Process design – FC3 Practice reserve	.873	<.001
F1 Basic Technology Literacy – F2 Technical Support Learning		.747	<.001
F1 Basic Technology Literacy – F3 Technical Support Teaching		.627	<.001
F2 Technical Support Learning – F3 Technical Support Teaching		.804	<.001

5.4. Exploring the analysis of influencing factors

5.4.1. Digital competence between pre-and in-service teachers

Before the inferential analysis between in-service and pre-service teachers, the Shapiro-Wilk test was applied to confirm the sample's normality, including the skewness and kurtosis statistics. Table 36 demonstrates the results of the Shapiro-Wilk test. Since the p-values of both pre-and in-service teachers were < .05, we reject the null hypothesis that the values of variables are a simple random sample from a normal distribution.

Table 36. Test of prior assumption of normality (Shapiro-Wilk)

	In-service (n=248)	**Pre-service (n=250)**

	Skewness	Kurt	W	Sig.	Skewness	Kurt	W	Sig.
FA1	-1.616	4.711	0.872	<.001	-1.631	4.034	0.872	<.001
FA2	-1.154	2.959	0.925	<.001	-1.263	2.870	0.918	<.001
FA3	-1.459	2.903	0.846	<.001	-1.450	2.660	0.848	<.001
FB1	-1.023	4.172	0.926	<.001	-1.093	2.773	0.930	<.001
FB2	-1.046	2.248	0.906	<.001	-1.183	2.977	0.905	<.001
FB3	-0.997	1.806	0.929	<.001	-1.116	2.606	0.916	<.001
FC1	-1.061	3.443	0.931	<.001	-0.806	1.108	0.942	<.001
FC2	-0.823	1.623	0.952	<.001	-0.715	0.810	0.954	<.001
FC3	-0.856	1.829	0.937	<.001	-0.660	0.605	0.949	<.001
F1	-1.692	5.493	0.878	<.001	-1.738	4.798	0.872	<.001
F2	-0.901	3.215	0.945	<.001	-1.201	3.369	0.919	<.001
F3	-0.822	2.329	0.954	<.001	-0.687	0.923	0.961	<.001

Therefore, the Mann-Whitney U non-parametric test was applied for the inferential analysis between in-service and pre-service teachers. Table 37 shows the results of the Mann-Whitney U test of the digital competence level for in-service and pre-service teachers. Results showed significant differences in *FA1 Consciousness and attitude* and *FA2 Technical environment* dimensions. The value of the rank-biserial correlation in these two contrasts evidenced small effect sizes of the differences. This means in-service teachers have higher levels of self-perceived *Digital Consciousness* and *Technical environment* than pre-service teachers.

Table 37. Digital competences levels of in-service teachers and pre-service teachers. Mann-Whitney U test

	In-service (n=248)		Pre-service (n=250)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	4.027	0.724	3.891	0.774	52457.50	.029	0.101
FA2	3.905	0.707	3.782	0.747	51782.00	.045	0.093
FA3	4.160	0.823	4.114	8.745	48094.50	.630	0.022

FB1	3.928	0.592	3.800	0,724	51100.50	.101	0.076
FB2	3.923	0.704	3.844	0.745	49036.00	.320	0.046
FB3	3.842	0.698	3.801	0.725	48134.00	.568	0.026
FC1	3.906	0.610	3.846	0.665	48125.50	.482	0.033
FC2	3.870	0.638	3.853	0.666	46232.50	.915	0.005
FC3	3.875	0.633	3.849	0.713	46407.00	.962	0.002
F1	4.032	0.680	3.915	0,752	51613.00	.088	0.079
F2	3.898	0.610	3.810	0.706	49469.50	.372	0.042
F3	3.885	0.591	3.844	0.658	47748.50	.650	0.021

Moreover, Figure 30 compares the mean scores of nine measured dimensions for pre-and in-service teachers. In general, in-service teachers had higher self-perceived digital competence than pre-service teachers. The mean scores for *Basic Technology Literacy* were higher for pre-service teachers than for *Technical Support learning* and *Technical Support Teaching*. However, the Mann-Whitney U test showed no significant differences.

Figure 30. Comparing mean scores of nine dimensions in two groups

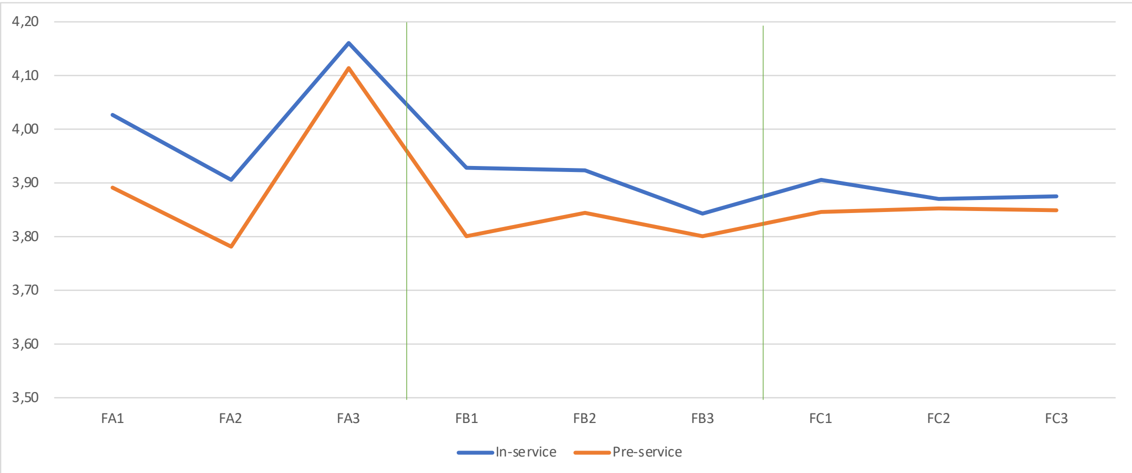
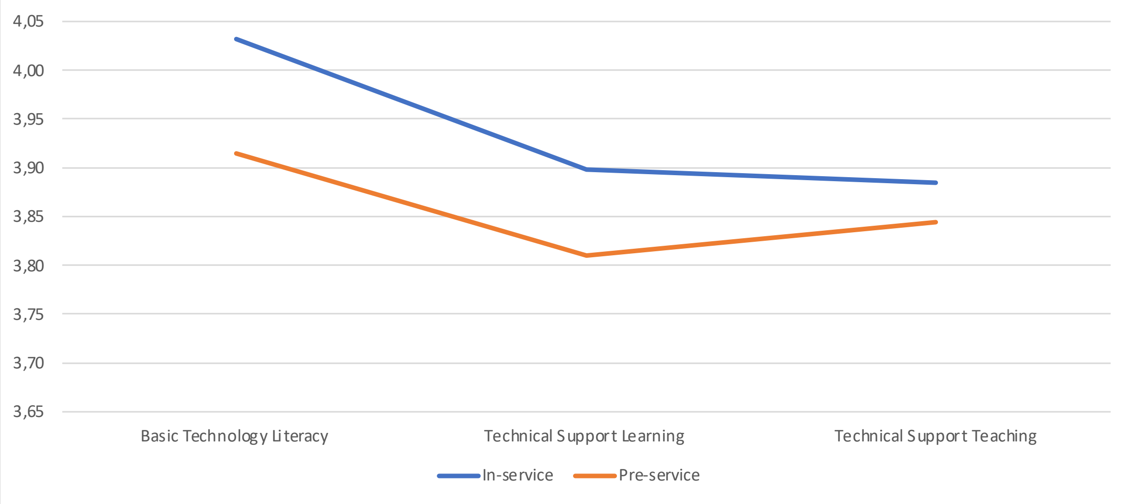


Figure 31 shows that pre-and in-service teachers had higher self-perceived levels of *Basic Technology Literacy* than *in Technical Support Teaching* and *Technical Support learning*, and their level of digital competence was higher in *Technical Support Teaching* than in *Technical Support learning*.

Figure 31. Comparing mean scores of three measured factors in two groups



5.4.2. Digital competence by sex

5.4.2.1. Pre-service teachers´ digital competence by sex

In the same way, we used the Shapiro-Wilk test to determine normality in the sample for pre-service teachers. According to the results of the Shapiro-Wilk test (Table 38), since the whole p-values obtained were < .05, the Mann-Whitney U test was applied for the non-parametric contrast tests.

Table 38. Test of prior assumption of normality for pre-service teachers (Shapiro-Wilk)

Pre-service	Female (n=122)				Male (n=128)			
	Skew	Kurt	W	Sig.	Skew	Kurt	W	Sig.
FA1	-1.880	5.938	0.848	<.001	-1.445	2.808	0.884	<.001
FA2	-1.326	4.091	0.905	<.001	-1.256	2.192	0.905	<.001
FA3	-1.579	3.639	0.833	<.001	-1.354	2.057	0.833	<.001
FB1	-1.062	3.264	0.928	<.001	-1.119	2.490	0.928	<.001
FB2	-1.087	3.269	0.910	<.001	-1.246	2.800	0.910	<.001
FB3	-1.191	3.273	0.914	<.001	-1.156	2.171	0.914	<.001
FC1	-0.730	1.113	0.943	<.001	-0.876	1.174	0.943	<.001
FC2	-0.680	1.264	0.952	<.001	-0.721	0.494	0.952	<.001
FC3	-0.606	0.958	0.950	<.001	-0.707	0.383	0.950	<.001

F1	-2.011	7.620	0.851	<.001	-1.541	3.075	0.851	<.001
F2	-1.187	4.020	0.916	<.001	-1.216	2.988	0.916	<.001
F3	-0.546	1.120	0.967	.004	-0.788	0.779	0.967	<.001

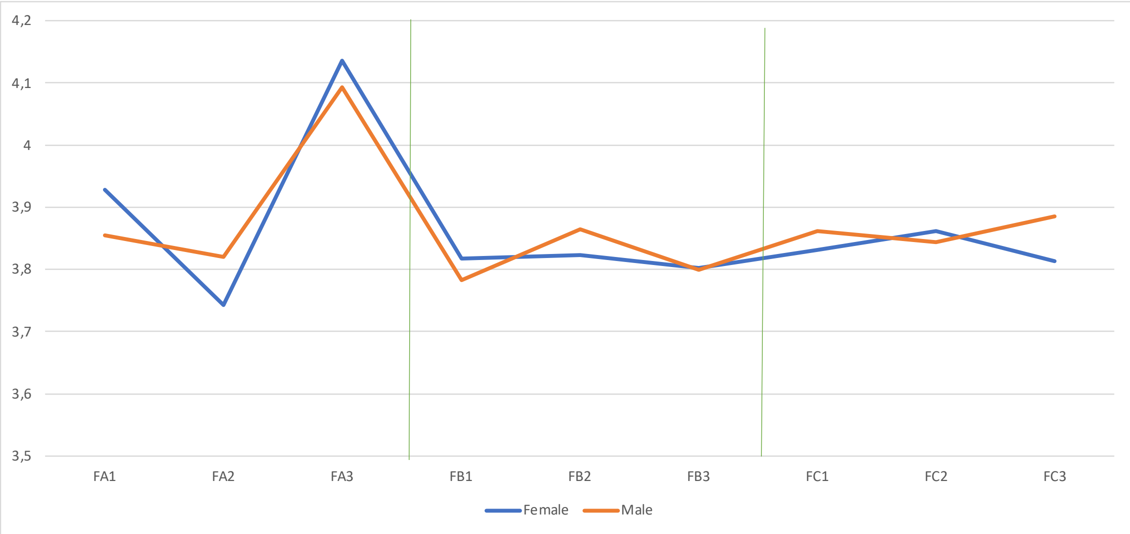
Table **39** Compare pre-service teachers´ digital competence in male and female service teachers in female and male groups. There were no significant differences between groups in any dimension, with small effect sizes. Combing with Figure 32, we can see that this result differed from the results for in-service teachers, though both had a mean value that is always very similar in each dimension.

Table 39 Compare pre-service teachers´ digital competence in male and female groups.

Pre-service	Female		Male		t/W	Sig.	Eff. Size
	Mean	SD	Mean	SD			
FA1	3.928	0.818	3.855	0.731	14181.50	.140	0.095
FA2	3.742	0.745	3.820	0.749	11835.50	.245	-0.075
FA3	4.136	0.883	4.093	0.867	13180.00	.569	0.036
FB1	3.818	0.735	3.783	0.716	13545.50	.478	0.046
FB2	3.823	0.786	3.865	0.700	12384.00	.682	-0.026
FB3	3.802	0.767	3.800	0.684	12832.00	.889	0.009
FC1	3.831	0.668	3.861	0.664	12164.50	.626	-0.031
FC2	3.862	0.658	3.844	0.677	12474.50	.850	0.012
FC3	3.813	0.742	3.885	0.685	11716.50	.394	-0.055
F1	3.923	0.769	3.908	0.737	13062.00	.899	0.008
F2	3.815	0.726	3.805	0.689	13088.00	.875	0.010
F3	3.832	0.654	3.855	0.663	12132.50	.601	-0.034

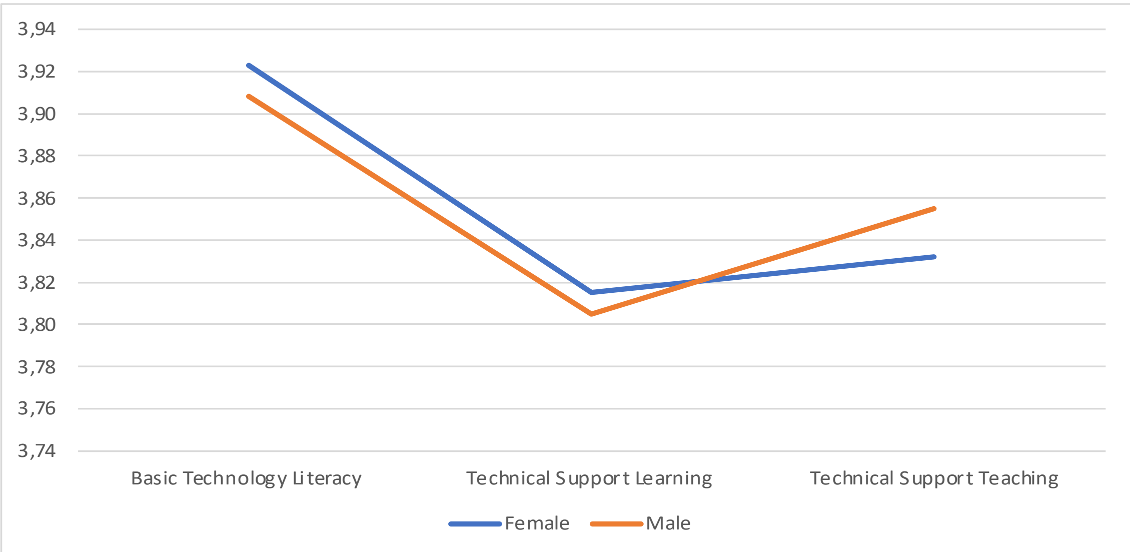
According to Figure 32, male and female pre-service teachers had similar levels of self-perceived digital competence. However, female pre-service teachers' mean values were higher than male teachers' in *FA1 Consciousness and attitude*. Then, males' mean values were still slightly higher than female pre-service teachers in *the FC3 Practice reserve*, but not significant.

Figure 32. Comparing mean value of nine dimensions for male and female pre-service teachers



As Figure 33 shows, the self-perceived digital competence level of female pre-service teachers was higher than male pre-service teachers in *Basic Technology Literacy* and *Technical Support Learning* aspects. However, the male pre-service teachers had a higher self-perceived digital competence in *Technical Support Teaching*.

Figure 33. Comparing mean value of three factors for male and female pre-service teachers



5.4.2.2. In-service teachers´ digital competence by sex

As Table 40 shows, the Shapiro-Wilk test was applied to determine normality in the sample for in-service teachers, and according to the values obtained (all p-value < .05) led us to use non-parametric contrast tests, such as the Mann-Whitney U test.

Table 40. Test of prior assumption of normality for in-service teachers (Shapiro-Wilk)

In-service	Female (n=136)				Male (n=112)			
	Skew	Kurt	W	Sig.	Skew	Kurt	W	Sig.
FA1	-1.470	4.612	0.892	<.001	-1.776	4.984	0.850	<.001
FA2	-0.884	2.327	0.942	<.001	-1.515	4.166	0.894	<.001
FA3	-1.206	1.858	0.873	<.001	-1.798	4.528	0.807	<.001
FB1	-0.997	4.274	0.927	<.001	-1.065	4.285	0.927	<.001
FB2	-0.984	2.201	0.915	<.001	-1.160	2.416	0.896	<.001
FB3	-0.870	1.555	0.938	<.001	-1.159	2.246	0.915	<.001
FC1	-0.870	2.602	0.941	<.001	-1.321	4.620	0.907	<.001
FC2	-0.464	0.255	0.971	.005*	-1.230	3.253	0.914	<.001
FC3	-0.719	0.958	0.938	<.001	-1.050	3.283	0.921	<.001
F1	-1.376	4.624	0.910	<.001	-2.070	6.855	0.833	<.001
F2	-0.820	3.208	0.949	<.001	-1.002	3.403	0.941	<.001
F3	-0.500	0.754	0.937	<.001	-1.213	4.372	0.919	.009**

Note. * Assumption of homoscedasticity: FC2 P-value (female) = .005

** Assumption of homoscedasticity: Technical support teaching P-value (male) =.009

Table 41 compares the digital competence levels of female and male. The results showed non-significant differences in any dimension or factor, with small and shallow effect sizes.

Table 41. Compare in-service teacher´s digital competence in male and female groups. Mann-Whitney U test

In-service	Female (n=136)	Male (n=112)	t/W	Sig.	Eff. Size

	Mean	SD	Mean	SD			
FA1	4.019	0.703	4.038	0.750	10447.50	.591	-0.036
FA2	3.880	0.700	3.938	0.717	10003.00	.261	-0.076
FA3	4.141	0.830	4.184	0.818	10482.50	.701	-0.026
FB1	3.914	0.590	3.944	0.597	10565.00	.790	-0.018
FB2	3.917	0.710	3.931	0.698	10710.50	.980	0.002
FB3	3.812	0.693	3.880	0.706	9936.50	.294	-0.071
FC1	3.849	0.600	3.975	0.616	9312.00	.053	-0.130
FC2	3.817	0.624	3.935	0.651	9274.50	.061	-0.127
FC3	3.832	0.644	3.928	0.619	9650.00	.146	-0.096
F1	4.013	0.665	4.055	0.699	10254.00	.376	-0.060
F2	3.882	0.609	3.918	0.613	10392.00	.616	-0.034
F3	3.833	0.587	3.947	0.592	9482.50	.077	-0.120

As Figure 34 shows, male teachers' self-perceived digital competence levels were generally higher than female teachers. The mean values of male teachers in each dimension were consistently higher than female teachers. Specifically, the mean values of male teachers were slightly higher than female in *FA1 Consciousness and attitude*, *FA2 Technical environment*, *FA3 Information Ethics and Information Security*, *FB1 Self-learning, and FB2 Communication and collaboration*.

Figure 34. Comparing mean value of nine dimensions for male and female in-service teachers

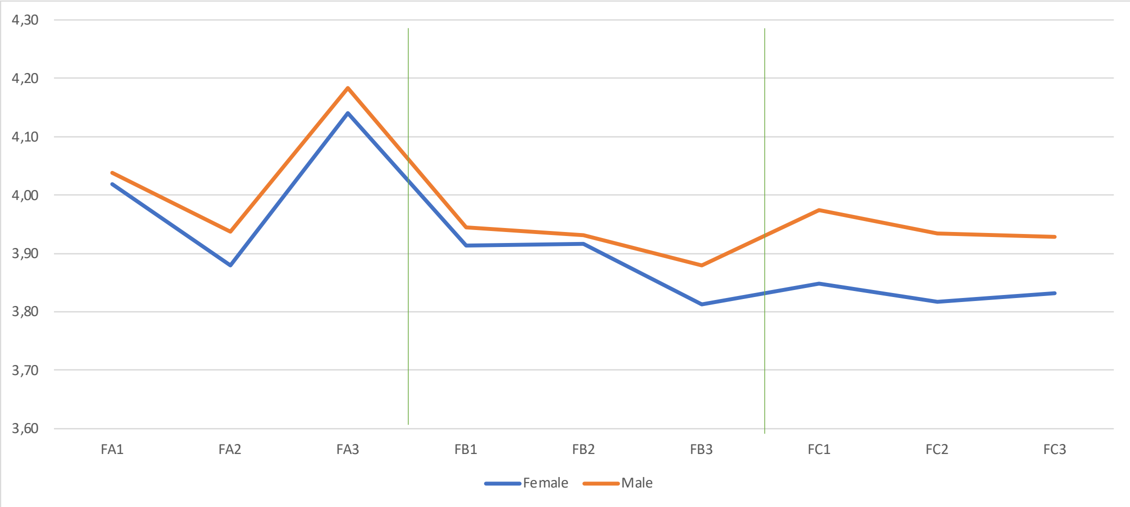
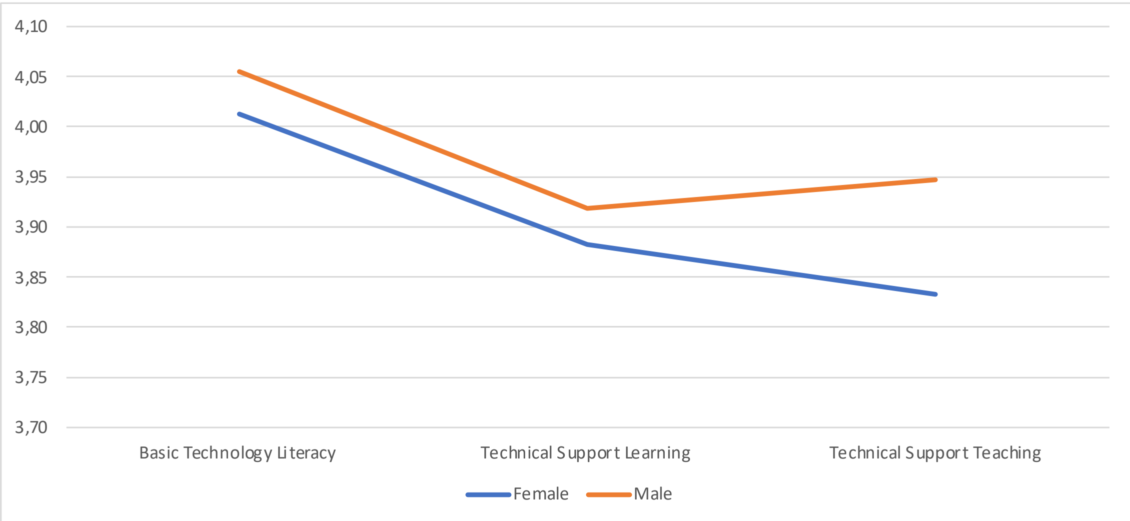


Figure 35 shows that male teacher had a higher digital competence than female teachers regarding *Technical Support Teaching*. Specially. Combined with Figure 34, the mean values of males were higher than female teachers in *FB3 Research and innovation*, *FC1 Resource preparation*, *FC2 Process design*, and *FC3 Practice reserve*.

Figure 35. Comparing mean value of three factors for male and female in-service teachers



5.4.3. Digital competence by education degree

5.4.3.1. Pre-service teachers´ digital competences by education degree

To compare different education degree levels and digital competence levels, we first used the Shapiro-Wilk test to determine normality in the sample for pre-service teachers. As Table 42 shows, the participants with master’s degrees obtained p-values > .05 in all dimensions and its three factors, indicating that this group of samples had normal distribution in all analyzed variables. However, college and bachelor's degree participants obtained p-values < .05, indicating that the samples had no normal distribution in all dimensions and factors.

Table 42. Test of prior assumption of normality for pre-service teachers (Shapiro-Wilk)

Pre-service	College (n=93)			Bachelor (n=119)			Master or PhD (n=15)		
	Skew	Kurt	p.	Skew	Kurt	p.	Skew	Kurt	p.
FA1	-1.640	3.063	<.001	-1.962	6.798	<.001	-0.756	-0.272	.251*
FA2	-1.145	2.021	<.001	-1.528	4.144	<.001	-0.792	0.628	.593*
FA3	-1.126	0.813	<.001	-1.694	3.811	<.001	-1.249	1.318	.017
FB1	-0.679	0.436	<.001	-1.462	4.312	<.001	0.544	0.164	.591*
FB2	-0.485	-0.107	<.001	-1.638	4.548	<.001	<.001	0.277	.446*
FB3	-0.653	0.469	<.001	-1.459	3.610	<.001	-0.901	1.255	.378*
FC1	-0.749	0.593	<.001	-0.911	1.757	<.001	-0.461	-0.215	.316*
FC2	-0.680	0.546	.001	-0.844	1.083	<.001	-0.562	0.136	.124*
FC3	-0.595	0.023	<.001	-0.630	0.790	<.001	-0.600	0.485	.399*
F1	-1.425	2.322	<.001	-2.157	7.187	<.001	-0.847	0.494	.410*
F2	-0.557	0.289	<.001	-1.644	5.015	<.001	0.121	0.860	.957*
F3	-0.660	0.494	.003	-0.796	1.421	<.001	-0.609	0.122	.307*

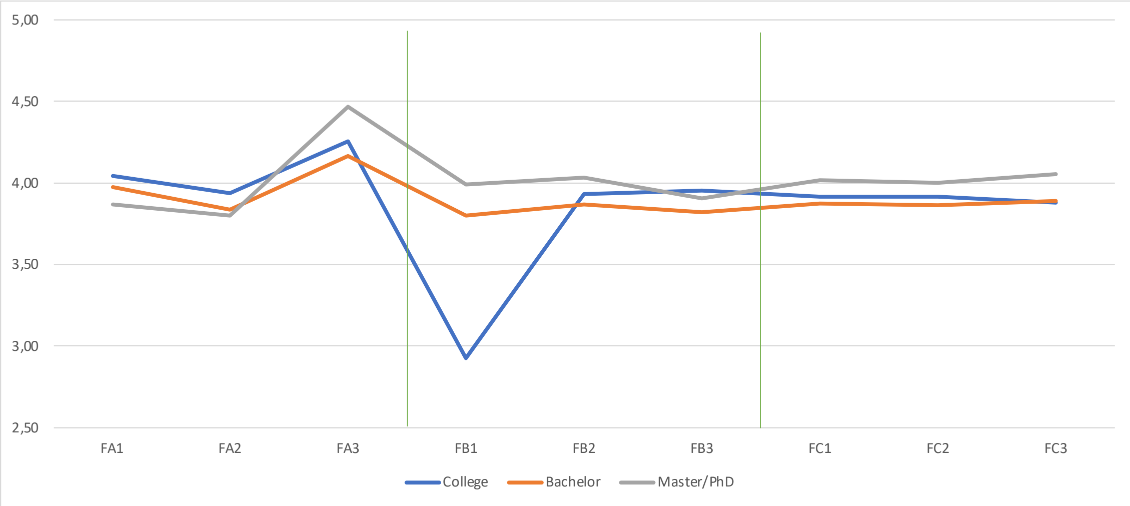
Table 43 shows results of Kruskal-Wallis H test between self-perceived digital competence levels and pre-service teacher´s educational background. There had no significant differences between pre-service teacher´s digital competence levels and their educational background, with the p-value of each dimension above .05. This indicated that the pre-service teachers´ education degree levels do not affect their digital competences.

Table 43. Results of Kruskal-Wallis H test between digital competence level and pre-service teacher´s educational background

	Mean					
Pre-service	College (n=93)	Bachelor (n=119)	Master/PhD (n=15)	H	Sig.	η^2
FA1	4.045	3.976	3.867	2.625	.269	0.005
FA2	3.940	3.838	3.800	1.638	.441	0.006
FA3	4.254	4.168	4.467	2.130	.345	0.009
FB1	2.927	3.801	3.989	2.409	.300	0.011
FB2	3.933	3.868	4.033	0.682	.711	0.005
FB3	3.951	3.820	3.905	1.451	.484	0.008
FC1	3.918	3.874	4.017	1.365	.505	0.004
FC2	3.918	3.861	4.000	1.108	.575	0.004
FC3	3.878	3.891	4.056	0.974	.614	0.004
F1	4.080	3.994	4.044	2.204	.332	0.004
F2	3.937	3.830	3.976	1.581	.456	0.008
F3	3.905	3.875	4.024	1.467	.480	0.003

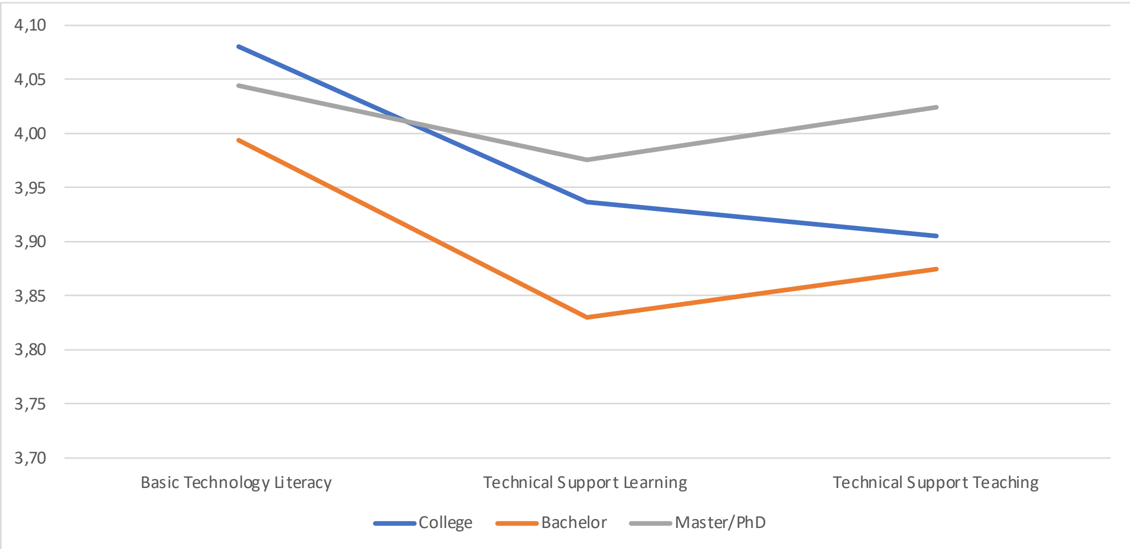
In the meantime, Figure 36 shows the tendency of the mean of pre-service teachers´ digital competence with different educational backgrounds. Generally, pre-service teachers with different educational backgrounds had very compact mean scores in most dimensions. However, the digital competence level for college student teachers is deficient in *FB1 self-learning*.

Figure 36. Mean value of pre-service teacher´s digital competence level with different educational degree level



On the other hand, Figure 37 clearly shows that the pre-service teachers with master´s or Ph.D. degrees almost had the highest digital competence self-perceived levels, and pre-service teachers with bachelor´s degrees had the lowest digital competence levels.

Figure 37. Mean value of pre-service teacher´s digital competence level in three factors with different education degree level



5.4.3.2. In-service teachers´ digital competences by education degree

Firstly, we used the Shapiro-Wilk test to determine normality in the sample for in-service teachers. According to the p-value of the assumption of normality (Table 44), some dimensions had normal distribution in the group of participants with a college degree (p-value_*FA1*= .137, p-value_*FA2* = .408, p-value_*Basic Technology Literacy* =.383, p-value_*Technical Support Learning* = .055). For the participants with master’s degrees, participants had normal distribution in *Technical Support Learning* with p-value = .099.

Table 44 Test of prior assumption of normality for in-service teachers (Shapiro-Wilk)

In-service	College (n=33)			Bachelor (n=138)			Master/PhD (n=68)		
	Skew	**Kur**	**p.**	**Skew**	**Kur**	**p.**	**Skew**	**Kur**	**p.**
FA1	-0.422	0.464	.137*	-1.749	4.946	<.001	-1.477	3.519	<.001
FA2	-0.437	-0.204	.408*	-1.285	3.258	<.001	-0.812	1.514	.001
FA3	-1.034	0.355	<.001	-1.344	2.143	<.001	-1.523	4.171	<.001
FB1	-0.336	1.029	.009	-1.151	4.452	<.001	-0.427	0.940	.009
FB2	-1.332	2.523	<.001	-1.050	2.264	<.001	-0.591	0.487	.003
FB3	-0.675	0.333	.035	-0.949	2.048	<.001	-1.091	1.901	<.001
FC1	-0.919	2.355	.008	-1.162	3.718	<.001	-0.417	0.795	.040
FC2	-0.776	0.700	.020	-0.731	2.234	<.001	-1.169	2.147	<.001
FC3	-1.390	3.765	<.001	-0.756	1.831	<.001	-1.009	1.835	<.001
F1	-0.084	-0.990	.383*	-1.731	5.059	<.001	-1.535	5.034	<.001
F2	-0.651	1.209	.055*	-0.981	3.876	<.001	-0.365	0.172	.099*
F3	-0.880	1.275	.006	-0.804	3.027	<.001	-0.905	1.701	.001

Table 45 shows the results of the Kruskal-Wallis H test between digital competence level and in-service teachers´ education background. Significant differences existed between self-perceived digital competence levels and in-service teachers´ educational backgrounds. Specifically, in-service teachers´ education background had a significant difference in *FB3 Research and innovation* (p=.007), *FC1 Resource preparation* (p-value=.010), *FC2 Process design* (p-value=.029) and with the factors *Technical Support Learning* (p-value =.03) and *Technical Support Teaching* (p-value=.020). This indicates that in-service teachers with higher levels of education have a better level of self-perceived digital competence in aspects like research and innovation, resource preparation, and process design. Moreover, this table indicates that in-service teachers with a higher level of education had better digital competence levels in technical support learning (p-value =.030 < .05) and technical support teaching (p-value=.020 < .05).

Table 45. Results of Kruskal-Wallis H test between digital competence level and in-service teacher´s education degree level

In-service	Mean					
	College (n=33)	**Bachelor (n=138)**	**Master/PhD (n=68)**	**H**	**Sig.**	**η^2**
FA1	4.121	4.007	4.068	0.313	.855	0.003
FA2	3.845	3.857	3.972	1.232	.540	0.005
FA3	4.404	4.075	4.240	3.947	.139	0.021
FB1	3.889	3.870	4.044	4.919	.085	0.017
FB2	3.939	3.844	4.051	4.228	.121	0.017
FB3	3.753	3.759	4.025	9.883	.007	0.029
FC1	3.848	3.838	4.092	9.178	.010	0.036
FC2	3.753	3.829	3.995	7.073	.029	0.018
FC3	3.843	3.818	3.983	4.374	.112	0.013
F1	4.123	3.980	4.093	0.995	.069	0.008
F2	3.861	3.824	4.040	6.988	.030	0.024
F3	3.815	3.824	4.023	7.767	.020	0.023

Based on the Kruskal-Wallis H test results, Dunn´s post-hoc test was applied to test for differences in a small subset of all possible pairs between teachers with college, bachelor, and Master/Ph.D. degrees. We mainly focus on *FB3 Research and* *innovation, FC1 Resource preparation, FC2 Process design, Technical Support Learning, and Technical Support Teaching.* Table 46 shows the results of Dunn´s post-hoc comparisons test.

Table 46. Dunn´s post-hoc comparisons test for several significant dimensions and factors

		Mean Diff.	Z	Sig.	d
FB3 R&I	College-Bachelor	-0.006	-0.019	0.492	-0.007
	College-Master/PhD	-0.272	-2.138	0.032	-0.416
	Bachelor-Master/PhD	-0.266	-3.037	0.004	-0.380
FC1 R&P	College-Bachelor	0.011	0.076	0.470	0.017
	College-Master/PhD	-0.243	-1.990	0.047	-0.468
	Bachelor-Master/PhD	-0.254	-2.950	0.005	-0.429
FC2 P&D	College-Bachelor	-0.077	-0.572	0.284	-0.121
	College-Master/PhD	-0.243	-2.177	0.029	-0.384
	Bachelor-Master/PhD	-0.166	-2.369	0.027	-0.261
F2	College-Bachelor	0.036	0.382	0.351	0.057
	College-Master/PhD	-0.180	-1.486	0.137	-0.334
	Bachelor-Master/PhD	-0.216	-2.627	0.013	-0.365
F3	College-Bachelor	-0.013	0.141	0.444	-0.022
	College-Master/PhD	-0.208	-1.777	0.076	-0.380
	Bachelor-Master/PhD	-0.195	-2.729	0.010	-0.329

In the meantime, Figure 38 demonstrates the tendency of mean scores of in-service teachers' digital competence with different education degree levels. Compared with other groups, the teachers with master's degrees had the highest level of self-perceived digital competence. Then, the teachers with master's or Ph.D. degrees had a digital competence level similar to those with bachelor's degrees. Moreover, Figure 38 and Figure 39 show that the teachers with master's degrees or Ph.D. had a generally highest digital competence level. It is especially demonstrated in the factor of *Technical Support Learning* (*FB1 Self-learning, FB2 Communication and collaboration,* *FB3* Research and innovation) and the factor of *Technical Support Teaching* (*FC1 Resource preparation, FC2 Process design, FC3 Practice reserve*).

Figure 38. Mean tendency of in-service teachers´ digital competence level with different education degree level

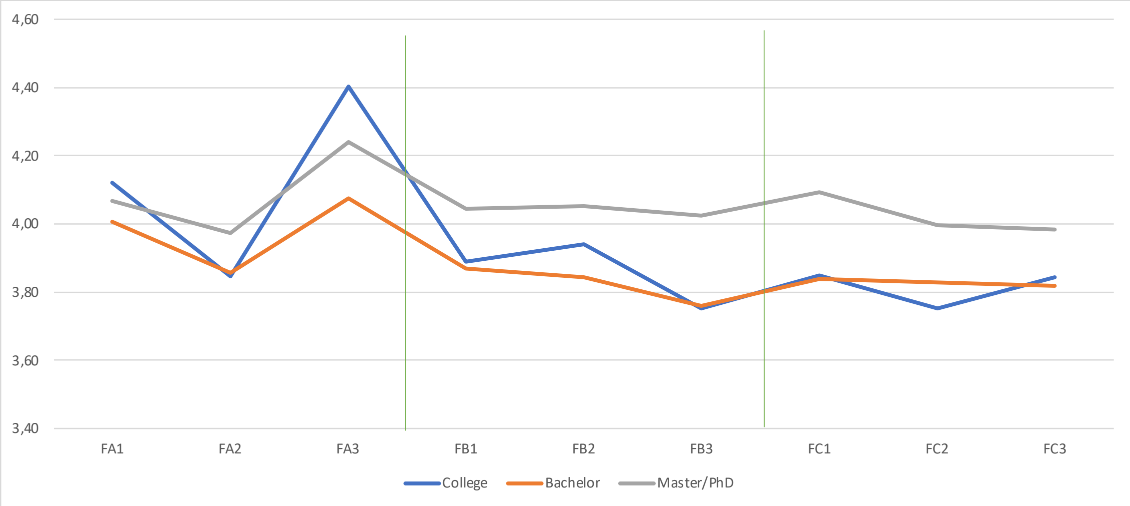
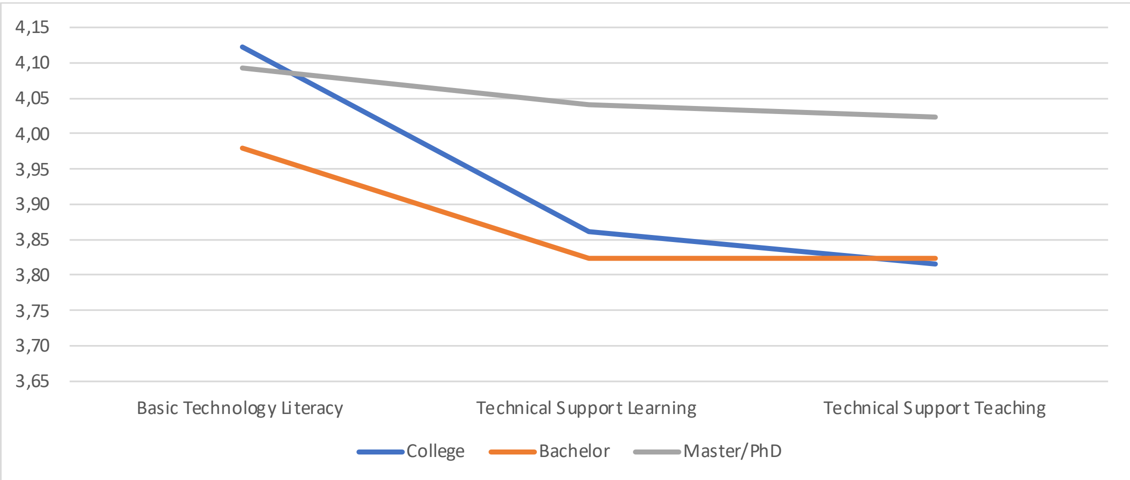


Figure 39. Mean tendency of in-service teachers´ digital competence level in three factors with different education degree level



5.4.4. Digital competence by age

5.4.4.1. Pre-service teachers´ digital competence by age

Table 47 shows significant differences between pre-service teachers' age and some dimensions. Such as *FA1 Consciousness and attitude* (Rxy=.168, p-value=.003), *FB2 Communication and collaboration* (Rxy=.135, p-value=.016), *FC1 Resource preparation* (Rxy=.113, p-value=.044), *FC2 Process design* (Rxy=.114, p-value=.043), *FC3 Practice reserve* (Rxy=.133, p-value=.019). Then, there are significant differences between age and three factors: *Basic Technology Literacy* (Rxy=.124, p-value=.027), *Technical Support Learning* (Rxy=.115, p-value=.039), *Technical Support Teaching* (Rxy=.112, p-value=.046).

This indicates that although there were no significant differences for pre-service teachers in *a technical environment, awareness of information ethics and information security, self-learning, and research and innovation*, older pre-service teachers have higher digital competence in the rest of digital competence dimensions.

Table 47. Pearson correlation analysis between age and digital competence level for pre-service teachers

Pre-service	R_{xy}	Sig.
Age – FA1 Consciousness and attitude	.168	.003
Age – FA2 Technical environment	.088	.116
Age – FA3 Information Ethics and Information Security	.062	.273
Age – FB1 Self-learning	.092	.099
Age – FB2 Communication and collaboration	.135	.016
Age – FB3 Research and innovation	.094	.094
Age -- FC1 Resource preparation	.113	.044
Age -- FC2 Process design	.114	.043
Age -- FC3 Practice reserve	.133	.019
Age – F1 Basic Technology Literacy	.124	.027
Age – F2 Technical Support Learning	.115	.039
Age – F3 Technical Support Teaching	.112	.046

5.4.4.2. In-service teachers´ digital competence by age

Table 48 shows the results of Pearson correlation analysis between age and digital competence levels for in-service teachers. There were significant differences between age and dimensions *FA2 Technical environment* (Rxy=-.117, P-value=.044), *FB2 Communication and collaboration* (Rxy=-.175, p-value=.003), *FB3 Research and innovation* (Rxy=-.116, p-value=.046), which meet the conditions of the p-value less than .05 with small effect sizes at the same time. Additionally, there were significant differences between age and the factor *of Technical Support*

Learning (Rxy=-.128, p-value=.028). This indicates that younger in-service teachers have higher self-perceived digital competences in aspects like technical environment, communication and collaboration, research and innovation, including in all dimensions of Technical Support Learning.

Table 48. Pearson correlation analysis between age and digital competence level for in-service teachers

In-service	R_{xy}	Sig.
Age – FA1 Consciousness and attitude	-.005	.927
Age – FA2 Technical environment	-.117	.044
Age – FA3 Information Ethics and Information Security	.029	.615
Age – FB1 Self-learning	-.051	.385
Age – FB2 Communication and collaboration	-.175	.003
Age – FB3 Research and innovation	-.116	.046
Age – FC1 Resource preparation	-.111	.058
Age – FC2 Process design	-.102	.081
Age – FC3 Practice reserve	-.073	.213
Age – F1 Basic Technology Literacy	-.029	.624
Age – F2 Technical Support Learning	-.128	.028
Age – F3 Technical Support Teaching	-.099	.091

5.4.5. Digital competence by ICT training course

5.4.5.1. Pre-service teachers´ digital competence by ICT training course

Table 49 shows significant differences between the ICT training course for pre-service teachers in dimensions *FA1 Consciousness and attitude* (P-value=.019) and *FA2 Technical environment* (P-value=.042). This indicated that the existing training courses only affect pre-service teachers´ self-perceived digital competence in consciousness and attitude to the use of ICT and proficiency in using standard and subject-specific software or platforms for teaching and learning.

Table 49. Digital competences levels with ICT training course for pre-service teachers. Mann-Whitney U test.

Pre-service	Yes (N=234)		No (N=12)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	3.992	4.200	3.631	3.600	2132.500	.019	.384
FA2	3.879	4.000	3.479	3.444	2057.500	.042	.336
FA3	4.195	4.333	4.077	4.333	1651.000	.660	.072
FB1	3.867	4.000	3.808	3.667	1612.500	.777	.047
FB2	3.910	4.000	3.692	3.750	1877.500	.178	.219
FB3	3.885	4.000	3.593	3.429	1971.000	.088	.279
FC1	3.899	4.000	3.654	3.750	1873.500	.187	.216
FC2	3.905	4.000	3.609	3.500	2010.000	.064	.305
FC3	3.907	4.000	3.679	3.667	1896.500	.158	.231
F1	4.022	4.133	3.729	3.793	2011.500	.064	.306
F2	3.888	4.000	3.698	3.810	1856.000	.214	.205
F3	3.904	3.986	3.647	3.653	1954.500	.103	.269

5.4.5.2. In-service teachers´ digital competence by ICT training course

As Table 50 shows, there were no significant differences between ICT training courses for the in-service teacher between their digital competence and any dimension or factor. This indicated that the current training course no affect teachers´ self-perceived digital competences.

Table 50. Digital competences levels with ICT training course for in-service teachers. Mann-Whitney U test.

In-service	Yes (N=212)		No (N=15)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	4.069	0.716	3.800	0.713	1998.000	.095	.257
FA2	3.871	0.724	3.859	0.822	1631.500	.867	.026
FA3	4.171	0.835	4.111	0.965	1586.000	.988	-.003
FB1	3.939	0.581	3.700	0.807	1891.500	.217	.190

FB2	3.913	0.713	3.750	0.802	1865.500	.252	.173
FB3	3.848	0.719	3.467	0.848	2008.000	.087	.263
FC1	3.922	0.607	3.658	0.613	2040.000	.066	.283
FC2	3.887	0.630	3.506	0.913	2000.000	.095	.258
FC3	3.892	0.629	3.500	0.913	1956.000	.133	.230
F1	4.037	0.692	3.923	0.720	1775.000	.453	.116
F2	3.900	0.612	3.639	0.771	1973.000	.119	.241
F3	3.900	0.590	3.555	0.748	2065.000	.053	.299

5.4.7. Digital competence by contextual factors. In-service teachers

5.4.7.1. Digital competence by teaching experience

As Table 51 shows, there were significant differences between the teaching experience of in-service teachers and dimensions like *FA2 Technical environment*, *FB2 Communication and collaboration*, *FB3 Research and innovation*, *FC1 Resource preparation, FC2 Process design, and FC3 Practice reserve. There* meet the conditions of the p-values below .05 with small effect sizes simultaneously. Then, there were significant differences between teaching experience and two factors: *Technical Support Learning and Technical Support Teaching*. These indicated that in-service teachers with more years of teaching experience have a lower self-perceived digital competence in mentioned digital aspects.

Table 51. Pearson correlation analysis between teaching experience and digital competence level for in-service teachers.

In-service teachers	R_{xy}	Sig.
FA1 Consciousness and attitude	-.088	.173
FA2 Technical environment	-.173	.007
FA3 Information Ethics and Information Security	-.040	.537
FB1 Self-learning	-.151	.019
FB2 Communication and collaboration	-.223	<.001
FB3 Research and innovation	-.224	<.001
FC1 Resource preparation	-.232	<.001

FC2 Process design	-.234	<.001
FC3 Practice reserve	-.193	0.003
F1 Basic Technology Literacy	-.108	.096
F2 Technical Support Learning	-.222	<.001
F3 Technical Support Teaching	-.236	<.001

5.4.7.2. Digital competence by school type.

As Table 52 shows, there were no significant differences between the types of schools for in-service teachers and any dimension or factor. This indicates that the type of school the teacher works in doesn’t depends on the teachers' digital competence level.

Table 52. Digital competences levels with school types. Mann-Whitney U test.

School Types	State (N=198)		Private (N=48)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	4.045	0.726	4.098	0.683	3626.500	.699	-.039
FA2	3.888	0.716	3.808	0.800	3885.500	.764	.030
FA3	4.221	0.802	3.976	0.973	4281.500	.169	.135
FB1	3.903	0.609	4.024	0.541	3361.000	.272	-.109
FB2	3.899	0.730	3.921	0.688	3833.000	.870	.016
FB3	3.814	0.756	3.885	0.634	3682.500	.812	-.024
FC1	3.904	0.612	3.918	0.621	3717.000	.884	-.015
FC2	3.856	0.642	3.884	0.738	3549.500	.554	-.059
FC3	3.850	0.624	3.915	0.795	3362.500	.272	-.109
F1	4.051	0.679	3.960	0.756	4034.000	.488	.069
F2	3.872	0.640	3.943	0.567	3677.500	.803	-.025
F3	3.870	0.589	3.905	0.694	3464.500	.415	-.082

5.4.7.3. Digital competence by available hardwires.

Available desktop computer

As Table 53 shows, there were no significant differences between the available desktop computer and any dimension or factor for in-service teachers, indicating that the available desktop computer does not affect the teachers' digital competence level.

Table 53. Digital competences levels with available desktop computer. Mann-Whitney U test

Available desktop computer	Yes (n=205)		No (n=20)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	4.055	0.725	4.017	0.669	2497.000	.612	.064
FA2	3.845	0.733	4.092	0.660	1864.500	.107	-.205
FA3	4.149	0.856	4.333	0.696	2072.500	.352	-.117
FB1	3.922	0.599	3.935	0.615	2378.000	.915	.014
FB2	3.904	0.728	3.880	0.643	2490.000	.623	.061
FB3	3.829	0.743	3.770	0.646	2578.000	.434	.099
FC1	3.901	0.619	3.940	0.533	2344.500	.997	-.394
FC2	3.873	0.663	3.761	0.597	2654.000	.301	.131
FC3	3.893	0.644	3.623	0.725	2834.000	.099	.208
F1	4.016	0.701	4.148	0.618	2068.500	.353	-.118
F2	3.885	0.629	3.862	0.604	2447.500	.735	.043
F3	3.889	0.609	3.775	0.579	2643.500	.319	.127

Available laptop or tablet

As Table 54 shows, there were significant differences between the available laptop or tablet and the dimension *FB3 Research and innovation* for in-service teachers. However, there were no significant differences between the available laptop or tablet and other dimensions or any factor for the in-service teacher. These indicate that the available laptop or tablet affects the teacher's self-perceived digital competence levels in research and innovation but does not affect the teachers' digital competence level in other aspect.

Table 54. Digital competences levels with available laptop / tablet. Mann-Whitney U test.

Available laptop / tablet	Yes (n=205)		No (n=18)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	4.060	0.723	3.978	0.675	1981.500	.602	.074
FA2	3.881	0.727	3.704	0.770	2071.500	.388	.123
FA3	4.166	0.848	4.185	0.818	1811.000	.896	-.018
FB1	3.930	0.595	3.778	0.644	2102.000	.324	.139
FB2	3.916	0.710	3.694	0.838	2111.000	.301	.144
FB3	3.856	0.718	3.460	0.786	2422.500	.026	.313
FC1	3.926	0.590	3.681	0.748	2248.000	.123	.218
FC2	3.890	0.621	3.579	0.841	2143.500	.254	.162
FC3	3.893	0.629	3.583	0.744	2232.500	.136	.210
F1	4.035	0.701	3.956	0.614	2036.000	.468	.104
F2	3.901	0.617	3.644	0.699	2263.500	.111	.227
F3	3.903	0.580	3.614	0.721	2149.000	.247	.165

Available smartboard interactive

As Table 55 shows, there were significant differences between the available smartboard interactive and the dimension *FC2 Process design* for the in-service teacher. However, no significant differences existed between the available smartboard interactive and other dimensions or any factor. These indicate that the available smartboard interactive affects the teachers' digital competence level in process design but does not affect the teachers' digital competence level in other aspect.

Table 55 Digital competences levels with available smartboard interactive. Mann-Whitney U test.

Available smartboard interactive	Yes (n=200)		No (n=22)				
	Mean	SD	Mean	SD	W	Sig.	r
FA1	4.058	0.748	3.945	0.471	2632.000	.129	.196

FA2	3.883	0.756	3.783	0.524	2474.500	.337	.125
FA3	4.182	0.858	4.076	0.783	2428.000	.417	.104
FB1	3.930	0.620	3.894	0.380	2384.000	.517	.084
FB2	3.908	0.752	3.886	0.421	2405.500	.463	.093
FB3	3.834	0.760	3.701	0.516	2650.500	.112	.205
FC1	3.913	0.630	3.824	0.473	2562.000	.204	.165
FC2	3.882	0.671	3.659	0.542	2764.500	.048	.257
FC3	3.882	0.662	3.689	0.618	2692.500	.082	.224
F1	4.041	0.717	3.935	0.535	2538.000	.238	.154
F2	3.890	0.653	3.827	0.388	2468.500	.348	.122
F3	3.893	0.619	3.724	0.519	2683.000	.091	.220

Available research projects.

As Table 56 shows, there were significant differences between available projects for teachers and dimensions like *FA2 Technical environment* (p-value=.002), *FB3 Research and innovation* (p-value=.030), *and FC1 Resource preparation* (p-value=.020, with small effect sizes at the same time. Then, there were significant differences between teaching experience and the factor *Technical Support Learning*. These indicate that available research projects of school affect in-service teachers' self-perceived digital competences in a technical environment, research and innovation, and resource preparation for teaching and learning.

Table 56. Digital competences levels with the sates of available. Mann-Whitney U test.

Available project	Yes (n=205)		No (n=20)				
	Mean	**SD**	**Mean**	**SD**	**W**	**Sig.**	**r**
FA1	4.061	0.724	3.970	0.681	2324.500	.321	.134
FA2	3.910	0.738	3.500	0.541	2911.500	.002	.420
FA3	4.185	0.839	4.000	0.905	2297.000	.366	.120
FB1	3.942	0.603	3.742	0.553	2573.500	.058	.255
FB2	3.928	0.720	3.650	0.709	2543.500	.070	.241

FB3	3.860	0.715	3.500	0.827	2648.500	.030	.292
FC1	3.934	0.607	3.656	0.583	2691.500	.020	.313
FC2	3.888	0.658	3.692	0.523	2575.500	.058	.256
FC3	3.885	0.649	3.750	0.601	2370.000	.245	.156
F1	4.052	0.701	3.823	0.602	2568.000	.063	.253
F2	3.910	0.627	3.631	0.593	2681.500	.023	.308
F3	3.903	0.603	3.699	0.538	2564.000	.064	.251

5.5. Conclusion

This chapter was not just measuring pre-service and in-service teachers' digital competence levels and explored influencing sociodemographic factors on their perceptions of digital competence in China, focusing on a group of samples in Anhui province.

Firstly, the descriptive results of this study demonstrated that both pre-service and in-service teachers in Anhui province have an excellent perception of digital competence in the three measured areas: basic technology literacy, technical support learning, and technical support teaching. Additionally, this study found that in-service teachers had higher perceived digital competence than pre-service teachers in three measured areas.

Secondly, factors (sex, age, educational background) influencing pre- and in-service teachers' digital competence have been investigated. Besides, some contextual factors for in-service teachers were investigated, such as the active school types, the years of teaching, the available hardware (desktop computer, laptop or tablet, smartboard interactive), and the available research project. The results mainly demonstrated:

- Sex as a sociodemographic factor has no impact on in-service teachers' perception of digital competence nor on pre-service teachers.
- Younger in-service teachers have a higher digital competence level than older in-service teachers, which is contrast to the results obtained from pre-service teacher.

- In-service teachers with higher educational background have better self-perception of the level of digital competence. However, there are no significant differences between their perception of digital competence and educational background.
- Except for the years of teaching, other contextual factors for in-service teachers were investigated. Such as the working school types of the teachers, the available hardware (desktop computer, laptop or tablet, smartboard interactive), and the available research projects. These factors had not an important impact on in-service teachers' digital competence.

Chapter 6. Theoretical Support in Digital Competence Training for K-12 Teacher

In line to the findings of several previous studies from different countries (Bartkowiak et al., 2022; Gisbert-Cervera et al., 2022; Karunaweera & Wah, 2021; Silva et al., 2022), our study reported that current teachers have a low or medium level of digital proficiency, making it difficult to cope with complex teaching and learning tasks with technology tools. In this case, attention has been paid to teacher training in digital competence from the perspective of higher education. Training pre-service teachers is seen as a critical element in improving the digital competence level of all teachers in the future.

This chapter aims to find theoretical support for pre-service and in-service K-12 teacher training, our primary recommendation for improving Chinese teachers´ digital competence in this dissertation. Hence, we conducted an SLR of empirical studies focusing on the implementation characteristics of teacher training programs for pre-service and in-service teachers.

6.1. Background, objectives, and research questions

Previous studies suggested that current teachers have a low or medium level of digital proficiency, making it difficult to cope with complex teaching and learning tasks with technology tools (Bartkowiak et al., 2022; Gisbert-Cervera et al., 2022; Karunaweera & Wah, 2021; Silva et al., 2022). In this case, teacher training in digital competence has been paid attention to from the perspective of higher education, and the training of pre-service teachers be considered a fundamental element for improving the whole teachers' digital competence level in the future.

Earlies review studies paid attention to the teachers' digital competence in higher education (HE), which mainly focused on the research trends and potential directions of teachers' digital competence (TDC) or digital teaching competence (DTC). Firstly, Rodríguez-García et al. (2019) conducted a systematic review, concluding the existence of more outstanding scientific production on teacher digital competence in Spain. Fernández-Batanero et al. (2020) carried out a systematic review of 21 identified studies published in 2008–2018 on teachers´ digital competence in professional development, concluding that most of the selected studies reveal a lack of teacher training and insufficient ICT training. Secondly, Basilotta-Gómez-Pablos et al. (2022) revealed that most research focuses on analyzing teachers' self-assessment and reflection of their digital competence, as well as teachers' absence of specific competence related to the evaluation of educational practice. However, the review of Garcia et al. (2022) found that there are generalized deficiencies in the areas of digital content creation, problem solving and digital security in teacher training process. The review of Torres-Hernández and Gallego-Arrufat (2022) analyzed the state of inquiry in the field of digital competence in security in initial teacher education, via indicators to assess pre-service teachers' digital competence in security. Lastly, in addition to give the view of characteristics of research, Peters et al. (2022) also concluded implications of practice for TDC development in HE by synthesizing 740 studies across 13 systematic reviews.

Teacher training in digital competence is a complex process that includes various strategies. Teacher training and professional development in higher education are essential factors influencing K-12 teacher professional development, including empowering students' digital abilities (Peters et al., 2022). So, training future teachers in a range of disciplines directly affects the digital competence of K-12 teachers, who are the driving force for broader social change. However, the current review about TCD mainly focused on higher education (Esteve-Mon et al., 2020), and few studies focused on digital competence training for K-12 pre-and in-service teachers. On the other hand, it is difficult to ensure the availability of adequate educational ICT tools and the essential need for training to avoid obstacles and difficulties arising from incorrect pedagogical applications (Sáez-López et al., 2020), Hence, some studies focused on investigating the use of ICT tools for strengthening teachers' digital competence in teacher training programs that go beyond exploring the teacher's acquaintance with ICT tools. Thus, there are some reviews about using educational tools for teacher training in digital competence (Koh, 2015; Santagata et al., 2021). For example, game-based learning as an instructional and training tool has been investigated by Tay et al. (2022), pointing to the need to strengthen digital competence in teacher training programs that go beyond mere acquaintance with ICT tools.

After reviewing the previous literature review, we found that no study has systematically reviewed the characteristics of implemented teacher training programs. Hence, this systematic review aims to synthesize the empirical research regarding teacher training in digital competence in higher education for K-12 pre- and in-service teachers. More specifically, this review of empirical research was used to synthesize their research themes and the evidence regarding which content, educational resources, and delivery methods for training practice for teachers to integrate technology into their classrooms.

Following these ideas, this systematic literature review (SLR) focuses on the following research questions:

RQ1. What are the main research themes related to K-12 pre-and in-service teachers' training in digital competence in the last decade, and its outcomes? What is the trend of research themes?

RQ2. What are the main characteristics of research (e.g., country of study, study design, sample, etc.)?

RQ3. For engaging teachers in technology-rich design activities, what are the leading educational resources used, how are their characteristics, and what are the challenges and strengths of these tools?

RQ4. What are the main types of limitations and further research directions of studies related to teacher training in digital competence?

6.2. Materials and methods

The primary purpose of an SLR is to identify, evaluate and interpret the available studies in the literature that consider the research questions proposed by the authors. A second purpose could be to gather evidence to identify gaps and research opportunities in interest. This chapter used the PRISMA method (Moher, Liberati, Tetzlaff, & Altman, 2009) to conduct an SLR on publications related to digital competence training for K-12 pre-and in-service teachers.

6.2.1. Inclusion/exclusion criteria

Articles should meet following criteria:

Inclusion criteria

a) The full version of the publication should be available to consult our via university library systems.
b) We selected articles written in English or Spanish to access as many articles as possible.
c) To ensure the identification of relevant articles, we only selected empirical research submitted to a peer-reviewed journal.
d) The studies focused on teacher training for K-12 pre-and in-service in digital competence based on training projects.

Exclusion criteria

a) The full version of the publication is not available to consult by our university library systems. For example, (Kjällander et al., 2018).
b) The articles are not written in English or Spanish languages, For example, (Collado-Ruano et al., 2020).
c) Theoretical research and secondary data analysis articles (e.g., systematic reviews and meta-analyzes). For example, (Spiteri & Chang Rundgren, 2020).
d) The articles described K-12 pre-and in-service teachers' digital competence but were not based on a training program, which only mentioned establishing a teacher training project as recommendations. For example, (Siddiq & Scherer, 2016).

6.2.2. Quality of the studies

For the quality of articles, the selected articles were followed by the five criteria adapted from the study of Pan et al. (2022): a clear description of the appropriate research design for the research questions; a clear description of the sample and population; appropriateness of methodology and data analysis; clear presentation of findings; the alignment of the study focuses and the research questions.

6.2.3. Sources and search string

We chose Scopus, Web of Science (WoS), and ERIC as three databases to perform the search. Concerning WoS database, both the main collection (SCI-SSCI) and the complete collection (ESCI-ESSCI) have included. The selection was made according to the following requirements: the database allows the use of logical expressions or a similar mechanism; it allows full-length searches or searches only in specific fields of the works; it is one of the most relevant in the research area of education; and is available for us (through our institution, scientific associations, etc.).

Queries were refined through pilot searches. Different combinations of keywords in the title, abstract, and keyword fields were entered across databases to determine if relevant articles would be identified. We identified that the query was designed based on the identified terms and using logical operators for the search. So, when the results were inspected for articles on K-12 pre-or in-service teachers in digital competence in the training program, the pilot queries revealed that critical articles would be missed if the educational program or training project were added in the title, abstract, or keyword search. In this case, to reduce the risk of omitting relevant studies, only the term teacher training was applicated to searched terms in titles, abstracts, and keywords: (("digital competenc*" OR "digital literac*" OR "digital skill*" OR "digital abilit*") AND ("teacher training*" OR "teacher education*" OR "student teacher’s training *" OR "student teacher’s education*")). We limited the search to studies published between 2010 and 2022 (13 October).

6.2.4. Review Process

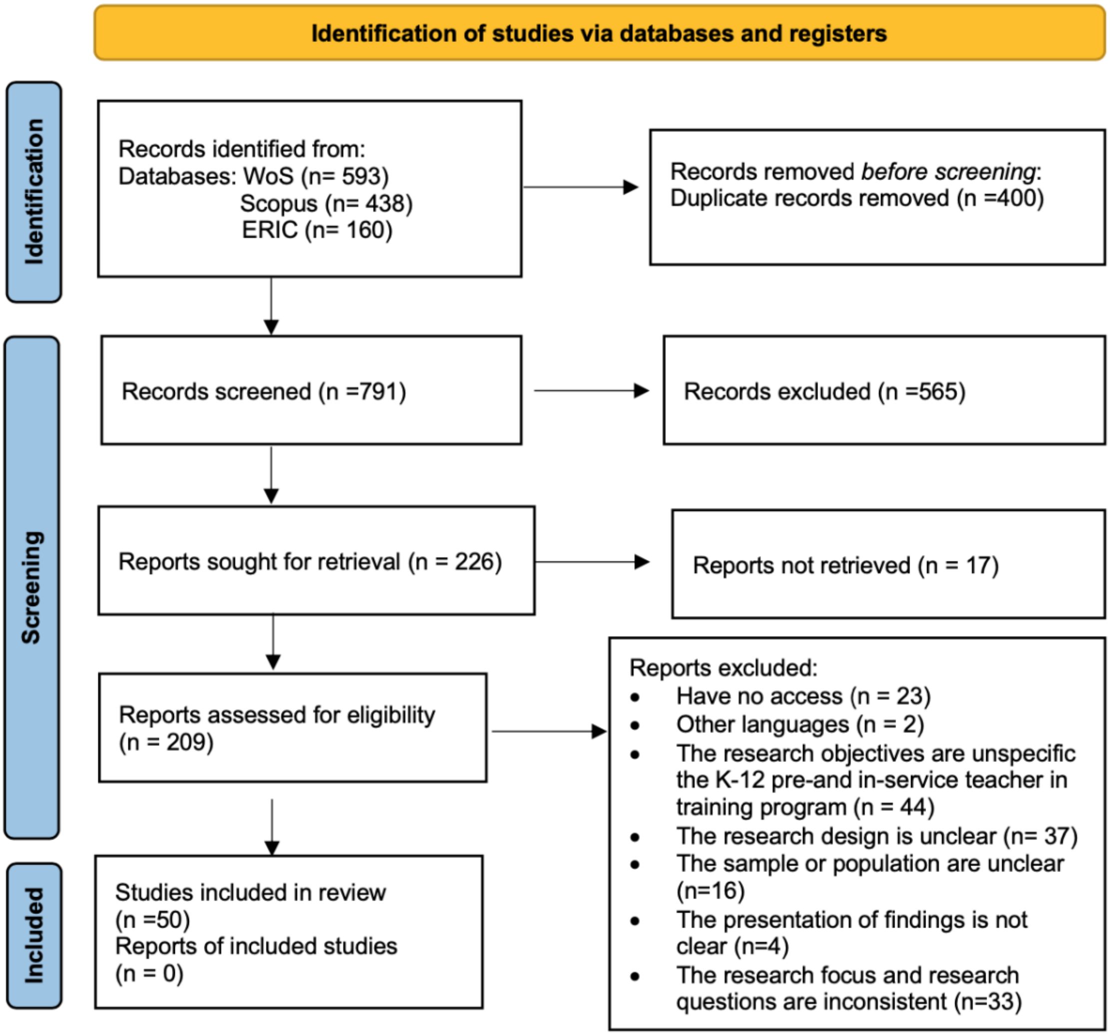
Searching the databases (identification phase): 1191 papers were retrieved (593 from Web of Science, 438 from SCOPUS, and 160 from ERIC), then all the raw results were collected. The analysis performed to achieve this number of papers was only based on their content and without concerning bibliometric measurements (number of citations, journal source) or other aspects. Based on inclusion and exclusion criteria, the next step was the selection of papers used for the SLR, as shown in Figure 40. It was performed following these steps:

Phase 1: The spreadsheet has already removed the 400 duplicates across the databases.

Phase 2: The resultant 791 candidate papers were added to another sheet of the spreadsheet document, which was analyzed based on the title, abstract, and keywords according to the inclusion/exclusion criteria (screening phase): c). empirical study; d). K-12 pre-and in-service teacher training in digital competence is not based on training projects. In those cases, 226 papers (28.6 %) were retrieved.

Phase 3: These 209 papers were read in full based on four exclusion criteria to filter articles: (a) full version not available (n= 23); (b) other languages (n= 2). Then, after reading the full text based on five quality criteria, 50 papers were selected for final analysis.

Figure 40. PRISMA 2020 flow diagram for new systematic reviews.



6.3. Results

6.3.1. Main research themes

Based on the synthesis of the research proposals, the results show five main categories of research themes: 1). Assessing perceptions and the level of digital competence of participants in a training project; 2). Investigating instructional effectiveness of the training project; 3). Developing digital competence skills in a training program; 4). Investigate influencing factors; 5). Designing and developing an evaluation instrument.

Theme I: Assessing perceptions and the level of digital competence of participants. Ten studies investigate participants´ specifical skills related digital competence and the participants´ attuites towards the implementation of training program. In this category, six articles (Cañete Estigarribia et al., 2022; Guillén-Gámez et al., 2020; Lopez-Belmonte et al., 2020; Ramírez-Montoya et al., 2017; Sánchez-Prieto et al., 2021; Serrano & Casanova, 2022) analyzed the perceptions of participants in training program regarding the use of some digital tools. Such as, Guillén-Gámez et al. (2020) investigated pre-service teachers´ level of digital competence and the perception regarding the use of 2.0 tools in the education training, Lopez-Belmonte et al. (2020) investigated per-service teachers´ perception regarding the use of augmented reality (AR). Four articles (Cañete Estigarribia et al., 2022; Sánchez-Prieto et al., 2021; Serrano & Casanova, 2022; Shively & Palilonis, 2018) analyzed the perception of participants´ digital competence in training stage. For example, Cañete Estigarribia et al. (2022) examined the perception of pre-service teachers about their digital competence in their final training years.

Theme II: Investigate instructional effectiveness. Twenty-four studies evaluated the gains in the participants' knowledge of concepts and attitudes towards instructional training program. In this category, six articles (Avci & Osman, 2021; Gómez-Trigueros, 2020; Gordillo, Barra, Garaizar, et al., 2021; Gordillo, Barra, López-Pernas, et al., 2021; Sáez-López et al., 2020; Schina et al., 2020) reported the effectiveness of some educational tools to improve participants´ digital competence. For example, Sáez-López et al. (2020) investigated the use of Scratch in the training of pre-service teachers. Four articles (García & Hernandez-Sanchez, 2020; Pombo et al., 2017; Romero-García et al., 2020; Tirado-Olivares et al., 2021) examined the effectiveness of the implementation based on some theorical learning supported methodology. For example, García and Hernandez-Sanchez (2020) and Romero-García et al. (2020) presented the impact of training programs about digital competences based on the affective methodology. Then, the other six articles (Gudmundsdottir & Hatlevik, 2018; Martínez-Abad et al., 2017; Miguel-Revilla et al., 2020; Romero-Tena et al., 2020; Strydom et al., 2021; Tømte et al., 2015; Zimmermann et al., 2021) examined the perceptions of effectiveness of general innovative projects for training K-12 pre-and in-service teacher´s digital competence. For example, Miguel-Revilla et al. (2020) assessed the effectiveness of a formative intervention based on TPACK-21 model.

Gordillo et al. (2019) and Tømte et al. (2015) examined the instructional effectiveness of courses in online format for teacher training.

Theme III: Influencing factors. Five studies explored factors or issues that influence participants' learning and teaching when conducting a training project (García et al., 2022; Howard et al., 2021; Ranieri et al., 2017; Tondeur et al., 2021; Záhorec, Hašková, Poliaková, et al., 2021). For example, the study of Záhorec, Hašková, Poliaková, et al. (2021) explored three factors (country, gender, the combination of country and gender) which can influence the integration of various kinds of digital didactic tools into pre-service teacher training. Ranieri et al. (2017) investigated the issue of teacher training focusing on strengths and challenges for implementing a teacher training program. The rest three articles in this category investigated how teaching strategies affected pre-service teacher´s experience developing digital competence in their teacher training based on the Synthesis of Qualitative Data (SQD) model. Such as, Tondeur et al. (2021) specifically explored the factor of attitudes towards digital technologies, Howard et al. (2021) examined relationships among six strategies in the SQD model for the development of digital competence in teacher training, and García et al. (2022) determined the key elements of teacher training in the use of innovative technologies and methodologies.

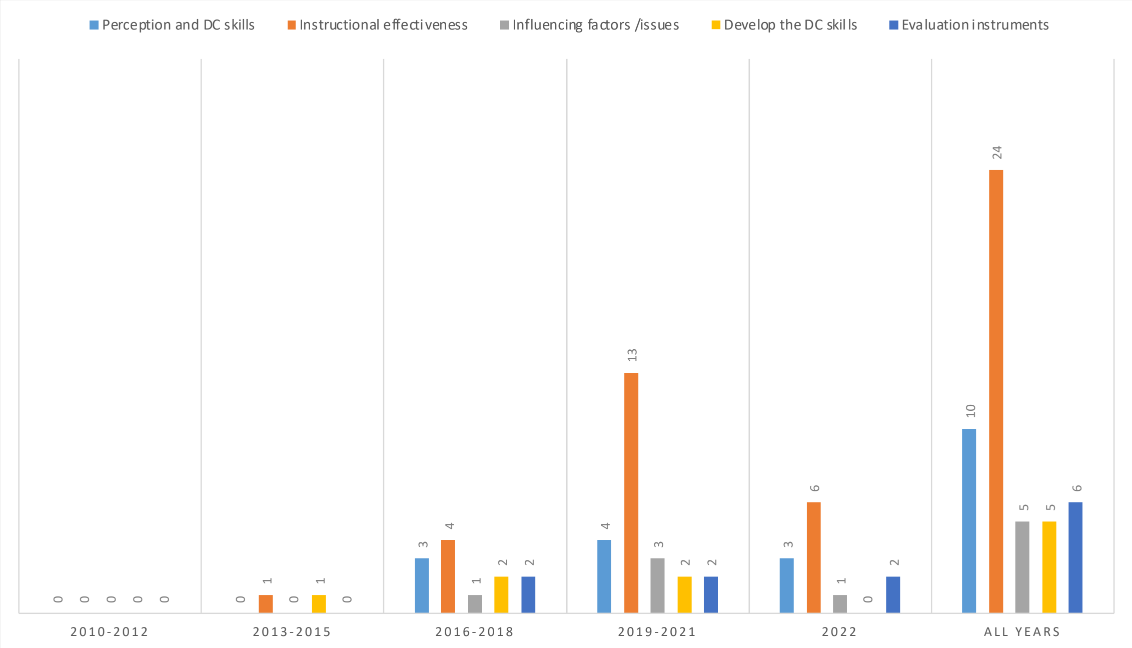
Theme IV: Developing digital competence skills. Five studies focus on giving an overview of how participants´ digital competence has been fostered in a training program (Brevik et al., 2019; Instefjord & Munthe, 2017; Kvale & Rambo, 2015; Novella-García & Cloquell-Lozano, 2021; Starčič et al., 2016). In this category, three articles presented how participants developed the digital competence in specifically digital use of digital resources. For instance, Starčič et al. (2016) intended to develop pre-service teachers´ digital competence skills by an integrative approach in digital storytelling. While, the study of Brevik et al. (2019) presented how student teachers develop their digital competence through a Small Private Online Course (SPOC) involving transformative agency, and how professional identity was expressed in the course through blogging in Norwegian in pre-school teacher education. On the other hand, the study of Instefjord and Munthe (2017) focused on the integration of professional digital competence related to workplace support in initial teacher education programs, through investigating teacher educators including mentor teachers' digital competence. Besides, one study (Novella-García & Cloquell-Lozano, 2021) pay attention on who are trained students in subjects related to the use and learning of ICT applied to Education, particularly addressing the ethical dimension.

Theme V: Designing and developing an evaluation instrument or framework for teacher training. Six studies intend to design and develop an evaluation instrument or framework (Fernandez-Cruz et al., 2018; González-Martínez et al., 2019; Große-Heilmann et al., 2022; Paige et al., 2016; Rodríguez et al., 2021; Thoms et al., 2022). In this category, Fernandez-Cruz et al. (2018) and Rodríguez et al. (2021) measured the reliability and validity of the self-assessment tool for teachers´ digital competence aligned to the Spanish contexts. Große-Heilmann et al. (2022) designed the assessment tool based on pedagogical content knowledge (PCK) for measuring pre-service teachers´ digital media. Moreover, González-Martínez et al. (2019) focused on designing and implementing instruments in 3D environments. Paige et al. (2016) established the modelling for practice assessment tools based on the educational tool of Slowmation.

6.3.1.1. Trend of research themes

Moreover, Figure 41 shows the trend of research themes. The research on digital training for teachers began to emerge in 2013, and the research in this area began to explode in 2019, whith most studies published between 2019- 2021 (n= 24). The data also show a total of 12 studies on teacher training in 2022 in one year alone.

Figure 41. Trend of research themes.



6.3.1.2. Outcomes of research themes

Theme I: Assessing perceptions and the level of digital competence of participants. Ten studies investigate participants´ specific skills related to digital competence, and the participants´ attitudes towards implementing the training program. In this category, six articles indicated that participants perceived themselves as without an optimal level of digital competence for teaching practice using technological tools. They lack advanced knowledge and confidence in using technological tools for complex educational practice (Cañete Estigarribia et al., 2022; Guillén-Gámez et al., 2020; Lopez-Belmonte et al., 2020; Ramírez-Montoya et al., 2017; Sánchez-Prieto et al., 2021; Serrano & Casanova, 2022). For example, Serrano and Casanova (2022) and Guillén-Gámez et al. (2020) indicated that pre-service teachers are conditioned by their practical thinking, which they continue to use traditional ways in teaching practice without producing any innovative changes while merely including some technology. This finding is similar to Ramírez-Montoya et al. (2017), stating that teachers are more confident with basic skills such as searching, selecting, and processing information than with digital media design, use, or reuse. In terms of practice for teaching and learning, Strydom et al. (2021) indicated that participants found value in authentic tasks and assignments as well as the process of knowledge creation. Karsli and Yagiz (2022) highlighted the effectiveness of teaching practice offered within the scope of the internship program as it responds to the needs of pre-service teachers in professional development and mentoring support.

Theme II: Investigating instructional effectiveness. Twenty-four studies evaluated the gains in the participants' knowledge of concepts and attitudes towards instructional training programs. In this category, firstly, Gudmundsdottir and Hatlevik (2018) reported poor quality of and contribution from their ICT training course. Secondly, five studies indicated that the implementation of training projects improved the digital competence of pre-and in-service teachers in digital knowledge and use of educational resources for learning and teaching (García & Hernandez-Sanchez, 2020; Martínez-Abad et al., 2017; Pombo et al., 2017; Romero-García et al., 2020; Strydom et al., 2021). Then, five studies based on the Technological Pedagogical Content Knowledge (TPACK) model pointed out that the developed teacher training projects increased participants´ TPACK self-efficacy, attitude, and ability to implement ICT into education (Çebi et al., 2022; Ciriza-Mendivil et al., 2022; Gómez-Trigueros, 2020; Miguel-Revilla et al., 2020; Zimmermann et al., 2021). However, participants still evidenced less significant progress in PK and PCK dimension and more difficulties with disciplinary content knowledge linked to CK and PCK dimensions (Gómez-Trigueros, 2020; Miguel-Revilla et al., 2020; Zimmermann et al., 2021).

Depending on the training objectives, twelve articles demonstrated that participants´ knowledge about, attitudes towards, and digital skills had been improved after receiving specific training projects. These specific training were mainly based on online training modality (Gordillo et al., 2019), framework or theoretical based-learning (Colomo-Magaña et al., 2022; Anna Henne et al., 2022; Magaña et al., 2022; Tirado-Olivares et al., 2021), or some educational tools (Avci & Osman, 2021; S.-M. Chireac et al., 2022; Gordillo, Barra, Garaizar, et al., 2021; Gordillo, Barra, López-Pernas, et al., 2021; Sáez-López et al., 2020; Schina et al., 2020). For instance, for improving pre-service teachers´ digital competence in the area of security and responsibility, Gordillo, Barra, Garaizar, et al. (2021), Gordillo, Barra, López-Pernas, et al. (2021) and Gordillo et al. (2019) respectively indicated that Social

Lab, educational video game-based learning and online courses in MOOC format are effective training methods.

Theme III: Influencing factors. Five studies explored factors or issues that influence participants' learning and teaching in digital competence. Several factors were presented in this category: attitude, familiarity with the ICT environment, knowledge of new technologies, received training, role model, feedback, the collaboration between teachers and students, etc. First, García et al. (2022) highlighted pre-service teachers´ positive attitudes towards digital technologies as a crucial factor affected their experience developing digital competence in their teacher training. Secondly, aside from collaboration and feedback (Miguel-Revilla et al., 2020), Tondeur et al. (2021) indicated that role models, instructional design, and authentic experiences are three essential factors that influence pre-service teachers´ digital competence in the training process. Particularly, Howard et al. (2021) and Tondeur et al. (2021) pointed out specific aspects of these three influencing factors, which highlighted role models in providing quality examples, motivating feelings to gain experience in class practice related to authentic experiences as well as the stimulated and supported feeling on the instructional design. Similar to the finding of Ranieri et al. (2017), a community manager as a trainer keeps a central role model to foster trainees' active participation and cooperation.

Theme IV: Developing digital competence skills. Five studies overview how participants´ digital competence has been fostered in a training program (Brevik et al., 2019; Instefjord & Munthe, 2017; Kvale & Rambo, 2015; Novella-García & Cloquell-Lozano, 2021; Starčič et al., 2016). In this category, there are three main findings for studies concerning developing teachers´ digital competence in training projects in this category. First, pre-service teachers were ready and motivated to integrate ICT to design pedagogical content, but the use of digital tools for pre-service teachers´ learning and teaching is still a lack in their training process (Instefjord & Munthe, 2017; Kvale & Rambo, 2015; Starčič et al., 2016). For example, Starčič et al. (2016) demonstrated that pre-service teachers were active in social networks but tended not to use other web tools such as Wikis and blogs. Second, pre-service teachers´

personal beliefs and conceptions of integrating ICT in their teaching and learning could be influenced by their teacher educators, who are role models for using technology for educational purposes (Instefjord & Munthe, 2017; Starčič et al., 2016). Third, preparing teacher´s digital competence should connect to the content of the subject-specific studies they are engaged in, specifically through the design of authentic tasks developed during the training course to focus on an expected learning outcome (Instefjord & Munthe, 2017; Kvale & Rambo, 2015; Starčič et al., 2016). Additionally, Novella-García and Cloquell-Lozano (2021) emphasized that the ethical dimension in subjects related to the use and learning of ICT should be incorporated into the current teaching guides of digital competence.

Theme V: Designing and developing an evaluation instrument or framework for teacher training. Six studies intend to design and develop an evaluation instrument or framework (Fernandez-Cruz et al., 2018; González-Martínez et al., 2019; Große-Heilmann et al., 2022; Paige et al., 2016; Rodríguez et al., 2021; Thoms et al., 2022). In this category, González-Martínez et al. (2019) aim to design and implement instruments in 3D environments to develop teacher digital competence. Fernandez-Cruz et al. (2018) design an instrument based on the standards developed by UNESCO, while Rodríguez et al. (2021) measured the reliability and validity of the self-assessment tool aligned to the proposal made by the Catalan government and to the Spanish and European contexts. Besides, the modeling for best practice assessment tools based on the educational tool of *Slowmation* was studied in the article of Paige et al. (2016). By 2022, two studies based on the DiKoLAN framework (Digital Competence for Teaching in Science Education) emerged, which Thoms et al. (2022) derived a framework of digital competence for teachers, and Große-Heilmann et al. (2022) developed an instrument to validly measure the digital-media PCK of pre-service physics teachers.

6.3.2. Main characteristics of research (e.g., country of study, study design, sample, etc.)

The characteristics of research in detail related to participants, sample size, research design, type of methodology, and methods to collect data is collected in Appendix 3_Table 76.

6.3.2.1. Country of study

More than half of the studies were conducted in European countries, with which 27/50 studies stemmed from Spain, 4/50 from Norway, and 3/50 from Turkey. Seven studies from America, Africa, and Australia met the inclusion criteria, but no one study from the Asia continent was included.

6.3.2.2. Study design

Quantitative, qualitative, and mixed methodological approaches were conducted in reviewed studies. Most studies employed a quantitative methodology (n = 29; 58%). The remaining studies applied the use of qualitative methodology (n=6; 12%), a mixed-method design (n =14; 28%) and design-based research (n=1; 2%). Concerning research design, non-experimental and experimental designs have been conducted in selected studies, in which the non-experimental design was prevalent (n=33; 74%) in the selected studies, while 12 studies (22.2%) carried out a pre-experimental design, four studies (6.7%) with a quasi-experimental design, and only 1 study conducted an experimental design. Table 57 shows the distribution of articles number for the different methodological approaches corresponding to the three research designs.

Table 57. Methodological approaches corresponding to the research designs

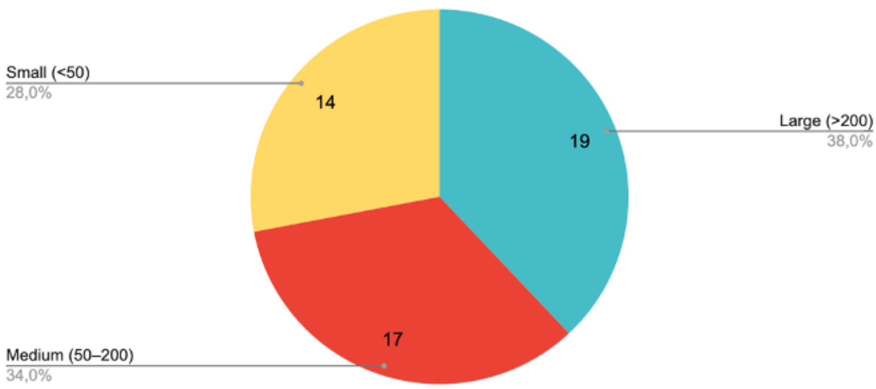
Study	Quantitative	Qualitative	Mixed	Design-based research
Non-experimental	17	6	9	1
Quasi-experimental	3	0	1	0
Pre-experimental	9	0	3	0
Experimental	0	0	1	0
Total	29	6	14	1

Regarding the data sources, the questionnaire and the interview are the most common techniques used in reviewed articles. Six studies used interviews, four of which used semi-structured interviews. More than 25 studies used questionnaires to collect the data, and nine used questionnaires with surveys or interviews. However, some articles also mentioned using a test, evaluation rubric, reflection, etc. to collect the data, such as, Tirado-Olivares et al. (2021) and Starčič et al. (2016) used test, del Moral et al. (2016) only applied evaluation rubric.

6.3.2.3. Population and sample

Regarding the population and sample, 38 studies (76%) were focused on the population of pre-service teachers, ten studies (20%) focused on in-service teachers, and the other two articles focused on both pre-service teachers and teacher educators. Besides, Figure 42 shows that 17 studies were conducted with a medium sample size ranging from 50 to 200, 14 studies had a small sample size with less than 50 participants, and 19 studies had a large sample size with more than 200 participants.

Figure 42. Sample size of selected papers



6.3.3. Leading educational resources used: characteristics, challenges, and strengths.

6.3.3.1. Primary educational resources and their characteristics

After scrutinizing the reporting of the content of each article, we found that 18 of 50 studies (36%) related to the use of main instructional and training educational resources for K-12 teachers. Table 58 shows the primary used educational resources and their characteristics. Regarding its characteristics, we mainly focused on its learning objects, training period, measured dimensions, and course modality (online / face-to-face). In terms of the classification of learning objects, we classified four types of educational resources based on the studies of Convertini and Bruno (2012) and Churchill (2007): instructional objects (e.g., articles, workshops, seminars, case studies, etc.); collaboration objects (e.g., forums, chat, Elluminate/Collaborate, online meetings, etc.); practice objects (e.g., simulations, software, online labs, research projects, etc.); assessment/evaluation objects (e.g., partial evaluation, final certification, etc.)

Frist of all, we found that cross-cutting technologies are actively used in teacher training (Vaganova et al., 2021; Valeeva et al., 2022). For example, González-Martínez et al. (2019) designed, implemented and evaluated a 3D simulations laboratory for developing teacher digital competence. Secondly, we found that most educational resources in selected studies are based on web 2.0 technologies, in which practice objects are the most frequent learning objects. Among these studies, some of them focus on developing specific digital competence. For example, Starčič et al. (2016) introduced digital storytelling to an ICT course for student-teachers to serve mathematical problem-solving. Besides, in the study of Schina et al. (2020), Scratch was used for addressing teachers´ Sustainable Development Goals (SDGs) in education. However, in the study of Sáez-López et al. (2020), Scratch was used to develop computing thinking skills. In addition, six of these 18 studies explicitly mentioned that their educational resources were applied through an online learning format.

Table 58. Characteristics of educational resources.

Study	Educational resources	Learning objects	Duration	Theoretical dimensions	Modality
(Avci & Osman, 2021)	Educational software evaluation	assessment/evaluation objects	12 weeks	Appropriateness for the target audience, User control, Clear instructions, Appropriateness for the hardship level, Ease of use, Being motivational, Authenticity, Technical properties, Objectivity in terms of cultural differences	N/A
(Brevik et al., 2019)	Small Private Online Course (SPOC)	instructional objects	100 days	Resisting, Critsiting, Explicating, Envisioning, Committing to actions, Taking actions	online learning
(del Moral et al., 2016)	Digital storytelling	practice objects	N/A	Communicative competence (written communication, oral communication), Narrative competence, Digital competence	N/A
(Gómez-Trigueros, 2020)	Mobile devices and geolocation software	practice objects	N/A	Knowledge of Content (CK), Pedagogical Technological Knowledge (TPK), Technological Knowledge of Content (TCK), Pedagogical and Content Knowledge (PCK)	N/A
(González-Martínez et al., 2019)	3D virtual environment simulation	practice objects	N/A	Realism (R), Dramatism (DR), Challenge (CH)	N/A
(Gordillo et al., 2019)	MOOCs	practice objects	80 h	N/A	online learning

(Gordillo, Barra, Garaizar, et al., 2021)	Social Lab simulated social network	practice objects	30 h	N/A	online learning
(Gordillo, Barra, López-Pernas, et al., 2021)	Educational video games (the SGAME platform)	practice objects	N/A	N/A	online learning
(Guillén-Gámez et al., 2020)	2.0 applications	practice objects	N/A	the use of electronic devices in teaching practice, the use of 2.0 tools, the use of Learning Management System (LMS), the use of other 2.0 resources	N/A
(Kvale & Rambo, 2015)	Didactic blogging (WordPress)	collaboration objects	11 weeks	Subject competence, Didactic competence, Social competence, Adaptive and developmental competence, Professional ethics competence	N/A
(Paige et al., 2016)	Slowmation	assessment/evaluation objects	N/A	Ways of thinking (creativity and innovation, critical thinking/problem solving/decision making, learning to learn), Ways of working (communication, collaboration), Tools for working (information literacy, ICT literacy), living in the world (citizenship, life and career,	N/A

				personal and social responsibility including cultural awareness)	
(Pombo et al., 2017)	AGIRE project	practice objects	15+64 h	Parental involvement, Flipped classroom, Collaborative work & learning, Educational digital resources	face to face
(Ramírez-Montoya et al., 2017)	Open Educational Resources (OER)	practice objects	30 h	N/A	online learning
(Sáez-López et al., 2020)	Visual block programming (Scratch)	practice objects	20h	Results and computational concepts, the Visual Blocks Creative Computing Test (VBCCT) was used; Programming in educational contexts (Knowledge and mastery of the programming, Visual block programming in educational contexts, Active learning, Fun); Programming Applications and Current Needs	N/A
(Schina et al., 2020)	Educational robotics (Scratch)	practice objects	4h	Didactic, curricular, and methodological aspects; Planning, organization, and management of digital technological resources and spaces; Relational aspects, ethics, and security; Personal and professional aspects	N/A
(Starčič et al., 2016)	Digital storytelling	practice objects	N/A	Models of representation, Mathematical arithmetic problem story types, Context, Numerical data	face-to-face

(Tirado-Olivares et al., 2021)	IBL methodology and student response system (SRS) (Kahoot!)	assessment/evaluation objects	10h	N/A	N/A
(Tømte et al., 2015)	Online teacher education programs	instructional objects	100 days	The TPACK-framework	online learning

Note. N/A = No mentioned.

6.3.3.2. Challenges and strengths of instructional and training tools

After scrutinizing the reporting of the content of each article, we found that 18 of 50 studies (36%) related to the use of main instructional and training educational resources for K-12 teachers. Among the 18 articles concerning the use of educational tools for teacher training, 11 articles mentioned the challenges and strengths of these tools from an educational perspective. All the detail were concluded in Appendix 3 _Table 77. The challenges and strengths of training tools for pre-and in-service teachers are mainly embodied in knowledge gained, beliefs and attitudes toward using educational tools, and behaviors for implementing educational tools into their practice.

Concerning the strengths of instructional and training tools in the knowledge gained, Avci and Osman (2021) indicated that evaluating educational software increased their knowledge and professionality about evaluation skills. Paige et al. (2016) verified that *Slowmation* is an authentic tool that enhances pre-service teachers' scientific conceptual understanding. In terms of beliefs and attitudes, several studies highlighted that the implementation of instructional tools creates pedagogical advantages for pre-and in-service teachers that take advantage of the strength of interest and motivation through collaboration, communication, creativity, and feedback (Gordillo, Barra, López-Pernas, et al., 2021; Kvale & Rambo, 2015; Paige et al., 2016; Sáez-López et al., 2020; Tirado-Olivares et al., 2021). For example, Gordillo, Barra, López-Pernas, et al. (2021) and Tirado-Olivares et al. (2021) demonstrated that educational video games promote pre-service teachers' motivation and critical thinking. In the study of Kvale and Rambo (2015), pre-service teachers developed their collaborative activities, reflective thinking, and effective communication, as well as the benefit from community feedback, validation, and further development of ideas through didactic blogging. Besides, three studies demonstrated that these educational tools enhanced pre-and in-service teachers' behaviors in implementing educational tools into practice (Brevik et al., 2019; Pombo et al., 2017; Starčič et al., 2016). For example, Starčič et al. (2016) emphasized that in their study, digital storytelling as an educational tool facilitates pre-service teachers' engagement with transformative pedagogical work. Additionally, educational tools have more excellent prospects of convenience, efficacy, and economic advantage (González-Martínez et al., 2019; Tømte et al., 2015).

On the other hand, six studies referred to challenges in the use of educational resources (González-Martínez et al., 2019; Gordillo, Barra, López-Pernas, et al., 2021; Kvale & Rambo, 2015; Starčič et al., 2016; Tirado-Olivares et al., 2021; Tømte et al., 2015). These challenges were mainly related to teachers' pedagogical beliefs and attitudes about barriers to using ICT educational resources in practice and their perceived competence, which are closely linked to acquired competence in using technological tools in advanced education. For instance, in the study of Gordillo, Barra, López-Pernas, et al. (2021), pre-service teachers expressed that the videogame was hard to use and that it did not mainly motivate them to learn. Besides, limited resources of ICT materials, the limited number of teaching staff interested in digital competence, lack of awareness about using educational tools, and the lack of professional digital skills, etc. are challenges for the implementation of educational tools in teacher training programs (González-Martínez et al., 2019; Kvale & Rambo, 2015; Tømte et al., 2015). For example, Tømte et al. (2015) indicated that the lack of digital competence and the limitations of the current authoring tools conducted difficulties for pre-service teachers in creating content with a high level of accessibility, as well as educational resources with the ability to provide feedback and adapt to the student's behavior. The participants in the study of Avci and Osman (2021) perceived that software engineering technical methods for evaluation required them to be more knowledgeable and professional

6.3.4. Limitations and further research directions

After examining all selected articles, we found that 35 of 50 articles presented the limitations and/or further directions of research. We classified three types of limitations and further directions of research. All these results in detail can be found in Appendix 2 _Table 78.

Sample size (n=18) of research is the most common limitation presented in selected articles, followed by measures used to collect data (n=12), and, finally, formulation of objectives, and aims of the research (n=10). Other limitations, such as research design (n=4) and self-reported data (n=3), are also mentioned. Lack of prior research studies on the topic (n=1), cultural basis (n=1), and longitudinal effects (n=2) are the rest limitations detected in the selected articles. In terms of the types of further research directions, building on a particular finding or aspect of this research (n= 18) is the most frequent further research direction, followed by constructing the same research in a new context, location, and/or culture (n=9), addressing limitations of research (n=9), and expanding a theory (framework or model) (n=4).

6.4. Conclusion

This chapter aims to provide an overview of teacher training programs' work in higher education on preparing K-12 pre-and in-service teachers to use technology for teaching and learning.

There are five primary findings: Firstly, investigating the instructional effectiveness by evaluating the gains in the participants' knowledge of concepts and attitudes towards instructional training program is the leading research theme related to teacher training in digital competence. Pre-and in-service teachers' affective outcomes for their digital teaching competence have changed positively after teacher training, but their cognitive outcomes related to pedagogical knowledge and pedagogical content knowledge have less significant progress as well as their behavioral outcomes. Secondly, pre-and in-service teachers' positive attitudes towards digital technologies, collaboration with peers, continuous feedback, teacher educators as role models, reflection on the role of technology in education, learning instructional design with technology, and scaffolding of authentic technology experiences are factors affected behavioral outcomes of teachers' training in digital competence. Thirdly, though the current educational tools used improved the beliefs and attitudes of pre-and in-service teachers by engaging their interest and motivation to learn and use ICT tools in practice, there are existing challenges to implementing educational tools in teacher training programs. Fourthly, a quantitative study with a non-experimental design is the leading study design used, and pre-service teachers are the main study population for teacher training in digital competence. Lastly, sample size and building on a particular finding or aspect of this research are the main limitations and further research directions mentioned.

In closing, we acknowledge the limitations of our review. First, due to this research was limited by focusing on the teacher training activities which have been applied, our findings were drawn from a limited number of empirical studies. Second, as this study was limited to high-quality peer-reviewed journals in three major databases, not many articles met our requirements. Lastly, this review might have excluded relevant articles published before 2010 and relevant books or conference papers.

Chapter 7. Educational Program for Improving Teachers´ Digital Competence in China´s Context.

Tondeur et al. (2012) mentioned that in the field of teacher development of digital competence, the scholarship emphasizes technology-centric research such as technology-related issues, distance education, communication strategies, and instructional methods for research on cognitive-related topics and learning issues. However, this might be hindering the ability to have as much influence on proactively developing the systems, models, pedagogies, policies, and technologies that will improve learning in the 21st century.

In recent China, systems, pedagogies, policies, and technologies were paid attention to improve teacher development of digital competence. It is clear from the government's development planning documents that the digitalization of education in China will enter a phase of in-depth development from 2021 onwards. According to the Outline of the Fourteenth Five-Year Plan for National Economic and Social Development of the People's Republic of China and Vision 2035 (Ministry of Education of People´s Republic of China, 2021), promoting the digital transformation of education is a strategic requirement for achieving high-quality development of education in China during the period 2021-2035.

Digital education is currently seen as an inevitable choice to address education equity, improve education quality and support education evaluation reform in China. In particular, the China government has now proposed to focus on optimizing the digital infrastructure of schools at all levels and building diverse open educational resources systematically. Infrastructure optimization accelerates 5G coverage, artificial intelligence, big data centers, and the Internet of Things (IoT) and explores hybrid resource provisioning models by further expanding cloud coverage.

The 14th Five-Year Plan (2021) calls for the development of smart education, which integrate high-quality social curriculum resources into the public teaching system and promote online access to high-quality educational resources for disadvantaged schools in rural and remote areas. For example, the platform of Smart Education of China has been created and is now in service for citizens. On the other hand, scenario-based, experiential learning, as well as intelligently managed assessment systems, are also being developed because of government policy.

On the other side, enterprises are seen as an essential force in driving digital education to the ground and delivering results in the context of China:

- It is recommended that education information technology enterprises take the in-depth integration of technology and education teaching applications as their guide and strengthen technology integration and product innovation for diversified education application scenarios. At the same time, enterprises pay attention to the hotspots and pain points of education reform, which continuously improve their key technological innovation and supply capabilities by promoting large-scale application and iterative optimization.
- Such enterprises should drive their product development to user needs to effectively provide teachers, students, and administrators with the most suitable, stable, accurate, and convenient products and services.
- Enterprises should also focus on training and guidance for using various types of users to ensure application effectiveness.

Under these circumstances, a systematic educational program is needed in China to improve the digital competence of in-service and pre-service teachers. This response to the current trend in China to develop digital education as a policy and social context requirement.

7.1. Background

The SLRs of this study showed that previous studies in the China context had indicated that factors based on the technology acceptance model, such as perceived usefulness, perceived ease of use, convenience, effort expectancy, performance expectancy, etc., can influence teachers' digital competence. Besides, factors such as teachers' self-efficacy, digital skills, age, gender/sex, years of teaching experience, etc., and external factors like the educational system, training experience, and ICT application atmosphere affect teachers' digital competence.

On the other hand, the quantitative analysis showed that Chinese pre-service and in-service teachers have a good perception of digital consciousness and attitude (Chapter 5). However, their educational practice in technical support teaching and technical support learning factors is insufficient. Moreover, educational background, age, and years of teaching experience are three factors that can affect teachers' digital awareness and their digital teaching and learning to vary degrees. For in-service teachers, teachers with higher education have a higher level of digital competence in technical support teaching and learning aspects, especially in research and innovation, resource preparation, and process design. Then, younger in-service teachers have better digital competence levels in technical learning and teaching than older teachers, particularly in a technical environment, communication and collaboration, research, and innovation. Despite this, in-service teachers with less teaching experience also showed more technical skills in resource preparation, process design, and practice reserve. However, pre-service teachers' age was positively correlated with the perception of digital competence. Older pre-service teachers have a higher level of digital competence in consciousness and attitude, communication and collaboration, resource preparation, process design, and practice reserve.

As the place for digital education is implemented, China needs a different transformation of schools from previous digital upgrades. It is a systemic change of all elements and processes and will fundamentally impact the existing perceptions, working models, teaching, and management methods of schools. The digital transformation of schools is no longer centered on innovation in information technology but on the deep integration of information technology into teaching and learning, focusing on the practical application and innovation in the model. This digital transformation requires that schools at all levels have a complete assurance system to consolidate the digital infrastructure environment and accelerate the digital transformation of their campuses. Therefore, ICT administrative services and management, a digital atmosphere, and teacher evaluation systems are the three main focused areas.

In terms of ICT administrative services and management, schools at all levels should adapt their policies to accelerate the reform of ICT administrative services and management in schools to provide comprehensive IT services for students and teachers. Our study demonstrated that pre-service teachers do not perceive a better technical environment in the same way as in-service teachers. So, firstly schools at all levels must be uniform and have complete rules and regulations to ensure the implementation of ICT administrative services and management. Secondly, schools must have a clear ICT organization and operating mechanism. Thirdly, technical support needs a professional ICT team and standardized scientific and mandatory technical standards to ensure smooth practice. Fourthly, fund management needs stable funding and standardized fund management practices to provide continuous and stable operation and maintenance services. Finally, scientific and sound assessment standards and systems need to be established.

Regarding the digital atmosphere, firstly we would like to highlight the impact of principals´ ICT leadership, which is will be crucial to increasing awareness of digital campuses among students and teacher. Previous research (Keengwe et al., 2009; Lai & Pratt, 2004; Yuen et al., 2003) showed that the strategies adopted by schools in implementing ICT change and the resulting changes in teaching and learning practices using ICT were highly dependent on the vision and understanding of school leaders of the role and impact of ICT in the curriculum, their goals and objectives for ICT integration, and the history, culture, and context of the school and its overall vision and mission. Secondly, we would like to highlight the impact of strengthen network security. The data disaster-tolerant environment can be improved by establishing a classification system to grade protection norms. An intelligent operation and maintenance security system can be built to ensure network information security and infrastructure security, information system security, information terminal security, data security, and content security.

Concerning the evaluation systems for teachers, the findings of the SLRs demonstrated that performance expectancy could influence in-service teachers' use of ICT for teaching and learning. This finding of our SLRs is again confirmed by other studies on the digitization of Chinese teachers (Kim & Lee, 2020; Xu et al., 2021). Hence, we recommend reforming the current teacher assessment system to stimulate in-service teachers' performance expectancy. In this case, in-service teachers' ICT competence should first be included in the teacher assessment system. Though in our research, there is no one study investigating the relationship between pre-service teachers' technology behavioral intention and the factor of performance expectancy. Despite this, the studies of Mu et al. (2019) and Li et al. (2019) highlighted to construct of pre-service teachers' digital competence evaluation system. They encouraged pre-service teachers to apply what they have learned in practice and promote the integration of theory and practice. In that case, we propose including pre-service teachers' digital competence in their assessment system at the professional education stage rather than just constructing an assessment system for their digital competence.

7.2. Characteristics and needs of training program.

One finding of the SLRs demonstrated that pre-and in-service teachers are willing to change teaching methods. However, their ability to integrate technology with teaching and learning is weak. Pre-service teachers' willingness to optimize teaching and learning with ICT tools is also weak (Zhou et al., 2017). Moreover, our quantitative data analysis showed that current ICT training programs have not significantly impacted in-service teachers' digital competence. Pre-service teachers thought that current ICT training courses influence their consciousness, attitude, and technical environment, but it has not helped them in technical practice.

Chinese K-12 teachers have insufficient ability for technological teaching and learning in advance, and the effectiveness of current teacher training programs in digital competence is not significant. The findings of the SLRs show that teacher training is considered a critical intervention to improve the digital competence of K-12 teachers in China's context. It promotes training content, enhances teachers' motivation and thinking, and optimizes systematic evaluation criteria. These three main aspects of proposals should optimize the phase of teacher training in digital competence. Though these proposals are based on the results of previous empirical assessment studies, they have not been tested with pre-and in-service teachers, which particularly lack the longitudinal experimental study with pre-/post-test for proving the effectiveness of these proposals in China. Hence, we cannot profoundly figure out the reason for the insignificant effectiveness of teacher training due to the lack of previous studies of teacher training in the context of China. Moreover, we consider that the effectiveness of these proposals related to training in digital competence for Chinese teachers is still to be supported by solid evidence.

According to the results of both SLRs, motivating trainees' positive attitudes toward digital technologies is a crucial way of teacher training, which has been proved several times in different countries. Based on the technology acceptance model, factors such as teacher self-efficacy, perceived usefulness, perceived ease of use, convenience, effort expectancy, performance expectancy, etc., are mainly explored because they are closely related to trainees' positive attitudes toward digital technologies. Therefore, we give an overview of previous studies from the global perspective, finding crucial factors that affected behavioral outcomes of teacher training in digital competence. These factors are positive attitudes toward digital technologies, collaboration with peers, continuous feedback, teacher educators as role models, the reflection on the role of technology in education, learning instructional design with technology, and scaffolding of authentic technology experiences. Then, we primarily draw some clear strategies on excellence or best practice for teacher training integrated approach to improving Chinese teacher training on five aspects: teacher educators as a role models, scaffolding of authentic technology experiences, learning instructional design with technology, the reflection on the role of technology in education, the training modality.

Teacher educators as role model, including providing quality examples. Howard et al. (2021) indicated that Role Model is presented as having an association with Instructional Design and Reflection, and Reflection has an association with Instructional Design. Role Models support pre-service teachers' Reflection on Instructional Design. However, the relationships between these factors are bi-directional instead of unidirectional. Moreover, one of the attributes of the Role Model strategy is 'Providing Quality Examples'. The use of a range of quality examples presented concretely was important in pre-service teachers' experiences, which could be used as practical tools to support their developing designs. As Tondeur et al. (2012) mentioned, teacher educators improve trainees' initial knowledge about the design of ICT-enhanced learning activities and influence their learning about instructional design and preparation of materials with ICT during a placement in primary and secondary schools.

Additionally, there are studies related to investigate how the experiences and examples that prospective teachers receive from teacher educators during their training serve to shape their teacher identity. For example, Hernández-Ramos et al. (2021) explored the effectiveness of use of video tutorials in distance higher education. They indicated that after implementing video tutorials, pre-service teachers obtained a high level of acceptance of the resource for analyzing and reflecting on the contents, solving practical problems and organizing the study.

Scaffolding of authentic technology experiences. As Kvale and Rambo (2015) mentioned, if ICT is not connected to the content of the specific subject studies the pre-service is engaged in, the digital practice in teacher education cannot be adequately understood or improved. Mouza et al. (2014) thought the most effective method for improving teachers' use of technology is an integrated approach that combines educational technology courses with methodology courses and field placements.

Hence, preparing trainees to integrate technology in lesson plans and activities through the design of authentic tasks should be linked to the specific disciplinary research content in which trainees are engaged. These authentic experiences strategies are directly related to 'doing' and design, such as working with examples and thinking about design and designing, stimulating trainees to gain experience in-class practice.

Learning instructional design with technology. It is commonly believed that teachers' use of technological tools for instructional design in advanced way strongly depends on their previous knowledge and skills with technologies (Barak, 2010; Kumar & Daniel, 2016; Spiteri & Chang Rundgren, 2020). Moreover, previous studies indicated that the implementation of lessons incorporating technology be seen as additional planning and preparation for teachers because they had no prior knowledge of the design of such learning activities (Thompson et al., 2003). This opinion is similar to the findings of Chapter 3 and Chapter 5 that pre-and in-service teachers are highly aware of the use of ICT in planning and preparing teaching sessions and learning development. However, they cannot use ICT tools for teaching and learning practice.

Two studies (Wu et al., 2016; X. M. Zhang et al., 2019) assessed the effectiveness of teacher training for instructional design with Web 2.0-based technology in a systematic review of Chinese teachers' digital competence. They concluded that after teacher training, most teachers not only have a higher level of educational technology awareness and responsibility, but their knowledge and skills, teaching design, implementation and evaluation, and innovation with educational technology were also improved.

Chapter 6 shows that pre-and in-service teachers' affective outcomes for their digital teaching competence had changed positively after teacher training. Their cognitive outcomes related to pedagogical knowledge and content knowledge have less significant progress directly linked to how teachers organize and deliver knowledge in the classroom. It means that after training, pre-service and in-service teachers still lack advanced knowledge and confidence in using technological tools for complex educational practices such as designing, using, or reusing educational resources.

Therefore, more systematic efforts for teacher training are recommended. They are needed to engage pre-service and in-service teachers in technology-rich design activities related to pedagogical and content knowledge to adequately develop their technical teaching and learning ability in an advanced way.

The reflection on the role of technology in education. The Reflection on the role of technology in education requires the engagement of pre-service teachers and teacher educators in conversations about their attitudes regarding the role of technology. The role of technology should play in teaching and learning in teacher education programs, which discussion groups can conduct with other peers, observation and writing analyzes, and critiquing the teaching process (Tondeur et al., 2012).

In the context of China, teachers' online discussions with their peers in workshops be seen as an important way of Reflection on the role of technology in education and collaborating with peers to identify and analyze the relevance of issues. The ineffectiveness of a large proportion of discussions in the workshop has been proved by Li and Huang (2018) and Huang et al. (2016). For example, Li and Huang (2018) suggested that the facilitator's guidance is the most critical aspect of the online discussion, as the facilitator in the workshop needs to take specific measures to guide the online discussion process at different stages of the workshop. Moreover, the current teacher training program has not mentioned other formats of reflection on the role of technology in education, such as observation and writing analyze and critiquing the teaching process.

In this case, we recommend developing more reflection formats, such as creating didactic blogging for writing the analyzes and critiquing the teaching process (Kvale & Rambo, 2015).

The training modality. In the context of China, due to none of the studies focused on the training methods of pre-service teachers, we infer that face-to-face is the primary training method for pre-service teachers, as these individuals are primarily provided with education on-site. Nonetheless, online training is currently the mainstream training method for in-service teachers, and there is a lack of research on other training methods.

According to the findings of Chapter 6, although current online models are an effective way to train pre-service and in-service teachers in the primary use of technology, this modality still needs to be explored to develop professional digital competence in advanced digital skills. On the other hand, the findings of our research indicated that both Chinese pre-and in-service teachers have a basically good digital competence level, and they lack of advanced digital skills for teaching and learning. In this case, we proposed a face-to-face lecture for this training program, supplemented by video tutorials after class.

7.3. Target population.

This training program is designed for Chinese pre-and in-service teachers, including a general program with different modules. This program offers different modules that will be developed for pre-and in-service teachers according to their identified needs. In line with the results obtained in the SLRs and empirical studies, while some modules were designed for all participants, other modules were designed specifically for pre-service teachers and for in-service teachers, according to their different identified needs.

At the same time, the training process takes into account differences in sociodemographic characteristics of participants. For pre-and in-service teachers, age is mainly considered when dividing the participants along the development of the modules. Particularly, in-service teachers´ teaching subject, teaching grade, teaching experience, as well as position are considered.

7.4. The used framework for training program.

In Chapter 2, we indicated that the Chinese framework "Information Technology Application Ability Standards for Primary and Secondary School Teachers (Trial)" comes from UNESCO's Teacher ICT competency (2nd edition). Although the 3rd edition of the Teacher ICT competency of UNESCO appeared in 2018, the Chinese framework has not been adapted yet. Hence, as the current framework in China is from a long time ago, we believe it is outdated.

On the other side, the instrument we have applied to collect the data is based on several frameworks (the UNESCO framework, the EU framework, the US framework, and even the Chinese framework), which are primarily intended to measure the digital competence of pre-service teachers. In this case, we consider that using this instrument's factors for in-service teacher training may cause a bias.

Under these circumstances, we decided to use the 3rd edition of the UNESCO ICT Competency Framework for Teachers as the framework for this training.

The 3rd edition of UNESCO ICT Competency Framework for Teachers (ICT CFT competence Version 3) (UNESCO, 2018) is consulted as general teacher digital competence in this study. ICT CFT competence Version 3 guides the development of effective ICT in Education teacher training programs intended to contextualize local and national needs. It incorporates several cross-cutting principles considerations for teacher training: 2a. Knowledge Societies, 2b. Universal Design for Learning, and 2c. Inclusive education (persons with disabilities, gender equality, ability). Moreover, it also introduces references to the current innovations in relevant aspects: Open Educational Resources (OER), Social networks, Mobile technologies, The Internet of Things, Artificial Intelligence (AI), Virtual Reality (VR), and Augmented Reality (AR), Big Data, Coding, Ethics and privacy protection.

7.4.1. Competences

7.4.1.1. Transversal competences

Transversal competences (TC) are often considered to be not explicitly related to a particular job, task, academic discipline, or area of knowledge. However, it is a competence that can be used in various situations and work environments (UNESCO, 2019). The UPV/EHU University (Basque Country, Spain) proposed defining a Catalogue of transversal competences linked to employability in undergraduate and postgraduate degrees in the educational field. It promotes the development of transversal competences linked to employability in undergraduate and postgraduate degrees for all students (Iturrioz-Uranga et al., 2019). The function of this catalog is considered a contrasting document that can be used by those in charge of centers and education programs to continue to make progress in specifying their transversal competences and subsequently work on and assess them.

Thus, we include in this program the eight transversal competences proposed by Iturrioz-Uranga et al. (2019): Autonomy and Self-Regulation (TC1); Social Commitment (TC2); Communication and Multilingualism (TC3); Ethics and Professional Responsibility (TC4); Information Management and Digital Citizenship (TC5); Innovation and Entrepreneurship (TC 6); Critical Thinking (TC7); and Teamwork (TC8).

The competence of *Autonomy and Self-Regulation* (TC1) implies that people continue to learn in an autonomous and self-regulated manner in different contexts and transfer knowledge to new situations. It enables the person to be responsible, persevering, and self-critical.

The competence of *Social Commitment* (TC2) involves analyzing and assessing the social and environmental impact of technical solutions and professional practices and acting responsibly, ensuring and promoting respect for diverse cultural, linguistic, and gender identities, fundamental rights, and equal opportunities.

The competence of *Communication and Multilingualism* (TC3) involves understanding concepts and ideas and expressing them clearly, considering the gender perspective, within an inclusive, multicultural, and multilingual context.

The competence of *Ethics and Professional Responsibility* (TC4) refers to ethical and deontological conceptions and those related to intellectual integrity. It involves internalizing that professional practice.

The competence of *Information Management and Digital Citizenship* (TC5) involve access to analog and digital content and resources, secure storage, transformation according to needs, and shared use to contribute to developing scientific-technical knowledge and professional practice.

The competence of *Innovation and Entrepreneurship* (TC6) refers to the generation, transformation, and implementation of an idea, a procedure, or an attitude to respond satisfactorily to different needs.

The competence of *Critical Thinking* (TC7) is an intellectual and systematic process that requires the mobilization of various mental actions such as questioning, analysis, interpretation, synthesis, evaluation, and the issuance of reasoned judgments.

The competence of *Teamwork* (TC8) refers to the relationship and integration in a group, collaborating actively to achieve common objectives, exchanging information, assuming responsibilities and leadership roles, solving difficulties, and contributing to improvement and collaborative development.

7.4.1.2. General teacher digital competences

As we take The ICT CFT Version 3 as the training framework, we use its six issues as general teacher digital competence for this training program: GC1. Understanding ICT in Education Policy; GC2. Curriculum and Assessment; GC3. Pedagogy; GC4. Application of Digital Skills; GC5. Organization and Administration; and GC6. Teacher Professional Learning. The general teacher digital competences included in this program, with their own indicators of three different performance levels, are shown in Table 59.

Table 59. General teacher competences

General competences (GC)
GC1. Understanding ICT in Education Policy
I. Teachers can articulate how their classroom practices correspond to and support institutional and/or national policy.

II. Teachers apply policies in designing classroom practices that implement national policies and address high-priority problems.

III. Teachers can critique institutional and national education policies alike, suggest revisions, design improvements and speculate on the impact of these changes.

GC2. Curriculum and Assessment

I. Teachers can analyze curriculum standards and identify how ICT can be used pedagogically to support attainment of the standards.

II. Teachers can integrate ICT across subject content, teaching and assessment processes, and grade levels, and create a conducive ICT-enhanced learning environment where students, supported by ICT, demonstrate mastery of curriculum standards.

III. Teachers can determine how best to incorporate student-centred and collaborative learning to ensure mastery of multidisciplinary curriculum standards.

GC3. Pedagogy

I. Teachers can take appropriate ICT choices to support specific teaching and learning methodologies.

II. Teachers can design ICT-supported project- based learning activities and use ICT to facilitate students to create, implement and monitor project plans, and solve complex problems.

III. While determining learning parameters, teachers can encourage student self-management in student- centered and collaborative learning.

GC4. Application of Digital Skills

I. Teachers can identify the function of hardware components and common productivity software applications and be able to use them.

II. Teachers can blend varied digital tools and resources to create an integrated digital learning environment to support students' higher-order thinking and problem-solving skills.

III. Teachers can design knowledge communities and use digital tools to support pervasive learning.

GC5. Organization and Administration

I. Teachers can organize the physical environment to ensure technology supports different learning methodologies in an inclusive manner.
II. Teachers can use digital tools flexibly to facilitate collaborative learning, manage students and other learning partners, and administer the learning process.
III. Teachers can play a leadership role in devising a technology strategy for their school to turn it into a learning organization.

GC6. Teacher Professional Learning

I. Teachers can use ICT to support their professional development.
II. Teachers can use technology to interact with professional networks to support their own professional development.
III. Teachers can continually develop, experiment, coach, innovate, and share best practice to determine how the school can best be served by technology.

7.4.1.3. Specific teacher digital competences

Specific competences, derived from the above teachers´ general competences, are demonstrated in the next tables (Table 60, Table 61, Table 62, Table 63, Table 64, Table 65).

Table 60. GC1_Understanding ICT in Education Policy

GC1	Understanding ICT in Education Policy
GC1. I_a.	Identify how policy implementation is shaping classroom practice.
GC1. I_b.	Identify the principles of using ICT in education in a safe and accessible manner.

GC1. II_a.	Apply principles of ICT in Education as expressed in policy in their own teaching. Analyze what issues arise in implementing these principles and how these issues can be addressed.
GC1. III_a.	Design, implement and modify school-level education reform programs.
GC1. III_b.	Reflect on implications of reform policies and the potential impact of these.
GC1. III_c.	Suggest improvements to existing national education reform policies.

Table 61. GC2_Curriculum and Assessment

GC2	Curriculum and Assessment
GC2. I_a.	Match specific curriculum standards to particular software packages and computer applications and describe how these standards are supported by these applications.
GC2. I_b.	Search for and identify OER to support curriculum standards.
GC2. I_c.	Select ICT to support assessment strategies.
GC2. II_a.	Use ICT appropriately to achieve curriculum standards.
GC2. II_b.	Develop and apply knowledge- and performance-based rubrics to assess students' understanding of subject matter concepts, skills and processes.
GC2. II_c.	Harness ICT to support alternative assessment strategies, including portfolios, graphic organizers, review and reflection tools, and peer assessment.
GC2. II_d.	Adapt OER to support local contexts and curriculum standards.

GC2. III_a.	Analyze the curriculum standards to identify opportunities where students can master Knowledge Society skills and complex cognitive skills, considering learning styles, abilities and sociolinguistic skills.
GC2. III_b.	Guide students to make sound ICT choices and acquire the appropriate skills to search for, manage, analyze, evaluate, and use information relevant to the curriculum.
GC2. III_c.	Guide students to make appropriate ICT choices to achieve curriculum standards that support reasoning, planning, reflection, and knowledge building.
GC2. III_d.	Guide students to use ICT to achieve curriculum statements that support the development of communication and collaboration skills.
GC2. III_e.	Help students develop assessment strategies to test their own understanding of key subject matter and ICT skills, including peer assessment.

Table 62. GC3_Pedagogy

GC3	**Pedagogy**
GC3. I_a.	Choose appropriate ICT solutions in teaching to support students' acquisition of subject knowledge.
GC3. I_b.	Devise lesson plans that incorporate ICT-supported activities to support students' acquisition of subject knowledge.
GC3. I_c.	Use presentation software and digital resources to support instruction.
GC3. II_a.	Describe how ICT can support project-based learning.
GC3. II_b.	Identify a real-world problem to support project-based learning.
GC3. II_c.	Identify and evaluate resources that support project-based learning.

GC3. II_d.	Design learning activities to engage students in reasoning with, collaborating on, and solving real-world problems.
GC3. III_a.	Explicitly model their own reasoning, problem-solving and knowledge creation while teaching students.
GC3. III_b.	Design online materials and activities that engage students in collaborative, problem-solving research.
GC3. III_c.	Help students design project plans and activities that engage them in collaborative, problem-solving research, or artistic creation.
GC3. III_d.	Help students create digital media resources that support their learning and interaction with other audiences.
GC3. III_e.	Help students reflect on their own learning.

Table 63. GC4_Application of Digital Skills

GC 4	**Application of Digital Skills**
GC4. I_a.	Describe and demonstrate the use of common hardware.
GC4. I_b.	Create simple text documents using word processor software, create simple presentations, and create simple graphics.
GC4. I_c.	Create an e-mail account and use it in their daily activities.
GC4. I_d.	Navigate the Internet and use a search engine to find curriculum resources.
GC4. I_e.	Identify and evaluate educational software and web resources and match them to curriculum standards and students' needs.
GC4. I_f.	Use record-keeping software to keep student records.
GC4. I_g.	Identify and use drill-and-practice software to support learning.

GC4. I_h.	Use communication and collaboration technologies, including mobile technologies, and use social networks to communicate with the wider learning community.
GC4. I_i.	Understand the basic principles of cyber safety/security and media and information literacy.
GC4. I_j.	Troubleshoot ICT problems when technology fails, to ensure minimal disruption to lessons.
GC4. II_a.	Operate software packages that are appropriate to subject areas to encourage higher-order thinking in students.
GC4. II_b.	Evaluate the accuracy and usefulness of web resources and web-based tools in support of subject areas.
GC4. II_c.	Use authoring tools to design curriculum materials.
GC4. II_d.	Use school management software.
GC4. II_e.	Use digital communication tools to support student collaboration within and beyond the classroom.
GC4. II_f.	Use interlinked digital devices to establish a network comprising students and the teacher, allowing them to share digital resources and work collaboratively on lesson activities.
GC4. II_g.	Source and evaluate digital tools to support students with disabilities and sociolinguistic minorities and ensure gender equality in the delivery of education.
GC4. III_a.	Create an online learning environment to support pervasive learning.
GC4. III_b.	Use digital tools to support online collaboration between students and members of the knowledge community.

GC4. III_c.	Use digital tools to track and evaluate student contributions to learning in the knowledge community.
GC4. III_d.	Encourage students to develop their own digital tools to support learning.

Table 64. GC5_Organization and Administration

GC 5	**Organization and Administration**
GC5. I_a.	Organize students and ICT in a learning environment to support teaching and learning.
GC5. I_b.	Support small groups and individuals – including those of different abilities, ages, genders, and socio-cultural and linguistic backgrounds – to use digital devices in the classroom.
GC5. I_c.	Identify appropriate technologies, including mobile devices, and pair with corresponding social arrangements to support learning goals. Identify why challenges to ensuring access to technology are affected by factors such as gender and ability.
GC5. I_d.	Monitor and protect hardware and software in the school environment.
GC5. II_a.	Access, evaluate and disseminate digital resources to support student- centred learning activities and social interactions.
GC5. II_b.	Manage student project-based learning activities in a technology-enhanced environment.
GC5. II_c.	Access, evaluate, organize, and disseminate digital resources to support students with disabilities.
GC5. II_d.	Devise an ICT integration strategy for their subject/department.

GC5. II_e.	Set up digital communication mechanisms so that the school can disseminate information to the wider school community.
GC5. III_a.	Organize digital knowledge-building environments to enhance teaching and learning.
GC5. III_b.	Identify and set up digital planning tools to support organization and administration of schools.
GC5. III_c.	Devise a strategy to implement a school-wide technology integration plan.
GC5. III_d.	Foster a reciprocal flow of information between all school stakeholders via school communication channels.

Table 65. GC6_Teacher Professional Learning

GC 6	**Teacher Professional Learning**
GC6. I_a.	Develop professionally by acquiring ICT skills to improve productivity.
GC6. I_b.	Develop professionally within subject areas by using ICT to acquire subject resources and discover new teaching strategies.
GC6. I_c.	Identify and manage Internet conduct and safety issues.
GC6. I_d.	Model the principles of digital citizenship.
GC6. I_e.	Analyze and evaluate digital teaching resources.
GC6. II_a.	Use ICT networks to access and share resources that support professional development goals.
GC6. II_b.	Use ICT networks to access external experts and learning communities to support professional development goals.

GC6. II_c.	Use professional networks to access, analyze and evaluate professional learning opportunities.
GC6. III_a.	Support the process of implementing a vision of what their school might be like when ICT is implemented in the curriculum and classroom practices.
GC6. III_b.	Foster innovation by promoting continuous learning among colleagues.
GC6. III_c.	Continually evaluate and reflect on professional practice to promote innovation and improvement.
GC6. III_d.	Share and discuss best practices in teaching via professional communities.
GC6. III_e.	License and distribute their original teaching resources as OER.

7.5. Resources required.

Human resources and ICT materials are the primary resources required for training activities. Regarding human resources, tutors, content experts, and technologists are needed. The tutor oversees the entire training process, including the organization of content experts and educational technologists, to ensure the smooth running of the course. In terms of ICT materials, we need to guarantee the following:

- One computer per student for completing individual exercises.
- Interactive whiteboard or projector.
- A Learning Management System (LMS) such as Moodle for importing and exporting teacher's courseware, electronic materials needed in class, and students' classwork and homework.
- Different ICT tools: Image creation learning tools (e.g., Adobe Photoshop), Video creation tools (Foxit clip, 蜜蜂剪辑, 剪映, 会声会影, Adobe Premiere Pro), Game

creation learning tools (Scratch, Lego Mindstorms), Platform learning tools (e.g., 国家中小学智慧教育平台，中国大学 MOOC, 百度传课，网易公开课，学课在线), Note taking learning tools (e.g., 涂书笔记，印象笔记，有道云笔记), Time learning tools (e.g., 番茄时间，我要当学霸).

7.6. Training duration

As shows in Table 66, the whole training courses are formatted by five modules for pre-service teacher or in-service teachers. Each module consists of two to seven lessons, and each lesson lasts 90 minutes. If we did one 90-minute training session per week, the training would last for 7 months.

Table 66. Plan of the training course

Module	Target Group	Month						
		M1	M2	M3	M4	M5	M6	M7
One (2 lessons)	In-service							
Two (7 lessons)	Both							
Three (5 lessons)	Both							
Four (7 lessons)	In-service							
Five (6 lessons)	In-service							

7.7. Description of each training modules

The first and second modules are the foundation modules for cognitive and skills training in the integration of IT into education, which train capacitate teachers with low or intermediate level of digital competence to be effective and productive members of the school community. The third module is a bridging module between the first two modules and the last one, which trains teachers to organize and adjust the spatial placement of the classroom or lab to integrate ICT into the lesson to support different learning methodologies. The fourth module is designed for teachers with advanced digital competences, which integrates the competence of the previous three modules through designing ICT-supported project-based learning activities. The last module is a special module which only trains teachers at management levels to play a leadership role in devising a technology strategy for their school to turn it into a learning organization.

Module 1 _ Understanding ICT in Education Policy aims to make connections between policy and classroom for in-service teachers, and to inspire them to articulate how their classroom practices correspond to and support institutional and/or national policy. Hence, this module is designed primarily for all in-service teachers, who have experience in daily classroom practice.

Module 2 _ Application of Digital Skills is aimed to train teachers to use computers, mobile devices, accessible software, and networks for both teaching and learning and management purposes within a framework of 'safe use'. This module therefore is designed for the participants with a low or low intermediate level of digital competence. In our case, we use it to train all pre-service and in-service teachers with 0-5 years or 15+ years of teaching experience.

Module 3 _ Curriculum and Assessment is designed to give teachers a basic knowledge of the potential benefits of a range of relevant ICT resources and productivity tools. Then, they can incorporate relevant ICT resources and productivity tools into subject content, teaching and assessment process, and grade levels and create a conducive ICT-enhanced students, supported by ICT, demonstrate mastery of curriculum standards. This module blends with the competences of *Pedagogy I* that requires teachers to make appropriate ICT choices to support the integration of ICT in subject content, teaching, and assessment processes. This module is designed for all pre-service and in-service teachers with 0-5 years or 15+ years of teaching experience.

Module 4 _ Design ICT-supported project- based learning activities is aimed to improve teachers´ professional effectiveness in aspects of *Pedagogy, Application of Digital Skills, Curriculum and Assessment*. The goal of this module is to enable teachers to blend varied digital tools and resources to design ICT-supported project-based learning activities across subject content, teaching, and assessment processes. These ICT-supported project-based learning activities can facilitate students to create, implement and monitor project plans, and solve complex problem. This module requires participants with a medium or medium-high levels of digital competence. This module also encourages teachers to create knowledge societies for students, school colleagues and the community. Teachers' competences are required in determining how best to incorporate student-centered and collaborative learning to ensure mastery of multidisciplinary curriculum standards, while encourage student self-management. In our case, this module is designed primarily for in-service teachers with 6-15 years of teaching experience, and those with 0-5 and 15+ years of teaching experience who have completed Modules 2 and 3 of their training.

Module 5_ Organization and Administration is aimed at training teachers at management levels to play a leadership role in devising a technology strategy for their school to turn it into a learning organization, including the competences to critique institutional and national education policies alike, suggesting revisions, designing improvements, and speculate on the impact of these changes. These teachers with advanced digital competences can model good practices and encourage others, who are encouraged to create Knowledge Societies for students, school colleagues and the community. Hence this module is designed for staff at all management levels with advanced digital competences, such as headmaster, deputy headmaster, middle school leadership, scientific research team leader.

7.8. Training contents

As for the specific competences of the training program, the training contents were designed by referring to the competences and the example activities in the third edition of UNESCO ICT Competency Framework for Teachers (UNESCO, 2018). All training contents are presented in the following 5 tables: Table 67, Table 68, Table 69,

Table 70, Table 71.

Table 67. Modulo 1_Understanding ICT in Education Policy

Module 1	**Understanding ICT in Education Policy**			
Activities	**Competences**		**Training Process**	**Duration**
1º Lecture & Problem sets	TC7 TC1	GC1. I_a.	1) Trainers present current Chinese national policies related to ICT in education. 2) By asking questions of connection between national policies and trainees' classroom practices to kick off their self-reflection: ◊ How the national policies affect your common classroom practices? ◊ What educational practices you have done / will do to support policy? ◊ How do you evaluate your classroom practice (in terms of problem-solving, communication, collaboration, experimentation, critical thinking and creative experimentation, critical thinking, and creative expression)? Did your teaching practices contribute to policy implementation?	90 mins
2º Class discussions	TC7	GC1. I_b. GC1. II_a. GC6. III_a.	1) Identify the current implementation of the school ICT strategy. Showcase to peers and management the benefits of collecting and interpreting data using a school management system or other databases. 2) Discuss the benefits and drawbacks of using ICT in education (in terms of productivity, teaching methods, class administration and continuing professional development). 3) Discuss what issues arise when attempting to implement	90 mins

		national ICT in Education policy principles in a school setting.	

Table 68. Modulo 2_Application of Digital Skills

Module 2	**Application of Digital Skills**		
Activities	**Competences**	**Training Process**	**Duration**
1º Lecture & Classwork	TC5 GC4. I_b. GC6. I_a.	1) Trainers discuss the purpose of various software (e.g., for word processed, presentation, creating graphics, creating photos, creating videos, etc.) and demonstrate general features and functions. 2) Trainers demonstrate these commonly used tools for education. 3) Classwork 1: Teachers create graphics, photos, videos, a presentation, including a videogame for a specific tutorial topic.	90 mins
2º Lecture & Discussion	TC5 TC2 GC4. I_d. GC4. I_e. GC5. I_b.	1) Discuss the purpose and structure of the Internet and the World Wide Web. Use a browser to access popular educational websites using URLs to navigate the web. 2) Access appropriate digital resources and tools for specified learning objectives or curriculum standards for their teaching.	90 mins
3º Lecture & Discussion	TC5 TC8 GC4. I_g. GC6. I_a.	1) Trainers explain what computer drill-and-practice is, its applications, its benefits etc. 2) Trainers demonstrate how to use some common drill-and-practice programs, such as Flashcard activity websites (Quizlet, Study Blue, or Flashcard Machine), Branching Drills (Flashcard Deluxe). 3) Discuss and analyze the effectiveness of tutorial and drill-	90 mins

			and-practice packages in supporting the acquisition of specific subject matter knowledge, for learning objecting to increasing learners´ interest, motivation, critical thinking, and creation. Homework 2: Teacher choose two drill-and-practice programs to set up a practice for learners in specific subject matter knowledge.	
4º Lecture & Discussion	TC5	GC4. I_f. GC6. I_a.	1) Discuss the purposes and advantages of a digital record-keeping system. 2) Demonstrate the use of some digital record-keeping system to record, for example, marks, attendance, and merit points (Edmatix, Class365, ScholarSYS, etc.). Classwork 3: Participants practice the use of some digital record-keeping system to record.	90 mins
5º Lecture & Discussion	TC7 TC3	GC4. I_c. GC4. I_h. GC4. II_e. GC5. II_e. GC6. I_a.	1) Trainers demonstrate e-mail functionality on web and mobile device. Classwork 4: Participants create and use an e-mail account to send and reply to e- mail, including group e-mails. Attach digital documents to e-mail messages. 2) Trainers demonstrate the functionality of the common social networking apps, such as QQ, WeChat, Ding Talk, Tencent video. Using communication tools to bulk texting, group e-mails and the use of social media. Classwork 5: Participants design a strategize and use social networking apps for incorporating teachers, students, parents into a wide support group.	90 mins

6º Lecture & Discussion	TC5 TC8	GC4. II_e. GC4. II_f. GC6. I_a.	1) Trainers demonstrate how to use interactive white boards that share their content and resources with learners' devices and allow learners to volunteer information back to the white board. 2) Trainers demonstrate how to incorporate online word processors, interactive boards and live video feeds, and presentation packages and spreadsheets that allow multiple developers to work on the same document.	90 mins
7º Lecture & Discussion	TC4 TC7	GC4. I_i. GC4. I_j. GC5. I_d. GC6. I_c.	1) Demonstrate knowledge of good practices of cyber security and media and information literacy, with the objectives of ensuring safe use of social media and mobile devices: ◊ Have an awareness of information security and understand the security risks and appropriate handling of information technology applications. ◊ Respect intellectual property rights and always give clear and regular credit to the source of the material cited in their own output. ◊ Screen information on the internet, do not obtain information about others illegally and do not disseminate false, violent or other undesirable information. ◊ Know how to identify the origins and impact of viruses, scams, spam, cookies and pop-up adverts. ◊ Manage confidentiality of personal data and know what	90 mins

		to do when confronted with inappropriate content. 2) Discuss and develop appropriate strategies to deal with cyberbullying, teachers ensure appropriate behavior and actions when interacting with others online.	

Table 69. Modulo 3_ Curriculum and Assessment

Module 3	**Curriculum and Assessment**		
Activities	**Competence**	**Training process**	**Duration**
1º Lecture & Practice	TC5 GC2. I_a. TC3 GC2. II_a. TC8 GC3. I_a. GC6. I_b. GC6. II_a.	Trainers demonstrate how to identify some software packages, digital tools and resources that can support the attainment of specific curriculum standards. Classwork 6: Trainees work in small group according to specific teaching subject. Each group present at least one software package, one digital tool. Firstly, participants need to declare what are specific curriculum standards. Then, they need to declare how these tools supported the attainment of their specific curriculum standards, as well as describe how these standards are supported by these applications.	90 mins
2º Lecture & Discussion	TC5 GC2. I_b. TC2 GC2.II_d. TC3 GC3. I_c. TC7 GC4. II_b. GC4. II_g. GC6. I_b. GC6. I_e. GC6. II_a.	1) Trainers present common and specialized search engines search for OER. 2) Trainers present how to identify, assess and select digital resources for teaching and learning. 3) Discuss whether the resources are really useful in supporting the curriculum standards or are acting as a distraction and discuss whether the chosen educational digital resources support students	90 mins

			with disabilities and sociolinguistic minorities and ensure gender equality.	
3º Lecture & Practice	TC5 TC6	GC2. II_b. GC6. I_e.	Trainers demonstrate the principal rules for rubrics to assess students' understanding of subject matter concepts, skills and processes. Classwork 7: Participants design and create a rubric across that provides guidance in assessing student responses in the class.	90 mins
4º Lecture and Practice	TD5 TC6	GC2. I_c. GC2. II_c. GC6. I_e.	Trainers demonstrate how to use ICT to support alternative assessment strategies for students and demonstrate dedicated tools for different way of assessment. Such as portfolios, graphic organizers, review and reflection tools, and peer assessment. Classwork 8: Participants design and create an assessment strategy in addition to tests and examinations that uses alternative assessment methods through digital tools and platforms. Such as e-portfolio storage, and peer assessment platforms and learning styles.	90 mins
5º Lecture and Practice	TC5 TC6	GC.4. II_d. GC4. II_g. GC5. II_c. GC6. I_e.	Trainers demonstrate how to capture marks, generate reports, and keep attendance records using some school or project management software. Homework 9: Teachers generate, select, critically analyze and interpret digital evidence on learner activity, performance and progress through some digital record-keeping system.	90 mins

Table 70. Modulo 4_Design ICT-supported project- based learning activities

Module 4	**Design ICT-supported project- based learning activities**			
Activities	**Competences**		**Training process**	**Duration**
1º Lecture & Practice	TC2 TC6	GC3. II_a. GC5. II_a. GC5. II_d.	1) Trainers demonstrate some commonly used technologies for supporting project-based learning tasks for student research, group communication, and presentation of findings in different grades and subjects. 2) Participants consider how this teaching technology can be organized to better support teaching, learning and administration in your school? What are the technology gaps that are barriers to achieve the vision? And what staff skills need to improve to achieve this? *Commonly used technologies might be ICT supported tutorials and drill-and-practice exercises or ICT providing access to a collection of accessible, multilingual digital resources to be manipulated and reinterpreted. Using technology to provide students with a platform for interaction, such as a learning management system (LMS), social media or blogging. As well as the use of platforms that offer AI-enabled diagnostic tools such as an LMS, to provide statistics measuring learner engagement.	90 mins
2º Lecture & Discussion	TC7	GC3. II_b.	1) By giving examples of some authentic problems introduced by trainers, discuss characteristics of authentic problems that incorporate key concepts. 2) Participants discuss how to inspire their students to generate authentic examples.	90 mins

3º Discussion & Practice	TC6 TC7 TC8	GC3. II_c.	Trainers and participants discuss the key features of the materials that support deep understanding of students.	90 mins
4º Practice		GC3. I_b. GC3. II_a. GC3. II_b. GC3. II_c. GC3. II_d. GC5. II_b.	Homework 10: Design and present project-based learning that allow students to collaborate to identify solutions to a real-world problem, for example, a specific community challenge: ◊ Identify some technologies for supporting designed project-based learning tasks depend on students´ grade and subject. ◊ Select some online materials and make sure these materials support deep students´ understanding, such as offering alternative perspectives for the students to debate and research, or encouraging them discussion and access to outside expertise, or supporting them to collect and analyze big data appropriately to solve their particular problem.	90 mins
5º Practice	TC5 TC8	GC3. III_b. GC3. III_c. GC3. III_d. GC3. III_e	Help students design project plans and activities that engage them in collaborative, problem-solving research or artistic creation. ◊ Identify and alert students to media tools that might prove useful for their projects. ◊ Devise a set of activities that require students to create a series of infographics on curriculum topics for prior practice. ◊ Provide students with organizational skills for developing project plans with	90 mins

			activities, timelines, milestones and allocation of responsibilities for each project team member. ◊ Devise a set of milestone activities within a project that encourage students to reflect on their learning processes.	
6º Lecture and discussion	TC5 TC8	GC4. III_a. GC4. III_b. GC4. III_c.	1) Consider and discuss how to assemble and integrate a set of technologies we mentioned before to support student learning that can function outside the classroom. 2) Identify and set up digital tools that encourage collaboration. Such as online word processors, interactive boards and live video feeds, and presentation packages and spreadsheets that allow multiple developers video feeds, and presentation packages and spreadsheets that allow multiple developers wiki platform that allows multiple users to create websites. 3) Consider using platforms that offer AI-enabled diagnostic tools to track and evaluate student contributions to learning in the knowledge community, such as an LMS, to provide statistics measuring student engagement. Big data can enable insight into student interactions.	90 mins
7º Discussion & Reflection	TC6 TC7	GC4. III_d.	Discuss for encouraging student-developers to create their own code new hardware and software by using available hardware and software programs. ◊ How can we do as their guider? ◊ What kinds of digital skills we must require?	90 mins

Table 71. Modulo 5_Organization and Administration

Modulo 5	**Organization and Administration**			
Activities	**Competences**		**Training process**	**Duration**
1º Classwork and Discussion	TC8 TC7	GC1. III_a. GC1. III_b. GC1. III_c. GC6. III_a.	1) Classwork 11: Participants collaborate with their staffs to design a series of initiatives for implementing to bring the school in line with the national vision as articulated in ICT and education policies. 2) Classwork 12: Reflect and articulate in writing what needs to change for ICT and education policy directives to be carried out. What needs to happen to ensure compliance? What are the implications of doing this at school and national levels? 3) Critique national ICT and education policies and draft recommendations on how components of these might be updated and improved to fully exploit new developments in ICT and education.	90 mins
2º Lecture	TC5	GC5. III_a.	Experiment with and evaluate different knowledge-building technology options and determine the implications for the school in adopting each. Evaluate tools and platforms such as an LMS, social networking groups and collaborative writing platforms.	90 mins
3º Lecture	TC5	GC5. III_b.	Through evaluating school management software, determine their implications for the school, and thus the suitability in terms of cost, staff development and infrastructure needs.	90 mins
4º Lecture	TC1 TC5	GC5. III_c.	Lead or advise management in the development of a strategy to manage	90 mins

			school ICT according to following aspects: ◊ Auditing existing ICT equipment, projecting future ICT needs. ◊ Creating a maintenance strategy. ◊ Determining staff training requirements, and consider what support the wider community could provide, such as university, company. ◊ Consider can radio-frequency identification (RFID) or similar technology assist with monitoring hardware and access control? ◊ Consider developing an ICT budget.	
5º Lecture	TC2 TC5	GC5. III_d.	Evaluate school communication channels between stakeholders and enhance the mechanism to ensure information flows both to and from the school. These communication channels might be Online Parents conferences (Zoom, Skype, Tencent Meeting, etc.), phone calls, messaging groups (WeChat), E-mail, school website or social media platforms.	90 mins
6º Lecture and Discussion	TC1 TC5 TC6 TC8	GC6. III_b. GC6. III_c. GC6. III_d. GC6. III_e.	Participants play a leadership role in devising a technology strategy for their school to turn it into a learning organization, and continually encourage teachers to develop, experiment, coach, innovate, and share best practice. ◊ Identify the current implementation of your school ICT strategy, collect and analyze data to develop an ICT strategy. ◊ Devise and offer a series of professional development initiatives aimed at supporting teachers in the acquisition of skills	

	to exploit technology, with the aim of enhancing teaching and learning. ◊ Organize staff development initiatives where colleagues present innovative teaching strategies, they either intend to implement or have implemented, and encourage discussion and reflection. ◊ Encourage teachers to share exemplary teaching and learning resources – such as lesson plans, worksheets, lab notes and tests – with the wider education community by releasing these resources with an open license.

7.9. Assessment of training program

Each level of the framework UNESCO (2018) builds on skills and knowledge acquired in the previous level to allow teachers continual growth and development, from remembering and understanding to applying and analyzing and finally to evaluating and creating. In this case, we use formative and summative assessments to evaluate the training activities.

7.9.1. Formative assessment

The principles of formative assessment may be applied at the school and policy levels to identify areas for improvement and promote effective and constructive evaluation cultures throughout education systems (OECD, 2008). At the school level, formative assessment refers to tools that identify misconceptions, struggles, and learning gaps along the way and assess how to close those gaps. It includes practical tools for helping to shape learning and can even bolster students’ abilities to take ownership of their learning when they understand that the goal is to improve learning, not apply final marks. In this study, 12 exercises were conducted for the formative assessment. Based on the document OECD (2008), the critical elements of the practices of this research are:

a) Establishment of a classroom culture that encourages interaction and the use of ICT tools.

b) Establishment of learning goals and tracking of student progress toward those goals.

c) Use of varied instruction methods to meet diverse learner needs.

d) Use of varied approaches to assessing learner understanding.

e) Feedback on student performance and adaptation of instruction to meet identified needs.

f) Active involvement of learners in the learning process.

According to the study of Hamodi et al. (2015), the formative assessment has three key elements: media of assessment, assessment techniques and assessment instrument. As Table 72 shows, they classified the media, techniques, and instruments of formative assessment.

Media of assessment are the learner's productions to demonstrate what learners have learned throughout a given process in three different forms (written, oral and practical).

Assessment techniques are the strategies that teachers use to collect information about the productions and evidence created by learners (from the means). The techniques to be used are different depending on whether the learner participates in the assessment process. If the techniques are applied unilaterally by the teacher, one or the other should be used depending on the form of the media (written, oral or practical). For the written media, the technique of documentary and production analysis (or work review) should be used; for oral or practical media, observation, or analysis of a recording (audio or video) should be used. If the learner participates in the assessment process, the assessment techniques can be self-assessment, peer or co-assessment, and collaborative or shared assessment:

a) Self-assessment, which is the learner's assessment of their own evidence or output against pre-negotiated criteria. It can be carried out through self-reflection and/or documental analysis.

b) Peer assessment or co-assessment, whereby the learner assesses his/her classmates on a reciprocal basis, applying previously negotiated assessment criteria. It can be carried out by means of documental analysis and/or observation.

c) Collaborative or shared evaluation, which is carried out by the teacher with the student on the evaluation of the teaching-learning processes that have taken place. These dialogues can be individual, or group based. It can be carried out using individual or group interviews between teachers and students.

Assessment instruments are the tools that both teachers and learners use to record in an organized way the information collected through a particular assessment technique. It is a rigorous process for recording information from assessment techniques systematically and accurately.

Table 72. Medias, techniques, and instruments of formative assessment

Medias	**Writings**	- Folder or dossier, collaborative portfolio - Control (exam) - Notebook, field notebook - Questionnaire - Reflective diary, class diary	- Case studies - Essay - Quiz - Virtual forum - Memory - Monograph - Report	- Portfolio, e-portfolio - Poster - Project - Objective test - Review - Diagnostic test - Written work
	Oral	- Communication - Oral quiz - Debate, group dialogue	- Presentation - Group discussion - Round table	- Lecture - Class question - Oral presentation
	Practical	- Supervised practice	-Demonstration, performance, or representation	- Role-playing

Techniques	**Students do not intervene**	- Documental analysis and analysis of productions (revision of personal and group work). - Observation, direct observation of the learner, observation of the group, systematic observation, analysis of audio or video recordings.		
	The students participate	- Self-assessment (through self-reflection and/or documental analysis). - Peer assessment (through documental analysis and/or observation). - Shared or collaborative assessment (through individual or group interview between teacher and learners).		
Instruments		- Teacher's diary - Checklist scale check scale - Differential scale semantic - Verbal or numerical scale - Descriptive scale or rubric	- Estimation scale - Observation sheet - Checklist - Decision matrixes - Monitoring sheets individual or group	- Self-assessment sheets - Peer evaluation sheets - Expert report - Self-evaluation report

Source: Hamodi et al. (2015)

Classwork 1_Teachers need to create a curriculum for specific tutorial topic in a presentation with graphics, photos, videos, including a videogame.

Media for assessment: presentation.

Assessment techniques: observation sheet.

Assessment instrument/s: checklist.

Evaluation standards:

Grade	**Criteria description**

Level A_60-70	Teachers create and modify digital presentation using simple graphics, photos, and videos for one specific tutorial topic.
Level C_ 70-80	- Teachers create and modify digital presentation using simple graphics, photos, and videos for one specific tutorial topic. - Teachers create and modify digital presentation integrating some animations, links, multimedia, or interactive elements.
Level B_ 80-90	- Teachers make some basic modifications (e.g., editing or deleting parts, adapting the general settings) to the digital resources (graphics, photos, videos, videogames) for fitting them to the learning context. - Teachers addressed a specific teaching objective when selecting, modifying, combining, and creating digital resources.
Level A_ 90+	- Teachers integrate a range of interactive elements and games into students-created instructional resources. - Teachers modify and combine existing resources to create learning activities that are tailored to a concrete learning context and objective, and to the characteristics of the learner group. - Teachers understand different licenses attributed to digital resources and know the permissions granted to themself as regards modifying resources.

Homework 2 _Teachers use drill-and-practice programs to set up a practice for learners in specific subject matter knowledge.

Media for assessment: project.

Assessment techniques: analysis of productions.

Assessment instrument/s: observation sheet.

Evaluation standards:

Grade	Criteria description
Level A_60-70 Level C_ 70-80	- Teachers demonstrate the ability of using two different drill-and-practice programs to provide them with timely feedback on learners' progress. - Teachers addressed a specific subject matter knowledge when design a drill-and-practice for learners.
Level B_ 80-90	Teachers demonstrate the ability of using the data analysis tools provided by the digital environments to monitor and visualize activity.
Level A_ 90+	Teachers can interpret the data and evidence available to better understand individual learners' needs for support.

Classwork 3_Participants use digital record-keeping systems to record.

Media for assessment: project.

Assessment techniques: analysis of productions.

Assessment instrument/s: observation.

Evaluation standards: Teachers use two different digital record systems for recording students' marks or attendance, or merit points.

Classwork 4_Participants create and use an e-mail account to send and reply to e-mail, including group e-mails. Attach digital documents to e-mail messages.

Media for assessment: demonstration.

Assessment techniques: peer assessment, student self-assessment.

Assessment instrument/s: checklist

Evaluation standards:

- Teachers share educational content via e-mail attachments or through links.

- Teachers send and reply to group e-mails.
- Teachers were aware that some resources distributed on the Internet are copyrighted.

Classwork 5_Participants work in groups (with 3 -4 people) demonstrating how to design a strategy and use social networking apps for incorporating teachers, students, parents into a wide support group.

Media for assessment: posters

Assessment techniques: peer assessment

Assessment instrument/s: observation

Evaluation standards:

- Three ideas or issues from what was presented in this poster.
- Two example or uses for how the ideas could be implemented.
- One unresolved area / muddiest point.

Classwork 6_Participants work in a group (with 2-3 people) to design a curriculum according to specific teaching subject.

Media for assessment: project.

Assessment techniques: *analysis of productions*.

Assessment instrument/s: checklist.

Evaluation standards:

- Teachers need to declare what are specific curriculum standards.
- Teachers need to declare how these tools supported the attainment of their specific curriculum standards, as well as describe how these standards are supported by these applications.
- Each work is presented at least with one software package and one digital tool.

Classwork 7_Participants design and create a rubric across that provides guidance in assessing student responses in the class.

Media for assessment: project.

Assessment techniques: observation.

Assessment instrument/s: checklist.

Evaluation standards:

- Teachers use digital technologies to create assessment tasks which are then administered in paper-format.
- Teachers use one of digital technologies (word processor, spreadsheet, or online rubric tool) for students' use of digital technologies in support of assignments.
- The rubric across at least four levels of sophistication.

Classwork 8_Participants design and create an assessment strategy in addition to tests and examinations that uses alternative assessment methods through digital tools and platforms. Such as e-portfolio storage, and peer assessment platforms and learning styles.

Media for assessment: portfolios.

Assessment techniques: observation.

Assessment instrument/s: descriptive scale.

Evaluation standards:

Grades	**Criteria description**
Level A_60-70	Teachers use some existing digital technologies for formative or summative assessment.
Level C_ 70-80	- Teachers demonstrated the ability of adapting digital assessment tools to support their specific assessment goal, e.g., create a test using a digital test system.

	- Teachers use a range of e-assessment software, tools, and approaches for formative assessment with specific assessment goal for learners´ use in or after school.
Level B_ 80-90	- Teachers can select one most adequately captures the nature of the learning outcome to be assessed between different assessment formats. - Teachers design valid and reliable digital assessments.
Level A_ 90+	- Teachers use a variety of digital and non-digital assessment formats, aligned with content and technology standards, and am aware of their benefits and drawbacks. - Teachers develop new digital formats for assessment, which reflect innovative pedagogic approaches and allow for the assessment of transversal skills.

Homework 9_Teachers generate, select, critically analyze, and interpret digital evidence on learner activity, performance and progress through some digital record-keeping system.

Media for assessment: project.

Assessment techniques: analysis of productions.

Assessment instrument/s: descriptive scale.

Evaluation standards:

Grades	**Criteria description**
Level A_60-70	- Teachers evaluate administrative data (e.g., attendance) and data on student performance (e.g. grades) for individual feedback and targeted interventions.

	- Teachers use digital technologies to compile an overview on learners' progress, which they use as a basis for offering feedback and advice.
Level C_ 70-80	- Teachers evaluate the data resulting from digital assessments to inform learning and teaching. - Teachers use digital technology to grade and give feedback on electronically submitted assignments. - Teachers help students and/or parents to access information on learners' performance, using digital technologies.
Level B_ 80-90	- Teachers adapt their teaching and assessment practices, based on the data generated by the digital technologies they use. - Teachers provide personal feedback and offer differentiated support to learners, based on the data generated by the digital technologies used. - Teachers use digital technologies to enable learners and parents to remain updated on progress and make informed choices on future learning priorities, optional subjects, or future studies.
Level A_ 90+	- Teachers continuously monitor digital activity and regularly reflect on digitally recorded learner data to timely identify and react upon critical behavior and individual problems. - Teachers evaluate and synthesize the data generated by the various digital technologies they use to reflect on the effectiveness and suitability of different teaching strategies and learning activities for certain learner groups.

Homework 10_Participants design and present project-based learning project that allow students to collaborate to identify solutions to a real-world problem, for example, a specific community challenge:

Media for assessment: project.

Assessment techniques: peer assessment.

Assessment instrument/s: peer assessment sheet

Evaluation standards:

Grades	Criteria description
Level A_60-70	- Teachers select and use some learning activities to support differentiation and personalization of learners by providing activities at different levels and speeds. - Teachers use digital technologies to visualize and explain some new concepts of project-based learning activities in a motivating and engaging way.
Level C_ 70-80	- Teachers put learners' active use of digital technologies for supporting designed project-based learning at the center of the instructional process. - Teachers choose the most appropriate tool for fostering learner active engagement in each learning context or for a specific learning objective. Such as for offering alternative perspectives for the students to debate and research, or encouraging them discussion and access to outside expertise, or supporting them to collect and analyze big data appropriately to solve their particular problem.
Level B_ 80-90	- Teachers use a range of different digital technologies for designing learning and assessment activities, which they adapt and adjust to account for different needs, levels, speeds, and preferences. - Teachers use a range of digital technologies to create a relevant, rich, and effective digital learning environment for project-based learning activities, e.g., by addressing different sensory channels,

		learning styles and strategies, by methodologically varying activity types and group compositions.
Level A_ 90+	-	Teachers select, design, employ and orchestrate the use of digital technologies within the learning process according to their potential for fostering learners' active, creative, and critical engagement with the subject matter.
	-	Teachers reflect on how suitable the different digital technologies they use are in increasing learners' active learning and adapt my strategies and choices accordingly.

Classwork 11_Participants collaborate with their staffs to design a series of initiatives for implementing to bring the school in line with the national vision as articulated in ICT and education policies.

Media for assessment: project.

Assessment techniques: shared or collaborative assessment.

Assessment instrument/s: checklist.

Evaluation standards:

- Building digital environments.
- Assessment strategies for teachers´ performance.
- Teachers´ professional development.

Classwork 12_Participants reflect and articulate in writing what needs to change for ICT and education policy directives to be carried out.

Media for assessment: essay.

Assessment techniques: peer assessment.

Assessment instrument/s: checklist.

Evaluation standards: It needs to focus on two aspects: what needs to happen to ensure compliance? What are the implications of doing this at school and national levels?

7.9.2. Summative assessment

With the development of the program, the teacher will obtain a numerical grade [0-100 points] in the final course, which is formatted by three parts of grade: the attendance rate, the classroom performance, and the classwork and homework. In the whole course, the attendance rate occupied 20 %, the classroom performance is 20 %, and the classwork and homework are 60 %.

For the attendance rate, if the attendance rate does not fulfill 80%, the trainees cannot get this part of a grade. In respect of the classroom performance of trainees, it will be observed and noted by trainers in each class (calculated method: average grades of all attend class* 20%). In terms of the exercise part, only when each exercise gets a PASS mark can the grade of this part be counted into the final course (calculated method: average grades of 12 exercises* 60%).

Moreover, we have established that the teacher must fulfill 60 points to obtain a PASS mark, 70-79 points for a SATISFACTORY mark, 80-89 points for a GOOD mark, and 90-100 points for an EXCELLENT mark.

7.10. Conclusions

The chapter 7 mainly focused on the implementation of educational program with the aim of improving teachers´ digital competence. Firstly, the characteristics and needs of training program were described. Several crucial factors have positive attitudes toward digital technologies. In this chapter we primarily draw some clear strategies on excellence or best practice for teacher training integrated approach to improving Chinese teacher training on five aspects: (1) teacher educators as a role models; (2) scaffolding of authentic technology experiences; (3) learning instructional design with technology; (4) the reflection on the role of technology in education; and (5) the training modality.

Secondly, the target training population, the resources required, as well as the used framework for training program were declared clearly. This training program is designed for Chinese pre-and in-service teachers depended on their differences of sociodemographic characteristics. Moreover, the 3rd edition of UNESCO ICT Competency Framework for Teachers (UNESCO, 2018) was selected as the used framework.

Then, the training duration and the description of five training modules were presented. According to the plan of training program, this training process will last almost seven months. In this training program, the first and second modules are the foundation modules for cognitive and skills training in the integration of IT into education. The third module is a bridging module between the first two modules and the latter one and the fourth module is designed for teachers with advanced digital competences. The last module trains in-service teachers at management levels to play a leadership role in devising a technology strategy for their school to turn it into a learning organization.

Lastly, the formative assessment with 12 practices were presented, and summative assessment. In terms of formative assessment, the media for assessment, assessment techniques, assessment instrument/s, as well as evaluation standards of each activity were described.

Chapter 8. Discussion and Conclusion

As the last chapter of the thesis, this section consisted of three parts. Firstly, this chapter discuss the research findings based on the quantitative analysis. Then, a summary of the whole research work is presented. Finally, the limitations of the research, and lines of research that can be developed from this work are presented.

8.1. Discussion

The focus of this study was not just measuring pre-service and in-service teachers' digital competence level but also an exploration of influencing sociodemographic factors on their perceptions of digital competence in China, which focuses on a group of samples in Anhui province. This sample can reflect the basic level of Chinese teachers' digital competence. An instrument designed by Yan et al. (2018) that was validated for Chinese pre-service teachers has been applied in this study. In this part we will discuss the general levels of self-perceived digital competence for pre-and in-service teachers and the factors influencing those levels.

8.1.1. Level of digital competence for pre-and in-service teachers

Firstly, the descriptive results of this study demonstrated that both pre-service and in-service teachers have a good perception of digital competence in the areas of basic technology literacy, technical support learning, and technical support teaching. This finding is in line with the results in studies of Chen et al. (2019), Galindo-Domínguez and Bezanilla (2021) and Valtonen et al. (2021), which respectively demonstrated a similar result: Chinese pre-and in-service teachers have good perception of digital competence.

Secondly, Chinese pre-service and in-service teachers showed that they have good consciousness and attitude towards using IT for their daily work-life, in which their information ethics and security awareness were quite good. These results were in line with the findings of the earlier studies in the context of China (Chen, Zhou, & Wu, 2020; Li et al., 2019; Ma et al., 2019a), but is opposite to the results of Chen, Zhou, Wang, et al. (2020) regarding information security cognition and solving skills. We conjecture that this highly variable finding may be due to the specificity of the sample population, which Chen, Zhou, Wang, et al. (2020) was concentrated in one of the different eastern provinces.

Thirdly, this study also suggested that Chinese pre-and in-service teacher’s technical support practice is not strong in the teaching and learning aspects, which replicate the findings of earlier studies in other countries (Charbonneau-Gowdy, 2015; Munyengabe et al., 2017; Ogodo et al., 2021; Valtonen et al., 2015; Wikan & Molster, 2011). Particularly, both pre- service and in-service teachers´ level of technical support teaching is higher than technical support learning.

On the other hand, this study found that in-service teacher´s perception of digital competence is higher than pre-service teachers in three areas (Basic Technology Literacy, Technical Support Learning, Technical Support Teaching). This phenomenon can be explained by Chen et al. (2019), who suggested that increasing the frequency of ICT use would probably enhance teachers’ digital competence. Specially, in-service teachers show a significantly higher level than pre-service teachers in the dimensions of consciousness and attitude, and technical environment.

In summary, the statistical results of level of digital competence of pre-and in-service teachers proved the governmental achievements in informatization construction for K-12 education. For pre-service teachers, although current university ICT course significantly predicted pre-service teachers' perception, it did not affect their educational practice. This is consistent with the findings of Escudero et al. (2019), who identified that pre-service teachers have a basic level in the areas studied as well as at the beginning and end of their Education. For in-service teachers, we indicated that the frequent professional practice may promote them to reflect on attitudes regarding technological education to aid them in adjusting their digital competence, skills, and knowledge for technical teaching requirements.

8.1.2. Relation between teachers’ digital competence and contextual factors

In the factor Basic Technological Literacy, the three dimensions (FA1 awareness and attitude, FA2 technological environment, and FA3 information ethics and information security) are mutually reinforcing and influencing each other. In the same way, FB1 Self-learning, FB2 Communication and collaboration, and FB3 Research and innovation are three dimensions that mutually reinforcing and influencing each other in the factor of Technical Support Learning. FC1 Resource preparation, FC2 Process design and FC3 Practice reserve mutually reinforcing and influencing each other in the factor of Technical Support Teaching. This mutual correlation is also observed among the three factors. These mean that each dimension and factor influences each other and is not independent of each other.

Moreover, other factors influencing pre-and in-service teacher´s digital competence has been investigated, such as sex, age, teaching experience of in-service teachers, educational background, or available ICT resources.

8.1.2.1. Sex

This study confirms the findings of previous studies, which indicate that sex as a sociodemographic factor has no impact on in-service teachers' perception of digital competence nor on pre-service teachers' (Cabero Almenara, 2017; Tondeur et al., 2018). However, this finding is opposed to the results of Guillén-Gámez et al. (2021) by following the order established in the various steps of the regression models, indicating that the variable of gender affect the level of PDC.

8.1.2.2. Age and Teaching experience

For pre-service teachers, age affects their perception of digital competence, but there have no significant differences between their perception of digital competence and gender/educational background. The relation between age and digital competence level for pre-service indicates that older teachers have a higher perception of digital competence than younger teachers in all three factors.

For in-service teachers, this study finds that comparing with older, younger teachers have a higher self-perceived digital competence level in terms of technical support learning. This result is similar to Barahona et al. (2020) and Li, Liao, et al. (2016) mentioned, in-service teachers' age significantly impacts their level of digital competence. This suggests that younger teachers generally have a higher self-perceived digital competence than elderly teachers.

However, a recent study of Nieto-Isidro et al. (2022) indicated that while younger pre-service and in-service teachers perceive themselves as more digitally competent in both technical proficiency and teaching use of technologies than older teachers, when scales of actual knowledge or level are applied, older teachers have similar levels of technical proficiency and higher levels of teaching use skills. This finding disproves the existence of a "generational" effect according to which younger teachers have a higher level of information literacy.

On the other hand, this study indicates that in-service teachers with less teaching experience possess higher digital competence levels, which has contrast findings from HIinojo-Lucana et al. (2019) and Pozo Sánchez et al. (2020). Specially, Lucas et al. (2021) through the multiple linear regression approach revealed that the teaching experience as an influencing factor loses its statistical significance. In this case, we assume that such a difference between the results of these two studies and those of the present study may be due to the specific characteristics of the population sample investigated, which consisted of Spanish teachers rather than Chinese teachers.

8.1.2.3. Educational background

Previous study of Zhao et al. (2021) found that Chinese in-service teachers with higher educational background have better self-perception of level of digital competence, which is in the line with the result of this study: teachers with higher education degree levels have a better levels of digital competence in technical support learning and teaching aspects. Additionally, several studies from different countries also proved this finding, for example, Portillo et al. (2020) indicated that teachers have the lower technological competence at lower educational levels. This implies that people with higher education may be more willing to learn and use ICT to service their professional practice.

8.1.2.4. Available resources for in-service teachers

This study demonstrated that whether in-service teachers have the available laptop or tablet can influence their level of digital competence in research and innovation, and whether they have the available smartboard interactive as classroom equipment can influence their level of digital competence in process design. In addition, this study indicated that the available project of school has a significant impact on the level of digital competence of in-service teachers in terms of technical environment, research and innovation, and resource preparation.

8.1.2.5. ICT training courses

Ministry of Education of People´s Republic of China (2019c) promotes the development of teacher IT ability training in various regions through demonstration projects. Each in-service teacher should receive more than 50 hours for 5 years, of which at least 50% should be practical application hours. Moreover, a series of governmental document has been issued with the objectives of improving teacher´s digital competence level, such as Guidance from the Ministry of Education on strengthening the application of the "three classrooms" (Ministry of Education of People´s Republic of China, 2020a), Guide for Online Training of Kindergarten Teachers in Primary and Secondary Schools (Ministry of Education of People´s Republic of China, 2020b).

Previous studies in different countries indicated that pre-service teacher's ICT training has a significant impact on their future ICT use for learning processes and strengthen their instructional practice (Al-Abdullatif, 2019; Aslan & Zhu, 2016; Cabello et al., 2020; Valtonen et al., 2021). For instance, Tondeur et al. (2018) suggest that the self-perception of pre-service teachers' digital competence has a significant impact on their future pupils' ICT use. Since digital competence for teaching is being a powerful skill for any education professional, Chinese universities commit to planning, designing, and evaluating digital competence throughout degrees.

Current Chinese teachers' digital competence training is learning from Western countries, a series of reform-minded teaching practice has been applied. Similar to the findings of Li, Wu, et al. (2016a), this study relevant that based on the influential policy recommendation documents, the current ICT training programs have no impact on pre- and in-service teachers' digital competence. This indicated that the reform-minded teaching practice that mentors developed does not necessarily guarantee the effective mentoring to support teacher´s IT learning and teaching reform. Therefore, further training (higher education or ICT training course) should be guided to make the most of digital tools in their professional practice. As well as Wang (2001) relevant idea of collaboration in teaching and planning of teaching, teacher educators should pay attention to the influences of digital instructional contexts on mentoring and the kinds of learning opportunities that mentoring creates for teachers in different digital contexts. When designing mentoring programs and arranging mentoring relationships, teacher educators need to consider how to restructure school contexts and help teachers learn how to instruct students.

8.2. Conclusion

As far as the development of digital education is concerned, China has introduced many supportive policies and given financial support to develop the hardware facilities of schools. Until 2020, China has achieved full coverage of Internet infrastructure. Rapid technological developments and changes put great demands on teachers' digital competence, and teachers are the key to the digital transformation of education, especially the digital competence of pre-service teachers. Hence, digital competence is formally integrated into pre-service teachers' curricula in China, which requires training teachers to adopt the new digital technologies for teaching, educational management, and professional learning.

In this section, we will draw some conclusions about the objectives proposed in the research, demonstrating that they have been achieved. The descriptions of the development of teachers' digital competence in the context of China (Chapter 3) and their quantitative data analysis (Chapter 5) are sufficiently eloquent not to fall into the repetitive temptation of showing some of the results obtained. In any case, it is worth reviewing how our research has met our objectives.

- **Identify frameworks related to digital competence and its key components for teachers in China, with particular attention to the Anhui region.**

Six main digital competence frameworks were identified in Chapter 2: Information technology application competency standards for primary and secondary school teachers (China), a series of DigComp frameworks, the International Society for Technology in Education (ISTE Standards), UNESCO ICT competency framework for teachers, Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2 of the SDGs and TPACK framework.

After reviewing the indicators defined in each framework, we found that each has its own indicators, and it took work to compare them. However, information and communication, content generation, well-being, and problem-solving are all around. In this indicator analysis process, we found that Information technology application competency standards for primary and secondary school teachers (China) is designed based on the UNESCO ICT competency framework for teachers (Version 2.0).

We also analyzed the indicators of Information technology application competency standards for primary and secondary school teachers at the level of Anhui province. The design of this regional framework for teachers' digital competence is based on the national framework, but its indicators that have been designed are confusing and illogical. In this case, we decided to abandon this regional framework and consider using mainly the national framework.

- **Determine the digital competence level of K-12 pre-service teachers and in-service teachers in Anhui province.**

According to the findings of the research (Chapter 5), pre-service and in-service teachers from Anhui province have an excellent perception of digital consciousness and attitude, particularly regarding information ethics and security awareness. However, pre-service and in-service teachers believed their educational practice in technical support teaching and technical support learning parts needs improvement. Besides, in-service teachers demonstrated a higher perception of digital competence in three areas than pre-service teachers.

On the other hand, the quantitative research found that several factors (e.g., educational background, age, years of teaching experience, ICT training courses, etc.) influence pre-service or in-service teachers' perception of digital competence. First, in-service teachers with higher education have a higher perception of digital competence, particularly in technical support teaching and technical support learning areas. Then, in-service teachers' age and years of teaching experience were negatively correlated with the perception of digital competence. However, pre-service teachers' age was positively correlated with the perception of digital competence. Therefore, this thesis indicated that age is a more decisive factor influencing the level of digital competence of pre-service and in-service teachers.

- **Design a training course for Chinese pre-service and in-service teachers to improve their digital competence level.**

Before designing the training course for Chinese pre-service and in-service teachers, we conducted an SLR of empirical studies related to the implementation of teacher training programs to find theoretical support for pre-service and in-service teachers (Chapter 6). The findings of this chapter emphasize serval protective factors that can affect behavioral outcomes of teachers' training in digital competence, such as collaboration with peers, continuous feedback, teacher educators as role models, reflection on the role of technology in education, learning instructional design with technology, and scaffolding of authentic technology experiences.

Based on the findings of the theoretical and empirical support from the Chapter 2, 3, 5 and 6, we finally design a training course for improving pre-service and in-service teachers' digital competence. Firstly, the 3rd edition of UNESCO ICT Competency Framework for Teachers (UNESCO, 2018) was selected as the framework for the training program with five modules. Then, this training process will last almost seven months, covering three main training parts: the foundation and the middle module for cognitive and skills training in the integration of ICT into education, advanced module to encourage teachers to use ICT to guide students in collaborative learning and real-world problem solving, management module to encourage in-service teachers to play a leadership role in devising a technology strategy for their school to turn it into a learning organization. Lastly, formative assessment and the summative assessment were presented for assessing participants learning outcome form this training program.

The present study makes contribution to the existing works related to the teachers´ digital competence that discussed in the theoretical framework. After the analysis of theoretical framework, we call for an update of the national framework for teachers´ digital competence and the development of some regional frameworks for teachers´ digital competence that can be put into practice, especially in Anhui Province.

On the other hand, the study adds to the results already shown in previous studies in the empirical studies related to the digital competence for teacher education, focusing on pre-and in-service teachers from one province of China to evaluate pre- and in-service teachers’ digital competence level, and to explore the influencing factors on their digital competence perception. The results of the study show the real status of teachers´ digital competence level in Anhui province by using statistical measurement method. The result of the study also brings an insight on the improvement on framework of teachers´ digital competence and innovations of teacher training in this region.

However, we emphasize to give the insight to work on pre-service teachers´ digital competence education in university and develop well-design teachers' ICT training courses for in-service teachers. Moreover, current teacher education today in the current context of China needs to consider not only the pedagogical use of ICT to prepare pre-service and in-service teachers for practice, but also to explore what digital competence mean at the individual level for pre-service and in-service teachers' learning during teacher education.

8.3. Limitations and further research directions

The limitations of this research were demonstrated in the following aspects: sample size, self-report data, and research design, including formulation of objectives and aims of the research.

The data collection, developed through an incidental sampling, consisted of primary and secondary education teachers in Anhui province, so the results cannot be generalized to the whole country. Then, the study conducted an online questionnaire to gather the data, excluding the participants with a low level of digital competence who were unwilling to answer the questionnaire. As the instrument was originally designed for pre-service teachers, the results of the digital competence assessment of in-service teachers obtained in this study may be controversial.

Regarding the limitations related to the study's findings, the assessment of this research has been made from scales of self-perception of competence, not actual competence. Moreover, this study indicated that younger in-service teachers have better perceived digital competence levels in technical learning and teaching than older teachers. Those with less teaching experience also showed more technical skills in resource preparation, process design, and practice reserve. However, the study lacks a deeper exploration of the professional expressiveness related to comparing the digital competence of pre-service and in-service teachers. For example, in the study of Nieto-Isidro et al. (2022) pre-service teachers performed worse than in-service teachers. This result shows the vital role of experience and disproves the existence of a "generational" effect according to which younger teachers have a higher level of information literacy. Therefore, the different research findings on teacher age and level of digital competence open an interesting line for future research work. Future work could focus on which age group or teaching age teachers have more robust digital practices in teaching and learning.

Then, this study not only has a limit to investigate how current ICT training courses impact pre-and in-service teachers' attitudes and behavioral intentions towards the use of ICT but also has a limit to investigate the impact on pre-and in-service teachers' learning outcomes. Therefore, the impact on pre-and in-service teachers' learning outcomes could be better established if a pretest-posttest quasi-experimental design provided randomized sampling and a control group with no intervention. Moreover, a longitudinal study could be applied to analyze the evolution of the in-service teachers' levels of digital teaching competence during the long training course. Another longitudinal study could be applied, investigating how ICT training course influences pre-service teachers' future work in transferring ICT skills and integration in teaching from pre-service education to classroom practice.

Lastly, based on this quantitative study that has given the complexity of digital competence and its interrelated factors, other exploratory lines of a qualitative analysis could be considered to contrast these results more profoundly and comprehensively. Therefore, future research may also consider applying a mixed methods approach capable of supplementing the data obtained using the questionnaire with interviews to understand better pre-and in-service teachers' opinions and experiences related to the use of ICT for teaching and learning.

8.4. Publications derived from doctoral thesis

Yang, L., García-Holgado, A., & Martínez-Abad, F. (2020). *A Study to Analyze the Digital Competence of Pre-service Teachers and In-service Teachers in China* [Conference paper]. ACM International Conference Proceeding Series, Salamanca (Spain). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85100581757&doi=10.1145%2f3434780.3436642&partnerID=40&md5=b93ad74390101ec12e5ed434e3a35925

Yang, L., García-Holgado, A., & Martínez-Abad, F. (2021). A Review and Comparative Study of Teacher's Digital Competence Frameworks: Lessons Learned. In F. J. García-Peñalvo (Ed.), *Information Technology Trends for a Global and Interdisciplinary Research Community* (pp. 51-71). IGI Global. https://doi.org/10.4018/978-1-7998-4156-2.ch003 (36 of 96 in SPI– Q2 – ICEE 79).

Yang, L., Martinez-Abad, F., & Garcia-Holgado, A. (2022). Exploring factors influencing pre-service and in-service teachers ' perception of digital competence in the

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Appendices

Appendix 1_Tables from the chapter 3.

Table 73. Terms and proposals presented in all selected articles

Study	Terms used	Proposals
He et al. (2018)	Teachers' ICT competency	Teacher training
Huang et al. (2016)	Teachers' ICT competency	Atmosphere(collaborative), teacher training
Kong and Zhao (2017)	Teachers' ICT competency	Atmosphere (school)
Kuang et al. (2018)	Teachers' ICT teaching ability	Educational resources, pedagogical strategies
Li and Huang (2018)	Teachers' ICT competency	Pedagogical strategies
Li et al. (2017)	Teachers' information literacy	Teacher training, atmosphere (school)
Li et al. (2018a)	Teachers' information technology application competency	Teacher training, pedagogical strategies
Li et al. (2019)	Teachers' TPACK	Atmosphere (government), teacher training
Li, Liao, et al. (2016)	Teachers' information literacy	Teacher training, pedagogical strategies
Li, Wu, et al. (2016a)	Teachers' information literacy	Teacher training
Li, Wu, et al. (2016b)	Teachers' information literacy	Teacher training, assessment system, atmosphere (government, school), teachers

Liang (2020)	Teachers' ICT application ability	Teacher training, pedagogical strategies
Liang et al. (2016)	Teachers' ICT teaching ability	Atmosphere (government and school), teachers
Liu et al. (2018)	Teachers' ICT competency	None
Ma et al. (2019b)	Teachers' information literacy	Framework, teacher training
Mu et al. (2019)	Teachers' TPACK	Teacher training
N. Zhang et al. (2019)	Teachers' information literacy	Teacher training, atmosphere (the operation mechanism and guarantee system of multi-cooperation)
Qi Zhang et al. (2015)	Teachers' information technology application competency	Atmosphere (government, school), teacher training, assessment system
Rao et al. (2019)	The ability of teachers' information technology application	Atmosphere (government), teacher training, assessment system, pedagogical strategies
Tang et al. (2019)	Teachers' informationized teaching ability	Atmosphere (government), teacher training
Wang and Guo (2017)	Teachers' ICT competency	Teacher training
Wang and Ren (2020)	Teachers' ICT competency	Atmosphere (government)
Wang and Wu (2018)	Teachers' TPACK	Teacher training, assessment system, pedagogical strategies
Wu et al. (2016)	Teachers' ability to apply information technology	Teacher training (evaluation system)
X. M. Zhang et al. (2019)	Teachers' ICT competency	None

Xia et al. (2017)	Teachers' ICT teaching ability	Pedagogical strategies: select tools, use tools, hanging the structure of teaching
Xu and Hu (2017)	Teachers' information technology application competency	Teacher training, atmosphere (school), assessment system
Yan et al. (2018)	Teachers' ICT competency	None
Yang and Hu (2019)	Teachers' information literacy	Teachers, pedagogical strategies, teacher training
Yao et al. (2019)	Teachers' ICT teaching ability	Teachers, atmosphere (school), pedagogical strategies
Z. Zhang et al. (2019)	Teachers' ICT teaching ability	teacher training, pedagogical strategies, evaluation system
Zhang et al. (2016)	Teachers' information technology application competency	None
Zhang et al. (2018)	Teachers' ICT teaching ability	Atmosphere (government, school), educational resources
Zhao et al. (2015)	Teachers' ICT competency	Teacher training
Zhao et al. (2018)	Teachers' digital literacy	None
Zhou et al. (2016)	Teachers' information literacy	Atmosphere (government), the role of enterprises
Zhou et al. (2017)	Teachers' IT application competence	Teacher training (systematic curriculum system)
Zhou et al. (2018)	Teachers' ability to apply information technology	Educational resources

Table 74. Dimensions and terms used

Articles	Terms used	Dimensions
(Chen, Zhou, Wang, et al., 2020) (Chen, Zhou, & Wu, 2020)	Teacher's information literacy	Information Awareness and Emotions, Information Knowledge, Information Use, Information Ethics and Security, Information Competency Continuing Development
(Chen & Lu, 2020)	Teacher's ICT competency	Application, Philosophy and Attitude, Knowledge and Skills
(Huang et al., 2021)	Teacher's ICT competency	Diagnostic Analysis, Training Design, Content Development, Training Implementation, Tracking and Evaluation
(Liu et al., 2012)	Teacher's ICT competency	Perceived Usefulness, Perceived Ease of Use, Intentional Behavior, Job relevance, Subjective Criteria
(Li, Wu, et al., 2016a)	Teacher's information technology literacy	Perceived Usefulness, Attitude to Use, Willingness to Use, Teaching Ability of IT Integration
(Li, Liao, et al., 2016)	Teacher's use of technology	Use attitude, Perceived usefulness, Perceived ease of use, Facilitating conditions, Subjective criteria, Use Behavior, Behavioral Intention
(Li et al., 2019)	Teacher's information literacy	Information Skills, Information Awareness and Attitudes, Information Ethics and Security
(Li, 2020)	Teacher's informatization	Autonomy Needs (knowledge sharing motivation), Competency Needs (technological application efficacy), Relationship Needs (interpersonal relationships)
(Li et al., 2021)	Teachers' digital competence	Teacher's Digital Competence, Student's Online Learning Difficulties, Use Intention of Online Teaching, Teaching Behavior
(Liu et al., 2018)	Teacher's ICT competency	Use Office and other tools (such as Word/PPT) to write instructional design, Use the school's digital teaching resource library or search for teaching resources online to prepare lessons, Use learning platforms, tools, etc. to obtain students' preview status and questions in advance, Use the

		classroom teaching system to organize teacher-student interaction and student discussion, Use information technology to carry out graded teaching according to students' situation and feedback information obtained
(Liang, 2020)	Teacher's ICT capacity	Value recognition of information technology, Professional development preparation for the application of information technology, Teaching practice using information technology
(Liu & Kong, 2017)	Teacher's ICT competency	Understanding ICT in Education, Curriculum Design, ICT, Pedagogy, Organization and Management, Assessment and Diagnosis, Teacher Professional Learning
(Qi Zhang et al., 2015)	Teacher's ICT competency	Optimizing Classroom Teaching Ability, Transforming Learning Style Ability, Teacher ICT Application Ability
(Sun et al., 2021)	Teacher's ICT teaching ability	Teaching Effectiveness, Reflection and Planning, Information Technology Competencies
(Tang et al., 2019)	Teacher's informatization teaching ability	Planning and Preparation, Organization and Administration, Assessment and Diagnosis, Teacher Professional Learning
(Yu & Zhang, 2020)	Teacher's information technology leadership	IT Teaching leadership, IT Professional Leadership, IT Management and Maintenance, IT Communication and Collaboration, IT Teaching Effectiveness
(Wang & Guo, 2017)	Teacher's ICT competency	Behavioral Intention, Use Behavior, Social Needs, Job Performance, Computer Efficacy, External Support, Objective Use, Perceived Usefulness
(Li, Wu, et al., 2016b)	Teacher's information literacy	Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Behavioral Intention, Use Behavior
(Zhang et al., 2016)	Teacher's ICT competency	

(Wan & Zhao, 2016)		
(Li et al., 2018b)	Teacher’s IT application ability	
(Wang & Ren, 2020)	Teacher’s ICT competency	Technology Literacy, Planning and Preparation, Organization and Administration, Assessment and Diagnosis, Teacher Professional Learning
(Zhang et al., 2014)		
(Zhang et al., 2017)		
(Ma et al., 2019a)	Teacher’s information literacy	
(Zhao et al., 2021)	Teacher’s informationization teaching ability	Understanding ICT in Education, Curriculum and Assessment, Pedagogy, ICT, Organization and Management, Teacher Professional Learning.
(Kong & Zhao, 2017)	Teacher’s ICT competency	
(Zhao et al., 2017)		
(Zhang et al., 2018)	Teacher’s use of IT	Attitude, Behavioral Intention, Use Behavior, Emergency Handling, Student Reaction, Teaching Plan Completion, Existing Technology Experience
(Zhang & Wu, 2018)	Teacher’s use of IT	Task Technology Fit, External Factors, Individual Factors, Perceived Usefulness, Perceived Ease of Use, Use Attitude, Use Behavior
(Zhu & Wang, 2019)	Teacher’s ICT literacy	Technical Identity, Technical Attitude, Knowledge and Skills, Application Practice, Integration of Children's Daily Life, Responsibility and Ethics
(Zhang et al., 2021)	Teacher’s informationization teaching ability	Subject Pedagogy Knowledge, Informatization Teaching Design Ability, Informatization Teaching Implementation Ability,

		Informatization Teaching Management Ability, Informatization Teaching Evaluation Ability, Informatization Teaching Reflection Ability
(Zhao et al., 2018)	Teacher's digital literacy	Functional skills, Creativity, Collaboration, Communication, Ability to find and select information, Critical thinking and evaluation, Cultural and social understanding, E-Safety
(Zhou et al., 2018)	Teacher's IT application ability	Information Technology Equipment Application, Digital Resource Application, Information Technology Teaching and Research Application
(Zhao et al., 2015)	Technological Pedagogical Content Knowledge	Technology knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical content knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological pedagogical content knowledge (TPACK)
(Wang & Wu, 2018)		Technology knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical content knowledge (PCK), Technological content knowledge (TCK), Technological Pedagogical Knowledge (TPK), Technological pedagogical content knowledge (TPACK)
(Mu et al., 2019)		Technology knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical content knowledge (PCK), Technological content knowledge (TCK), Technological Pedagogical Knowledge (TPK)

Appendix 2_ Questionnaire of research

General information

Q001. Sex

Q002. Age

Q003. Educational backgrounds (PhD, Master's, Bachelor's degree, Specialist degree, Other).

Q004. Major (Chinese Language and Literature, Mathematics and Applied Mathematics, Physics, Chemistry, Fine Arts, Ideological and political education, History, Biology, Music, Computer Science and Technology, Special education, Public utility management, Preschool education, Applied Psychology, Educational Technology, Pedagogy, Psychology, Primary education).

Q005. Vocation (Student teacher, Teacher).

Support and infrastructure

Q006. Do you have computers? (Yes / No)

- Q006_1. How often do you use it? (I never use it, Once a month or less, Once a week or less, Several days per week, Every day)

Q007. Do you have Laptops or tablets? (Yes / No)

- Q007_1. How often do you use it? (I never use it, Once a month or less, Once a week or less, Several days per week, Every day)

Q008. Do you have smart boards / interactive whiteboard in your class? (Yes / No)

- Q008_1. How often do you use it? (I never use it, Once a month or less, Once a week or less, Several days per week, Every day)

Q009. Do you have Digital Projector in your class (Yes / No)

- Q009_1. How often you use them (I never use it, Once a month or less, Once a week or less, Several days per week, Every day)

For pre-service teachers

Q0010. Registration

Q0011. Does the university offer courses related to the use of digital tools in future teaching? (Yes, No, I don't know).

- Q011_1. If not, would you like the university to offer such courses? (Yes, No)

Q0012. Whether you have the internet access resources at your university? (Yes, No, I don't know).

- Q0012_1. How often do you use it? (I never use it, Once a month or less, Once a week or less, Several days per week, Every day)

For in-service teachers

Q0013. Teaching stages (Primary school, Middle school, High school, Other)

Q0014. Type of center (public, private)

Q0015. Prefecture-level city (a list of the 16 "regions in Anhui": Hefei, An'qing, Bengbu…)

Q0016. Which subject are you teaching? (Multiple choice): Chinese, Mathematics, English, Physical, Chemistry, Biology, Ideology and politics, History, Geography, Physical education, Art, Music, Information Technology, Common technology, Psychological counseling, Development, Other.

Q0017. Teaching experience (years):

Q0018. Professional tittle: (Headmaster or Deputy Headmaster, Middle school leadership, Scientific research team leader, Head of year, Subject teachers, Other)

Q0019. If you have the Internet access resources at your school (Yes, No)

- Q019_1. How often you use them with your students? (I never use it, Once a month or less, Once a week or less, Several days per week, Every day)

Q0020. Does the school or other organization offer training related to the use of digital tools in teaching? (Yes, No)

- Q0020_1. Is free? (Yes, it is free; No, I have to pay a partial fee; No, I have to pay the full fee)
- Q0200_2. In the past five years, have you attended any courses on this subject? (Yes, No)
    - Q020_2-1. If so, how many times have you attended such courses?

Q024. Are there any ICT-related education projects being developed at the University / School for both pre-and in-teachers? (Yes / No).

Table 75 Likert scale for the questions of Q021, Q022, Q023

	Q021_BASIC TECHNOLOGY LITERACY	
FA1 Consciousness and attitude	A1	I like to learn some new applications of information technology.
	A2	I pay special attention to the application and progress of information technology in education and teaching.
	A3	I am willing to share and exchange information about the application experience and new discoveries of information technology with others.
	A4	I have at least one favorite online open course, online learning channel, online journal, etc.
	A5	I will consciously use information technology to learn anytime, anywhere.
FA2 Technical environment	A6	I can skillfully operate the multimedia teaching equipment in the classroom.
	A7	I can solve common problems in the application of multimedia teaching equipment.
	A8	I can skillfully operate common office software (such as word processing, presentations, spreadsheets, etc.).
	A9	I can skillfully operate at least one informatization teaching or learning aid tool suitable for this major.
	A10	I am proficient in using at least one graphics/image processing software.
	A11	I am proficient in using at least one audio and video editing software.
	A12	I am proficient in using at least one information communication tool (such as QQ, Weibo, blog, WeChat, etc.).
	A13	I am skilled enough to use at least one network storage tool.
	A14	I am proficient in using an e-learning platform.
FA3 Information Ethics and Information Security	A15	When I cite other people's materials, I always indicate the source normatively.
	A16	I have a legal awareness of information security and will not illegally obtain information from others or spread false, pornographic, violent and other bad information.
	A17	In the network interaction, I can actively create a healthy and civilized communication environment.
	Q022_TECHNICAL SUPPORT LEARNING	

FB1 Self-learning	B1	When faced with a lot of resources on the Internet, I was able to identify and select the required resources.
	B3	I am able to track the frontiers of professional development and accumulate key clues that reflect my professional vision (such as key people, key meetings, key communities, key journals, etc.).
	B4	My learning or task completion progress will not be disturbed by irrelevant information or communication.
	B5	I can use technical tools (such as time management, information management software) to strengthen self-discipline.
	B6	I often use technical tools (such as cloud notes, electronic files, and other tools that help knowledge management) to plan and record the learning process, and store the learning results.
	B7	I can use information technology tools to support rational reflection.
FB2 Communication and collaboration	B8	I can communicate with alumni smoothly in various information environments.
	B9	In order to promote effective collaboration, I can agree on clear collaboration rules with relevant participants (such as their respective responsibilities, communication time, application tools, collaboration strategies, etc.).
	B10	I can consciously abide by the rules of collaboration and use information technology tools to enhance collaborative communication.
	B11	I am able to use technology tools to conduct mutual evaluations and promote collaboration.
FB3 Research and innovation	B12	I can use thinking tools to find valuable questions.
	B13	I can analyze things rationally and comprehensively with the help of technical tools.
	B14	In order to discuss or explain things, I can make full use of technical tools (such as online questionnaire system, survey system) to collect data.
	B15	I am able to reasonably use data processing software to process and analyze data for specific problems.
	B16	I can make reasonable judgments, summaries, and predictions based on the results of data analysis.
	B17	I am able to creatively design solutions in combination with specific information environments.

	B17	According to the needs of the project, I can use technical tools to design and produce high-quality original works (such as posters, promotional videos, digital stories, three-dimensional models, etc.).
	B12	I can use thinking tools to find valuable questions.
	Q023_TECHNICAL SUPPORT TEACHING	
FC1 Resource preparation	C1	I can produce digital education resources proficiently according to technical requirements.
	C2	Before making digital educational resources, I can carefully design from the perspective of effectively supporting teaching.
	C3	I can judge the quality of digital education resources according to certain criteria.
	C4	I am able to make targeted improvements to digital education resources made by others.
	C5	I am able to consciously plan and enrich my personal digital education resource library.
	C6	I can reasonably choose technical tools to manage digital education resources according to the needs of backup, sharing and collaboration.
	C7	I know the role of different types of technical tools (including learning websites, apps, etc.) in providing students with learning opportunities and learning experiences.
	C8	I am able to select technical tools reasonably for learners' personalized learning.
FC2 Process design	C9	I can fully state at least two information-based teaching modes (such as project-based learning, resource-based learning, WebQuest, MiniQuest, mixed learning, etc.).
	C10	I can illustrate how information technology supports the optimization of classroom teaching in a multimedia classroom environment.
	C11	I can give an example of how information technology can promote the transformation of learning methods in a network environment or a mobile environment.
	C12	I can choose or integrate the appropriate information-based teaching model according to the conditions of the course standards, learning objectives, teaching content, etc.
	C13	I know how to use teaching media to support different aspects of teaching.
	C14	My information-based instructional design plan has been approved by teachers and alumni.

	C15	I can give an example of the active role of information technology in autonomy, cooperation, inquiry learning, etc.
	C16	I can provide different learners with learning suggestions in the information-based instructional design.
	C17	I can provide valuable support tools for learners' autonomy, cooperation, and inquiry activities (such as study guides, study flowcharts, thinking templates, etc.).
	C18	I can give an example to illustrate the concepts, principles and methods of process evaluation.
	C19	I can design an evaluation scheme that can take into account both process and personalization based on course standards, learning objectives, student characteristics and technical conditions.
	C20	I can reasonably choose, modify or develop suitable evaluation tools (such as evaluation gauges, observation records, questionnaires, etc.) based on the content or process to be evaluated.
	C9	I can fully state at least two information-based teaching modes (such as project-based learning, resource-based learning, WebQuest, MiniQuest, mixed learning, etc.).
	C10	I can illustrate how information technology supports the optimization of classroom teaching in a multimedia classroom environment.
	C11	I can give an example of how information technology can promote the transformation of learning methods in a network environment or a mobile environment.
	C12	I can choose or integrate the appropriate information-based teaching model according to the conditions of the course standards, learning objectives, teaching content, etc.
	C13	I know how to use teaching media to support different aspects of teaching.
	C14	My information-based instructional design plan has been approved by teachers and alumni.
	C15	I can give an example of the active role of information technology in autonomy, cooperation, inquiry learning, etc.
	C16	I can provide different learners with learning suggestions in the information-based instructional design.

	C17	I can provide valuable support tools for learners' autonomy, cooperation, and inquiry activities (such as study guides, study flowcharts, thinking templates, etc.).
	C18	I can give an example to illustrate the concepts, principles and methods of process evaluation.
	C19	I can design an evaluation scheme that can take into account both process and personalization based on course standards, learning objectives, student characteristics and technical conditions.
	C20	I can reasonably choose, modify or develop suitable evaluation tools (such as evaluation gauges, observation records, questionnaires, etc.) based on the content or process to be evaluated.
FC3 Practice reserve	C21	I clearly know the basic principles and methods of teaching intervention (such as student assistance, monitoring, management, etc.) in the information-based teaching environment.
	C22	During the class observation (including the real class or the classroom record), my evaluation of the class has been recognized by everyone (classmates, teachers, etc.).
	C23	I have mastered at least one method of analyzing classroom teaching (including live and recorded).
	C24	In the teaching process of others (such as teaching teachers), I can observe and use technical means to collect process data in a targeted manner.
	C25	When analyzing other people’s classrooms, I can put forward my own insights and improvement measures based on the collected data.
	C26	I can successfully implement it in a real or simulated teaching situation based on the pre-designed informational teaching design plan.

Appendix 3_Tables from the chapter 6

Table 76. Characteristics of the research (participants, sample size, research design, type of methodology, methods to collect data).

	Participant	Sample size	Research design	Type of methodology	Methods to collect data
(A. Henne et al., 2022)	Pre-service	13	Non-experimental	Quantitative	Survey
(Avci & Osman, 2021)	Pre-service	25	Non-experimental	Mixed	Questionnaire
(Brevik et al., 2019)	Pre-service	196	Non-experimental	Mixed	Survey & Interview
(Cañete Estigarribia et al., 2022)	Pre-service	330	Non-experimental	Quantitative	N/A
(Çebi et al., 2022)	Pre-service	24	Non-experimental	Mixed	Questionnaire & Interview
(Ciriza-Mendívil et al., 2022)	Pre-service	235	Pre-experimental (pre-and post-test)	Mixed	Questionnaire & Interview
(Colomo-Magaña et al., 2022)	Pre-service	284	Non-experimental	Quantitative	Questionnaire
(del Moral et al., 2016)	Pre-service	143	Non-experimental	Quantitative	Evaluation Rubric
(Fernandez-Cruz et al., 2018)	In-service	1433	Non-experimental	Quantitative	N/A
(García & Hernandez-Sanchez, 2020)	Pre-service	109	Pre-experimental	Quantitative	Questionnaire
(García et al., 2022)	Pre-service	8	Non-experimental	Qualitative	Semi-structured interview

(Gómez-Trigueros, 2020)	Pre-service	421	Non-experimental	Mixed	Questionnaire
(González-Martínez et al., 2019)	Pre-service	69	Non-experimental	Qualitative	Semi-structured interview
(Gordillo et al., 2019)	In-service	809	Pre-experimental	Quantitative	Questionnaire
(Gordillo, Barra, Garaizar, et al., 2021)	In-service	70	Non-experimental	Quantitative	Questionnaire
(Gordillo, Barra, López-Pernas, et al., 2021)	In-service	179	Pre-experimental	Quantitative	Questionnaire
(Große-Heilmann et al., 2022)	Pre-service	116	Quasi-experimental	Quantitative	Questionnaire
(Gudmundsdottir & Hatlevik, 2018)	In-service	356	Non-experimental	Quantitative	Questionnaire
(Guillén-Gámez et al., 2020)	Pre-service	108	Non-experimental	Quantitative	Questionnaire
(Howard et al., 2021)	Pre-service	931	Non-experimental	Quantitative	Questionnaire
(Instefjord & Munthe, 2017)	Pre-service & Teacher educators & Mentor teacher	654 + 387+ 288	Non-experimental	Quantitative	Questionnaire
(Karsli & Yagiz, 2022)	Pre-service	65	Pre-experimental (pre-and post-test)	Mixed	Questionnaire & Interview

(Kvale & Rambo, 2015)	Pre-service	8	Non-experimental	Qualitative	Content analysis
(Lopez-Belmonte et al., 2020)	In-service	627	Non-experimental	Quantitative	Questionnaire
(Magaña et al., 2022)	Pre-service	248	Non-experimental	Quantitative	Questionnaire
(Martínez-Abad et al., 2017)	Pre-service	260	Pre-experimental	Quantitative	Questionnaire
(Miguel-Revilla et al., 2020)	Pre-service	50	Quasi-experimental	Quantitative	Questionnaire
(Miralles-Martínez et al., 2019)	Pre-service	506	Non-experimental	Quantitative	Questionnaire
(Novella-García & Cloquell-Lozano, 2021)	Pre-service	118	Non-experimental	Quantitative	Content analysis
(Paige et al., 2016)	Pre-service	31	Non-experimental	Quantitative	Questionnaire
(Pombo et al., 2017)	In-service	13	Non-experimental	Design-based research	Questionnaire, Observation, Reflexive reports
(Ramírez-Montoya et al., 2017)	In-service	863	Non-experimental	Mixed	Questionnaire & Survey
(Ranieri et al., 2017)	In-service	81	Pre-experimental	Quantitative	Survey
(Rodríguez et al., 2021)	Pre-service	144	Non-experimental	Quantitative	Questionnaire
(Romero-García et al., 2020)	Pre-service	30	Pre-experimental	Quantitative	Questionnaire

(Romero-Tena et al., 2020)	Pre-service	535	Pre-experimental	Quantitative	Questionnaire
(S. M. Chireac et al., 2022)	Pre-service	80	Experimental	Quantitative	Questionnaire
(Sáez-López et al., 2020)	Pre-service	79	Pre-experimental	Mixed	Questionnaire & Survey
(Sánchez-Prieto et al., 2021)	In-service	1568	Non-experimental	Quantitative	Questionnaire
(Schina et al., 2020)	Pre-service	21	Non-experimental	Mixed	Questionnaire, Students' Lesson Plans—Template, Evaluation Rubric
(Serrano & Casanova, 2022)	Pre-service	91	Non-experimental	Qualitative	Semi-structured interviews
(Shively & Palilonis, 2018)	Pre-service	40	Non-experimental	Qualitative	Survey
(Starčič et al., 2016)	Pre-service	50+65	Quasi-experimental	Mixed	Test & Reflection
(Strydom et al., 2021)	Pre-service	24	Non-experimental	Qualitative	Semi-structured interviews
(Thoms et al., 2022)	Pre-service	9	Non-experimental	Mixed	Questionnaire & Interview
(Tirado-Olivares et al., 2021)	Pre-service	240	Quasi-experimental	Quantitative	Ad hoc test & SRS-based formative assessment

(Tømte et al., 2015)	Pre-service & teacher educators	94+51	Pre-experimental	Mixed	Survey & Observations & Learning management system (LMS)
(Tondeur et al., 2021)	Pre-service	931	Non-experimental	Quantitative	Questionnaire
(Záhorec, Hašková, Poliaková, et al., 2021)	Pre-service	280	Non-experimental	Mixed	Questionnaire & Survey
(Zimmermann et al., 2021)	Pre-service	26+15	Pre-experimental	Mixed	Questionnaire & Interview

Table 77. The challenges and strengths of educational resources of selected articles

Tools	Challenges	Strengths
Educational software evaluation (Avci & Osman, 2021)	N/A	1. software evaluation methods supported pre-service teachers in evaluating educational software and increased their knowledge and professionality about evaluation skills. 2. The introduction of the software engineering evaluation methods enhanced the technical abilities of pre-service teachers. 3. the software engineering methods assisted in closing the technical skills gap identified in previous studies. 4. The software engineering technical methods can be tailored in a way where more emphasis is on educational functionalities and characteristics and on enhancing the ability of pre-service teachers to conduct teacher and pupil evaluations.
Transformative agency (Brevik et al., 2019)	N/A	Transformative agency is a future orientation and involves decision making with both immediate and long-term consequences; Transformative agency can be as springboards for practices to be more fully developed.

3D virtual environment simulation (González-Martínez et al., 2019)	1. Simulation in 3D environments a certain disagreement among the participants because of its contrast with the actual situation faced by schools today (especially those with limited resources) 2. The limitations of the immersive environment are not allowing the participants to interact massively with controlled avatars that simulate being students (or with bots), affected how the participants assessed which functions should be developed in the environment. This in turn affected the psychological realism of the simulation, but the students had a stronger perception of psychological realism and felt that what they were simulating was faithful to reality.	3D simulation environments can be highly productive, and their cost is generally lower than other complex learning situations (such as actual simulation or supervised teaching practice). 3D simulation environments enable us to recreate realistic and authentic learning situations that have a genuine impact on learning of quality.
Educational video games (Gordillo, Barra, López-Pernas, et al., 2021)	The video game hard to use or not particularly motivating for their learning.	The video game used was didactic, motivating and fun.

Didactic blogging (Kvale & Rambo, 2015)	Minimal communication between students. Poor quality reflection on the course materials. Lack of awareness about using blogs alongside other e-learning tools. Lack of understanding of purpose and contents created of the blogging.	It develops collaborative activities, reflective thinking, effective communication, interactivity and active learning, a classroom community. It is a personal space for learning; the benefit from community feedback, validation and further development of ideas.
Slowmation (Paige et al., 2016)	N/A	Slowmation provides authentic, rich and creative opportunities for novice teachers. 1. Slowmation as an authentic tool that enhanced pre-service teachers´ scientific conceptual understanding. 2. Slowmation was created based on ways of thinking, ways of working and tools for working. 3. Slowmation is motivating and contextually relevant that pre-service teachers have intention to transfer and use it in their own future classroom practice.
AGIRE project (Pombo et al., 2017)	N/A	This model put the focus on the integration of technology in the classroom, and in the training and support of teachers and evaluation of its impacts on teaching and learning, optimizing the technologies and educational formats.

Visual block programming (Sáez-López et al., 2020)	N/A	Block programming showed positive and significant values for the importance of creativity, interactive, collaborative advantages, and the development of competencies. The implementation of visual block programming creates pedagogical advantages that allow greater student activity and prominence, taking advantage of the strength of interest and motivation that these approaches elicit, through collaboration, communication, creativity and student satisfaction.
Digital storytelling (Starčič et al., 2016)	1. The use of ICT by preservicere-service teachers is not as extensive or individually engaged. Far from being lead-users in ICT, most of the subjects had experiences limited to the use of the office software. 2. Digital story composition is sometimes limited to stylized artefacts with no intellectual challenge. 3. The danger of becoming overwhelmed with technical possibilities and lack of sufficient attention to meaning-making processes that support learning of concepts and develop skills in mathematical problem solving. 4. Preservicere-service teachers found shifting different modes and enabling transitions between representations for meaning making very demanding.	Storytelling is applied as a pedagogical strategy for preservicere-service teacher education and as a research method facilitating preservicere-service teachers in engagement with transformative pedagogical work. Storytelling is described in the literature on constructivist learning as facilitating student-centered learning through student engagement and reflection for deep learning.

IBL methodology and student response system (SRS) (Tirado-Olivares et al., 2021)	Gamification is not common either in the university context or in the teaching of social science subjects.	This playful educational context allows the implementation of methodologies based on cooperation and problem-solving in the classroom. Games promote the acquisition of contents, motivation and critical thinking. Motivation: stimulate their participation through attaining achievement or receiving rewards. Students are active learners who construct their own knowledge through the application of problem-solving skills. IBL enhances students' curiosity, exploration and experiential learning.
Online teacher education programs (Tømte et al., 2015)	A limited number of teaching staff are interested in digital competence as part of their professional development, more than as part of an overall strategy implemented at their institution. The discourse that covers online learning and the discourse on digital competence thus derive from different stakeholders.	Online education has been flagged as opening important avenues for future education to develop digital competence, in recruiting new groups of students, along with offering more flexible solutions to existing students and future students. Online education has prospects of efficacy and economic advantage.

Table 78. Limitations and further research directions of selected studies

Article	Limitations	Further research directions
(Brevik et al., 2019)	- This study has not ventured into the representativity of the patterns and snapshots analyzed. The data corpus holds empirical carriers of patterns and agencies that do not necessarily qualify as transformative. - This study has been beyond the scope and aims of this study to examine the relative representation of such patterns by identifying and counting instances to map the complete corpus.	- The need for additional research on how the links between PDC, double stimulation and transformative agency can be further operationalized in teacher education programs, or in any kind of learning situation where status quo is deemed insufficient.
(Cañete Estigarribia et al., 2022)	- The lack of inclusion in the study of all the courses offered in the selected training institution, as well as procedure for data collection was made in a virtual manner, which made it impossible to control the students at the time of completion of the questionnaire.	- It is planned to broaden the scope of the participants to make a comparative study between Teacher Training Institutes and public or private universities, as well as obtaining data at a national level.
(García & Hernandez-Sanchez, 2020)	- Some aspects cannot be assessed in a cross-sectional manner and require the implementation of a longitudinal program and study.	- N/A

(García et al., 2022)	- The interview conducted by email was the most restrained and the responses were collected directly in writing.	- Future research could focus on the degree to which each of the key elements impacts on different educational contexts. - A specific educational context could be evaluated, and key elements could be reinforced to ascertain the degree of educational improvement.
(Gómez-Trigueros, 2020)	- It is partial data, since it is an incipient, wide-ranging investigation that will last over time, for at least two academic years.	- Future work could assess the qualitative and perception results by gender in order to evaluate possible variations based on this factor. - Future work could investigate the relationship between the beliefs and practices of future teachers, extending the study to active teachers.
(González-Martínez et al., 2019)	N/A	- We should continue to explore learning experiences that take more advantage of these situations. - More characteristics of multi-user virtual environments should be explored to service teacher training simulations.
(Gordillo et al., 2019)	N/A	- Future works should investigate the training activities that address the content creation of the digital competence in technical aspects, such as accessibility and content reusability, and delve into the creation of adaptive resources and the provision of feedback. These training activities should include active learning. - Future research works should examine the instructional effectiveness of online courses in MOOC format for teacher training in digital competence.

		- Future research works should compare the instructional effectiveness of courses in MOOC format with that of other training activities according to the profile of the participants.
(Gordillo, Barra, Garaizar, et al., 2021)	- The evaluation of Social Lab usefulness is based exclusively on measurements reported by the participants themselves. - This usefulness was not compared with that of alternative forms of learning.	- Future works should investigate the training activities that address the content creation area of the digital competence should, in addition to teaching teachers how to use authoring tools, pay special attention to technical aspects such as accessibility and content reusability, and delve into the creation of adaptive resources and the provision of feedback. These training activities should include active learning, one of the most popular strategies for teacher training in ICT use. - Future research works should examine the instructional effectiveness of online courses in MOOC format for teacher training in areas of teacher's digital competence other than safe and responsible use of ICT and digital content creation. - To compare the instructional effectiveness of courses in MOOC format with that of other training activities. Of special interest would be to analyze effectiveness according to the profile of the participants since, that way, it would be possible to determine when the use of courses in MOOC format is the most suitable solution for overcoming the training shortcomings of teachers, and when the most suitable solution is another type of training activity.
(Gordillo, Barra, López-	- The effectiveness of educational video game-based learning approach to promote highly practical skills related to	- Future studies should assess the effectiveness of this learning approach to promote highly practical skills related to teacher digital competence

Pernas, et al., 2021)	teacher digital competence was not assessed.	- Future research should study how the incorporation of learning experiences based on educational video games influences the completion rates of MOOCs, which are usually very low compared to those of face-to-face courses. - Future studies should analyze the effectiveness and acceptance of these experiences for teacher training in other topics and areas of teacher digital competence. - Further research is needed to investigate the influence of teacher characteristics on these factors, for instance the influence of liking games, gaming habits or the player type (e.g., “killer”, “achiever”, “socializer” or “explorer”.
(Gudmundsdottir & Hatlevik, 2018)	- Authors were not able to include and examine all possible aspects that do influence the development of teachers’ PDC.	- It is therefore desirable to conduct further research that includes other aspects that can be associated with teachers’ ICT self-efficacy. - Future research is required to understand how teachers develop their negative experiences with ICT and what can be done to assist these teachers to see the potential of ICTs rather than the restrictions. - To best utilize and maintain teachers’ positive attitudes toward ICT, further research on classroom management in technology-rich environments can be identified as an important aspect of ICT training in ITE.
(Guillén-Gámez et al., 2020)	- The sample was small and not representative of the entire population. Therefore, the results are not applicable to all future teachers.	- To carry out this same study taking into account the gender variable in order to find out to what extent gender influences or not the use of 2.0 tools.

	- Because the sample has been mostly female, no statistical analyzes have been carried out in relation to gender to verify any significant differences between both. - Only one component of digital competence has been considered when it is composed of knowledge, use and attitude.	- To correlate the years that teachers have been active with their motivation towards the use of ICT and their level of digital competence. - It would also be relevant to find out through which procedures the faculty has acquired their real digital competence: through regulated permanent training, self-training, etc. - To correlate the socio-educational contexts of the centres where the professors teach with their level of use of the 2.0 tools.
(Howard et al., 2021)	- Since the association rules approach is based on frequency of associations appearing in the dataset, it can potentially eliminate important associations that may not appear as often but are highly predictive. This can produce an incomplete understanding of what is important in a dataset. - Preservicere-service teacher experiences have not been considered in the conceptualization of the SQD strategies, although it dictates how the teaching strategies associate.	- It is necessary in further analysis to adjust confidence, support and lift thresholds to capture additional associations and check if additional relationships need to be included in the graph. - To investigate how preservicere-service teachers experience formative feedback and if this changes how they experience the Feedback strategies by conducting an updated systematic literature review of teaching strategies to develop digital competence, to capture any changes in this area. - Further work should explore connections between preservicere-service teachers' experiences and the design of their training programs, to confirm how the teaching strategies are implemented and how they are experienced. To confirm relationships among strategies, it will be important to compare results across institutions to explore how the strategies self-organize and if different themes emerge in different teaching cultures.

(Instefjord & Munthe, 2017)	- This study has clear limitations in the variation in responses from HEIs, which prevented a multi-level analysis to investigate workplace support variables' influence on use of instructional technology.	- Future studies develop second order latent measures to address the multidimensionality of the concept of "professional digital competence". - There is a need to look more closely at how HEI workplace support can influence integration of digital competence among teacher educators, and that there is a need to look more closely at how and where digital competence for pre-service teachers is developed. There is a need to look what role does modelling play in teacher education and where will pre-service teachers gain access to necessary role models.
(Kvale & Rambo, 2015)	- Sample sizes, Implementation of date collection methods	- N/A
(Lopez-Belmonte et al., 2020)	- Some of participation of the subjects initially selected have not actively collaborated during the data collection process, which hindered the course of the study.	- It is intended to analyze the participation of teachers in training programs of a technopedagogical nature with the purpose of associating the results achieved in this study with other types of factors that may influence the use of AR in teachers who practice their profession in the Vocational Training stage.
(Martínez-Abad et al., 2017)	- Regarding the design used, the lack of control over the intervening variables that pre-experimental designs bring with them. - As for the pretest-posttest measures incorporated in the study, the performance of the teachers in the formative phase both at the beginning	- Future work could avoid these limitations by employing different research methods, for example, through randomized controlled trial experiments using pre-tests and post-tests.

	and at the end of the program was not considered. This issue detracts from the control of the design. - For problems related to sampling, the success rates in the completion of the training program by teachers between two regions were very disparate.	
(Miguel-Revilla et al., 2020)	- This study has a relatively small size and only restricted to a specific context, potentially limiting the generalization of the results. - This study is lack of a control group for providing additional information. - This study has the potential difficulties to replicate the intervention in other educational contexts due to the specificity of this particular course. - This study has no back-translation procedures were used to translate the TPACK-21 questionnaire into the Spanish language, due to it was conducted in a context other than Finland, where the instrument was originally applied.	- Future studies might try to establish a protocol that could orient teaching practices and that may be replicated elsewhere. This might encompass more than one course or type of intervention and could also be adapted to other disciplines. - Future research may also consider applying a mixed-methods approach capable of supplementing the data obtained using the TPACK-21 questionnaire with one-to-one interviews. - Future research directions might involve a bigger focus on the examination of new instruments and theoretical frameworks, as well as how to adapt the specificities of social studies education in such models. - There is a comparative approach to be done with other disciplines might be useful to determine if progress in all TPACK factors is equivalent or there are differences in other domains or contexts in initial teacher training.
(Paige et al., 2016)	N/A	- Slowmation as a formative process and summative product need to be explored.

		- Exploring how and to what extent constructing a Slowmation relied upon prior knowledge of science and mathematics conceptual understanding. - To figure out the factors influence challengs of Slowmations for pre-service teachers.
(Ramírez-Montoya et al., 2017)	- The study only assessed personal teachers' self-perceptions on DC and OER use, but the actual teachers' performance in both constructs was not measured.	- More systematic research should be conducted in actual teachers' performance to explore how teachers are implementing those digital materials in their teaching and to confirm whether these actions align with their self-perceptions.
(Ranieri et al., 2017)	- The general sample was small and there were several differences between the different national contexts.	-
(Rodríguez et al., 2021)	N/A	- To use a bigger sample for running a confirmatory factor analysis (CFA). - The instrument also needs to be studied in samples of in-service teachers and in relation to other demographic information. - To continue studying causal models for contributing a step forward in terms of curricular design.
(Romero-García et al., 2020)	N/A	- It would also be of interest to incorporate proposals of this type into other modules to contribute to better training in digital competence for future biology, geology, and secondary education teachers, as well as extending this experience to other specialties on the master's degree in question.

		- Another potential line of research focuses on the design of instruments for real measurement of digital competence.
(Romero-Tena et al., 2020)	- This is due to limiting a specific Faculty of Education, as well as the sample size.	- According to the section "Sustainable Education and Approaches", this topic is integrated into its line of interest, which is related to education, culture, and economic and social sustainability.
(Sánchez-Prieto et al., 2021)	- The study only provides for the dual formation of a single autonomous community.	- It is proposed as a future line of research to extend the research to the rest of Autonomous Communities of the national territory with the intention of comparing and checking whether the results are similar.
(Serrano & Casanova, 2022)	- The results cannot be generalized since this is a case study limited to students of the Education Faculty of the University of Zaragoza who participated in a technological-methodological integration project. - This research was conducted prior to the pandemic situation of recent months. Undoubtedly, since then the use and management of technology has changed.	- The study would be more valuable if it had been complemented with quantitative information stemming from all project participants. - It is desirable to continue analyzing, in the following courses, the use of technology to compare the situation pre and post COVID. - Further study and reflection should be devoted to the incorporation of digital technology in general teaching and in musical teaching: we should further analyze the use of digital resources, their usefulness, their advantages and difficulties, and learn to identify when they have been successfully applied in SEAs. In-depth analysis of experiences with technology in other locations, along with case studies of other university practices identifiable as SEAs will undoubtedly continue to nurture knowledge in this field.

(Shively & Palilonis, 2018)	N/A	- This study calls for further investigation regarding the role digital literacy plays across elementary teacher preparation programs, as well as the implementation of DT strategies to develop curriculum and build diverse and creative learning environments.
(Starčič et al., 2016)	- Lack of use of a true experimental design to provide a random sample and a control group without intervention. - The impact of teaching practice or other extraneous variables was not examined in this study.	- A follow-up study would be needed to identify the impact of the digital multimodal storytelling approach on actual teaching practice after graduation. - A true experimental design provided randomized sampling and a control group with no intervention need to be conducted for investigating the impact on preservicere-service teacher learning outcomes with greater reliability. - More random sampling and cross-cultural studies would provide grounds for greater generalization of the results.
(Tirado-Olivares et al., 2021)	- The IBL methodology implemented together with SRS-based formative assessment, has led to an improvement in the academic performance of prospective teachers. However, it is necessary to clearly identify which of these elements caused this effect or if it originated by the combination of both. - The current study focused only on analyzing the advantages in terms of learning gain. - The instruments used in our study focused exclusively on the assessment	- Future studies should compare different settings for the experimental condition, making it possible, for example, to compare results from IBL methodology alone and from IBL coupled with the use of SRSs. - Future studies could also explore students' motivation towards the methodologies and tools used. This aspect may be especially relevant considering that our sample consisted of pre-service teachers. In this case, their satisfaction as trainees could influence the possibility of employing these methodologies in their future professional practice. - It would be interesting to carry out further studies using complementary instruments that help researchers to assess

	of the learning of factual contents but were not designed to measure more complex skills. - The number of students who completed all the tasks was reduced.	students’ acquisition of other skills, such as historical thinking. - Future studies with a larger sample could offer more emphatic results and resounding conclusions. This is something that, due to the lack of studies in this field, could be a starting point for new gamified formative assessment approaches.
(Tondeur et al., 2021)	- The responses of this study were voluntary and thus inevitably subject to self-selection biases. - Another limitation is related to the association rules analysis.	- Interpretative research could be adopted to explore reasons why the strategies are related, and differences observed among groups and/or contexts. - Future research could explore, compare and contrast the development of preservicere-service teachers’ digital competencies over time. - Future research could explore preservicere-service teachers’ experiences developing digital competence outside of the Flemish context through a random sampling approach. - Future research should explore the key themes at the outer circle (institutional level), such as “collaboration within and between institutions” or “the development of a shared vision”. - A wider analysis of the datasets is needed to confirm that all important associations have been captured.
(Záhorec, Hašková, Poliaková, et al., 2021)	- Most of respondents had not passed their pre-service teaching practice, which could limit to the generalization of the research results.	- N/A

	- The research was carried out before the coronavirus pandemic occurred, when the main teacher training in digital technologies was the appropriate implementation of different software applications into teaching. In the conditions of the pandemic, to train teachers to work with different online systems is more important.	
(Zimmermann et al., 2021)	- A relatively small sample is lowers the generalization of the results. - We were not able to include all facets of possible prior experiences and influences that might have had an additional impact on the findings of the study. - Since the participants thus cannot show their acquired competence in actual teaching activities, we do not observe the participants' actual implementation of educational technology in a classroom setting.	- In order to increase the study's generalizability, it would be necessary to implement it at more than two universities and with more than one additional lecturer. When applying the seminar at a further university, the study should comprise master students. - Applying the study on a larger sample would allow to take the participants' prior conditions and experiences more specifically into account.

Appendix 4_Resumen extendido: Evaluación de la competencia digital docente del profesorado y futuro profesorado en la provincia de Anhui, China

Evaluación de la competencia digital docente del profesorado y futuro profesorado en la provincia de Anhui, China

Tesis Doctoral

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Resumen extendido

Palabras clave: competencia digital, China, evaluación, profesores en servicio, profesores en formación, formación del profesorado.

Con la integración de las tecnologías en la educación, todos los países han propuesto planes de desarrollo tecnológico en el ámbito educativo y han aumentado la inversión. En este mismo contexto, China también ha sido consciente de que las Tecnologías de la Información y la Comunicación (TIC) desempeñan un papel fundamental en la promoción del futuro desarrollo educativo y ha establecido una estrategia nacional para determinar la situación del desarrollo tecnológico para la educación. Esto ha llevado a realizar profundos cambios en los entornos de enseñanza-aprendizaje del profesorado. Se trata de un proceso de cambio que está creando y seguirá creando nuevos retos respecto a los métodos y técnicas utilizadas por los docentes en contextos pedagógicos, didácticos y administrativos, así como para sus conocimientos especializados y habilidades básicas.

El docente es el elemento clave en todo el proceso educativo, en particular, en la acción educativa para la transformación y la mejora de la educación en el fomento de las competencias digitales, los conocimientos especializados y las competencias básicas de los estudiantes (Tondeur et al., 2017). En estas circunstancias, la competencia digital del profesorado ha recibido atención mundial, requiriendo desarrollar habilidades de aprendizaje y recibir conocimientos de diversas fuentes disponibles en la sociedad moderna, y produciendo nuevas demandas para comprender y utilizar las oportunidades de aprendizaje digital en el ámbito educativo.

Las TIC han impulsado los avances y el crecimiento de la sociedad, la cultura y la educación en el siglo XXI. Los cambios en la sociedad y la cultura afectan a las concepciones relacionadas con las competencias digitales y el saber que deben tener las personas en la sociedad del conocimiento. Esta gran variedad de concepciones refleja el rápido desarrollo de las tecnologías y los distintos ámbitos de interés.

Según la revisión de Ilomäki et al. (2016), estas concepciones de uso común son la alfabetización digital (incl. alfabetizaciones digitales o habilidades de alfabetización digital), las nuevas alfabetizaciones (incl. nuevas habilidades/prácticas de alfabetización), la alfabetización mediática (incl. alfabetizaciones mediáticas o habilidades de alfabetización mediática), la multialfabetización (incl. alfabetizaciones múltiples) y la competencia digital (incl. competencia digital o competencia digital).

Asimismo, se han utilizado varios conceptos para describir el uso de las TIC por parte del profesorado, como la alfabetización informacional, alfabetización digital, competencias o competencia TIC, competencias informáticas, competencia digital y conocimiento tecnológico pedagógico del contenido (TPACK).

Existe una estrecha relación entre estos conceptos de uso común. Como mencionaron Tondeur et al. (2017), las habilidades TIC y las habilidades informáticas se refieren al uso técnico de las TIC por parte del docente, mientras que tanto la competencia TIC como la competencia digital se conceptualizan como el uso integrado y funcional de conocimientos, habilidades y actitudes digitales. En particular, Krumsvik (2008, 2009) destacó que la competencia digital del profesorado está relacionada con las habilidades para utilizar las TIC con criterio pedagógico-didáctico y la conciencia de su impacto en las estrategias de aprendizaje y en la educación digital del alumnado.

Sin embargo, el concepto de competencia y alfabetización digital es bastante más cercano en el ámbito de la educación superior (Spante et al., 2018). Paynton (2012) describió la alfabetización digital como la integración de la alfabetización informática, la alfabetización informacional y la alfabetización mediática. Según Martin and Grudziecki (2006) y Ferrari et al. (2013), la concepción de la competencia digital se sustenta en la alfabetización digital. Entonces, basándose en la definición de competencia digital, se llega a la conclusión de que la competencia digital es un concepto fronterizo sustentado por la alfabetización digital, la alfabetización mediática, la alfabetización informacional y la alfabetización de datos. Por lo tanto, el concepto de competencia digital se utiliza para describir el uso de las TIC en el presente estudio porque ofrece una visión más completa del uso de la tecnología.

Las TIC ofrecen oportunidades para desarrollar la educación. "La competencia digital se ha ido introduciendo gradualmente en los programas escolares, las pruebas de evaluación y la práctica en el aula durante la última década" (Ottestad et al., 2014, p. 223). De ahí que los sistemas educativos de muchos países necesiten que los profesores estén dotados de competencia digital (UNESCO, 2011). Además, el rápido desarrollo del marco de competencias digitales en la última década se ha concentrado en muchos países y organizaciones. Estos países u organizaciones han establecido exigencias considerables en relación con la competencia digital de los profesores, y se ha lanzado un marco teórico relacionado con la competencia digital del profesorado, destacando la Unión Europea (UE), seguida de la UNESCO y Estados Unidos (EE.UU.), entre otros.

La presente tesis doctoral ofrece una visión global de los seis principales marcos nacionales e internacionales publicados, y analiza estos seis marcos relevantes para el desarrollo de la competencia digital de los profesores mediante un análisis comparativo de Debilidades, Amenazas, Fortalezas y Oportunidades (DAFO) (Helms & Nixon, 2010). Estos marcos están apoyados por la Unión Europea, China, Estados Unidos, y la UNESCO. En particular, se han analizado los siguientes marcos: “Information technology application competency standards for primary and secondary school teachers” (China), varias versiones del DigComp (Unión Europea), el “International Society for Technology in Education (ISTE Standards)” (EE.UU.), “ICT competency framework for teachers” (UNESCO), el “Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2” (UNESCO), y el marco TPACK.

Basándose en el análisis comparativo DAFO de los marcos (Ghazinoory et al., 2011; Hill & Westbrook, 1997), se discuten los niveles de competencia que actualmente prevén estos marcos y como resultado se proponen descriptores específicos de competencia digital. El objetivo general es facilitar la integración de un marco de competencia digital de evaluación para el profesorado de otras regiones del mundo que no dispongan de un marco propio.

Una vez realizado el análisis, se concluye que estos marcos presentan coincidencias y matices a la hora de entender el desarrollo de la competencia digital. Aunque algunos de estos conceptos identificados en las dimensiones de la competencia difieren en algún aspecto, los estándares de los marcos y los resultados del currículo están estrechamente relacionados. Por lo general, existen cinco elementos principales: (1) propósito del marco; (2) áreas de competencia; (3) competencia, dominios de aprendizaje (como conocimientos, habilidades y actitudes); (4) cómo realizar las tareas; y (5) herramientas digitales que deben utilizarse. Estos descriptores resumen y reúnen las áreas de competencia tal y como se describen en los marcos seleccionados.

Todos los marcos seleccionados se centraban en competencias como la reflexión, la práctica continua, la colaboración, la participación social de los ciudadanos o las TIC. Sin embargo, el reto destacado es la implementación de estos marcos, así como cuestiones críticas sobre el apoyo institucional a los ciudadanos para promover el desarrollo de su competencia digital. Dado que hay muchos factores contextuales y culturales diferentes que influyen en la aplicación de los marcos curriculares, no es posible concluir que estos marcos sean comparables en cuanto a su ejecución o impacto.

Sin embargo, se observa que DigComp está sujeto a la creación de consenso sobre los componentes de la Competencia Digital únicamente a nivel europeo. Sin embargo, es uno de los marcos más completos y bien desarrollados, y puede servir como modelo conceptual de referencia para otros países o instituciones educativas, además de ser la piedra angular del desarrollo del Marco Global de Referencia sobre Competencias Digitales de la UNESCO.

Además, la colaboración o el intercambio de buenas prácticas y experiencias en la implementación de la competencia digital, podría aportar gran valor a todos los países del mundo. Por lo tanto, existe una oportunidad de desarrollo de la competencia digital entre Europa y China para unir los avances en tecnologías renovables de China y la capacidad de Europa para explorar el establecimiento de un marco de competencia digital y la renovación de un marco de competencia digital para profesores en China. La cooperación entre Europa y China tiene el potencial de aumentar las oportunidades para que China mejore su marco de competencias digitales.

Otro de los objetivos de esta tesis doctoral es ofrecer una visión general de la investigación sobre la competencia digital del profesorado de primaria y secundaria en China. Para ello, se han llevado a cabo dos revisiones sistemáticas de la literatura con el fin de ofrecer una visión general de los esfuerzos y retos en materia de competencia digital de los profesores en China, sirviendo como punto de partida para reflexionar y analizar la situación de la competencia digital de los profesores chinos. La revisión bibliográfica se ha centrado en los principales términos utilizados para hablar del uso que hace el profesorado de la tecnología para la enseñanza y el aprendizaje, los principales objetivos de los estudios previos relacionados con las competencias digitales de los profesores, las principales características de los métodos de investigación y las principales propuestas realizadas para mejorar la competencia digital.

Como mencionan Llomäki et al.(2011, p. 1), "se han utilizado varios términos para describir las habilidades y competencias en el uso de las tecnologías digitales, como habilidades TIC, habilidades tecnológicas, habilidades en tecnologías de la información, habilidades del siglo XXI, alfabetización informacional, alfabetización digital y habilidades digitales". En el contexto de China, el término más utilizado fue "competencia en TIC de los profesores", seguido de "alfabetización informacional de los profesores", "capacidad didáctica en TIC de los profesores" y "aplicación de las tecnologías de la información por parte de los profesores".

Los términos "competencia TIC de los profesores" y "alfabetización informacional de los profesores" son conceptos basados inicialmente en el Marco de Competencias TIC para Profesores de la UNESCO (2011). Este marco enfatiza que tener competencia en TIC no es suficiente para que los profesores sean capaces de enseñar a sus alumnos. Tienen que ser capaces de utilizar las TIC para ayudar a los estudiantes a ser estudiantes colaborativos, resolutivos e innovadores.

Las dimensiones comunes utilizadas para evaluar la competencia digital de los profesores de primaria y secundaria de China giran en torno a tres temas: (1) concienciación sobre el uso de las tecnologías digitales; (2) habilidades técnicas y prácticas de uso de las tecnologías digitales (preparación, implementación y evaluación); y (3) uso de las tecnologías digitales para el aprendizaje profesional, en el que las habilidades técnicas y prácticas de uso de las tecnologías digitales son la principal dirección de investigación.

Hay cuatro temas principales de estudio para los artículos seleccionados como resultado de las revisiones sistemáticas realizadas: (1) el statu quo de la competencia digital, que incluye artículos que valoran y evalúan la percepción de los participantes o su nivel de competencia digital; (2) los factores influyentes, que incluye artículos que exploran los factores que podrían influir y marcar diferencias en la competencia digital de los participantes; (3) la formación de los profesores antes y durante el servicio; y (4) la validación de instrumentos, que incluye artículos que construyen modelos relacionados con la competencia digital y utilizan su correspondiente instrumento para medir la fiabilidad y validez del cuestionario.

Respecto a los principales temas identificados como resultados en los artículos seleccionados, en primer lugar, el nivel de informatización de las regiones está desequilibrado en China entre sus regiones oriental, central y occidental. La zona oriental tiene un nivel de informatización más alto que las zonas central y occidental. Los profesores tienen mayores niveles de concienciación y ética en el uso de las TIC, pero su práctica profesional para la enseñanza y el aprendizaje es débil.

Por otro lado, varios factores tienen un impacto directo e indirecto significativo en la competencia digital de los profesores, como el género, los años de experiencia docente, las materias de enseñanza, la formación académica, la experiencia formativa de los profesores, el entorno tecnológico y la autoeficacia.

Por último, los resultados relacionados con la formación del profesorado en competencia digital demostraron que el formato de formación en línea y la eficacia de la formación del profesorado son el principal foco de estudio en el contexto de China.

En cuanto a las principales características de los métodos de investigación de los artículos seleccionados, se investigaron la población y la muestra, las regiones de estudio, la metodología, el método de recogida de datos y los instrumentos. En primer lugar, los profesores en activo son la principal población estudiada en los artículos seleccionados; en segundo lugar, más de la mitad de los estudios tenían muestras pequeñas de menos de 500 participantes; en tercer lugar, las principales conclusiones sobre el diseño y la validación aportadas por estos artículos se centraban en la evaluación diagnóstica del nivel de competencia digital con un diseño no experimental; por último, los cuestionarios eran el instrumento más utilizado para la recogida de datos, y la mayoría de los artículos seleccionados no incluían ninguna referencia a la validación de los instrumentos utilizados.

Tras esta revisión bibliográfica, ua vez realizado el análisis de los marcos de la competencia digital y analizada la situación de la investigación en competencia digital del profesorado en China, se ha llevado a cabo una evaluación diagnóstica de la competencia digital del profesorado en formación y en servicio en la región de Anhui (China). Para ello se ha seguido un paradigma cuantitativo, que utilizó un diseño no experimental-transversal. Así, se implementó una metodología ex-post-facto basada en estudios de encuesta para evaluar y analizar la percepción de la competencia digital de los profesores chinos en formación y en servicio en la provincia de Anhui. Además, este estudio cuantitativo explora la relación entre los factores sociodemográficos (edad, nivel de estudios, cursos de TIC, años de experiencia docente) y su nivel de competencia digital.

La muestra de esta investigación se obtuvo con un cuestionario en línea recogiendo datos de profesores en activo y en formación entre febrero y mayo de 2021 en la provincia china de Anhui. Se aplicó un procedimiento de muestreo no probabilístico (muestra de respuesta voluntaria), con el que se obtuvo la muestra inicial (n=498).

La mayoría de los participantes (116) procedían de Hefei (capital de la provincia de Anhui). En las 498 respuestas iniciales obtenidas, hay 248 profesores en activo y 250 profesores en formación. De los 248 profesores en activo, 136 (55%) eran mujeres y 112 (45%) hombres. Por otra parte, de los 250 profesores en formación, 122 (49%) eran mujeres y 128 (51%) hombres.

La evaluación de la percepción consideró tres tipos de variables, diferenciando entre variables explicativas, predictoras y criterio. Las variables criterio fueron la competencia digital autopercibida, que se dividen en las dimensiones del cuestionario descritas a continuación. Las variables explicativas y predictoras (sexo, edad, nivel de estudios, profesión) incluidas en el cuestionario se analizaron en relación a los resultados sobre la competencia digital autopercibida (las variables criterio). Además, se obtuvieron otras variables explicativas, como el tipo de centro de trabajo de los profesores, los años de experiencia docente o el *hardware* disponible (ordenador de sobremesa, portátil o tableta, pizarra inteligente interactiva).

El cuestionario de esta investigación cuantitativa proviene del instrumento diseñado por Yan et al. (2018) para diagnosticar la competencia digital autopercibida de los profesores en formación. Este instrumento está formado por tres factores fundamentales: (1) Alfabetización Tecnológica Básica (dividida en tres dimensiones: Ideólogo; Entorno Técnico; y Seguridad de la Información); (2) Aprendizaje de Apoyo Técnico (dividido en tres dimensiones: Autoaprendizaje; Comunicación y Colaboración; e Investigación e Innovación); y (3) Enseñanza de Soporte Técnico (dividido en tres dimensiones: Preparación de recursos; Diseño de procesos; y Reserva de prácticas).

Los resultados de este estudio cuantitativo incluyen tres partes principales: el análisis de fiabilidad y validez de la escala de competencia digital en la muestra obtenida, el análisis descriptivo del nivel de competencia digital de los profesores en activo y en formación, y los factores relacionados con el nivel de competencia digital de los profesores en activo y en formación.

En primer lugar, los resultados descriptivos de este estudio demostraron que tanto los profesores en activo como los profesores en formación de la provincia de Anhui tienen una excelente percepción de la competencia digital en las tres áreas medidas: alfabetización tecnológica básica, aprendizaje de apoyo técnico y enseñanza de apoyo técnico. Además, este estudio descubrió que los profesores en activo tenían una mayor percepción de la competencia digital que los profesores en formación en las tres áreas medidas.

En segundo lugar, se investigó la influencia de los factores (sexo, edad, nivel educativo) sobre la competencia digital de los profesores en activo y en formación. Además, se investigaron algunos factores contextuales de los profesores en activo, como los tipos de centro, los años experiencia docente o el *hardware* disponible (ordenador de sobremesa, portátil o tableta, pizarra inteligente interactiva).

La formación inicial de los profesores se considera un elemento fundamental para mejorar el nivel de competencia digital de todos los profesores en el futuro. Por lo tanto, este estudio aporta apoyo teórico a la formación inicial y continua de los profesores de K-12 en China, siendo una de las principales recomendaciones para mejorar la competencia digital de los profesores chinos en esta disertación.

Varios factores cruciales fomentan actitudes positivas hacia las tecnologías digitales. Principalmente se extraen algunas estrategias clave sobre la excelencia o las mejores prácticas para el enfoque integrado de la formación del profesorado y para mejorar la formación del profesorado chino: (1) los formadores de profesores como modelos a seguir; (2) el andamiaje de experiencias tecnológicas auténticas; (3) el aprendizaje del diseño instruccional con tecnología; (4) la reflexión sobre el papel de la tecnología en la educación; y (5) la modalidad de formación.

Por último, a partir de las conclusiones obtenidas en el diagnóstico de la autopercepción del profesorado en la provincia de Anhui, teniendo como principal recomendación para la mejora de la competencia digital de los profesores chinos la formación, se ha diseñado un programa de formación adaptado a las necesidades identificadas en el contexto chino. En concreto se han integrado cinco estrategias claras sobre la excelencia o las mejores prácticas para la formación del profesorado para mejorar la formación del profesorado chino.

El programa de formación está diseñado para profesores chinos en formación y en activo en función de sus diferencias de características sociodemográficas. Según el plan del programa de formación, este proceso de formación durará en torno a siete meses.

Se seleccionó la tercera edición del Marco de competencias TIC para docentes de la UNESCO (UNESCO, 2018) como marco utilizado. En este programa de formación, el primer y el segundo módulo son los módulos base para la formación cognitiva y de habilidades en la integración de las TIC en la educación. El tercer módulo es un módulo puente entre los dos primeros, y los dos últimos módulos están diseñados para profesores con competencias digitales avanzadas. El último módulo forma a los profesores en activo en los niveles de gestión para que desempeñen un papel de liderazgo en la concepción de una estrategia tecnológica para su centro educativo con el fin de convertirlo en una organización de aprendizaje.

En este programa de formación también se incluye una planificación de la evaluación formativa, con doce prácticas, y de la evaluación sumativa. A partir de las indicaciones de Hamodi et al. (2015), en cada actividad se describen los medios de evaluación, las técnicas de evaluación, los instrumentos de evaluación y las normas de evaluación.

En cuanto a los medios de evaluación, serán los productos realizados por el alumnado para demostrar lo que han aprendido a lo largo del proceso teniendo en cuenta tres formatos diferentes (escrito, oral y práctico).

Con respecto a las técnicas de evaluación, son las estrategias que utilizan los profesores para recoger información sobre los productos y las pruebas creadas por los participantes (a partir de los medios). Las técnicas para utilizar son diferentes en función de si el estudiante participa o no en el proceso de evaluación. Si las técnicas son aplicadas unilateralmente por el profesor, se utilizará una u otra en función del formato del medio (escrito, oral o práctico). Para los medios escritos, se utilizará la técnica de análisis documental y de producción (o revisión de trabajos); para los medios orales o prácticos, se utilizará la observación o el análisis de una grabación (audio o vídeo). Si el estudiante participa en el proceso de evaluación, las técnicas de evaluación pueden ser la autoevaluación, la evaluación entre iguales o coevaluación y la evaluación colaborativa o compartida:

> a) La autoevaluación, que consiste en la valoración por parte del alumno de sus propias pruebas o resultados en función de criterios previamente negociados. Puede llevarse a cabo mediante la autorreflexión y/o el análisis documental.
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> b) Evaluación entre iguales o coevaluación, por la que el alumno evalúa a sus compañeros de forma recíproca, aplicando criterios de evaluación previamente negociados. Puede realizarse mediante el análisis documental y/o la observación.
>
> c) Evaluación colaborativa o compartida, que realiza el profesor con el alumno sobre la valoración de los procesos de enseñanza-aprendizaje que han tenido lugar. Estos diálogos pueden ser individuales, o grupales. Puede llevarse a cabo mediante entrevistas individuales o grupales entre profesores y alumnos.

Sobre los instrumentos de evaluación, serán las herramientas que tanto profesores como alumnado utilizan para registrar de forma organizada la información recogida a través de una determinada técnica de evaluación. Se trata de un proceso riguroso para registrar la información procedente de las técnicas de evaluación de forma sistemática y precisa.

Finalmente, el presente estudio contribuye a los trabajos existentes relacionados con la competencia digital de los profesores que se discuten en el marco teórico. Tras el análisis del marco teórico, se identifica la necesidad de una actualización del marco nacional chino para la competencia digital de los profesores, así como el desarrollo de algunos marcos regionales para la competencia digital de los profesores que se puedan poner en práctica, especialmente en la provincia de Anhui.

En suma, la presente tesis doctoral se suma a los resultados ya mostrados en trabajos previos en los estudios empíricos relacionados con la competencia digital para la formación del profesorado, centrándose en los profesores en formación de una provincia de China para evaluar el nivel de competencia digital de los profesores en formación y explorar los factores que influyen en su percepción de la competencia digital. Los resultados del estudio realizado como parte de esta disertación muestran el estado del nivel de competencia digital de los profesores en la provincia de Anhui mediante el uso de un método de medición estadística. El resultado del estudio también aporta una visión sobre la mejora en el marco de la competencia digital de los profesores y las innovaciones de la formación del profesorado en esta región.

Sin embargo, es importante enfatizar la necesidad de trabajar en la formación de la competencia digital de los profesores durante su preparación en la universidad y desarrollar cursos de formación en TIC bien diseñados para los profesores en activo. Por otra parte, la formación del profesorado actual en el contexto actual de China necesita considerar no solo el uso pedagógico de las TIC para preparar a los profesores en formación y en servicio para la práctica, sino también explorar lo que significa la competencia digital a nivel individual para el aprendizaje de los profesores en formación y en servicio durante la formación del profesorado.

Por último, se identificaron un conjunto de limitaciones:

1) La recogida de datos, desarrollada mediante un muestreo incidental, consistió en profesores de educación primaria y secundaria de la provincia de Anhui, por lo que los resultados no pueden generalizarse a todo el país. A continuación, el estudio realizó un cuestionario en línea para recopilar los datos, excluyendo a los participantes con un bajo nivel de competencia digital que no estaban dispuestos a responder al cuestionario. Dado que el instrumento se diseñó originalmente para profesores en formación, los resultados de la evaluación de la competencia digital de los profesores en formación obtenidos en este estudio pueden ser controvertidos.

2) En cuanto a las limitaciones relacionadas con los resultados del estudio, la evaluación de esta investigación se ha realizado a partir de escalas de autopercepción de la competencia, no de la competencia real. Además, este estudio indicó que los profesores en activo más jóvenes tienen mejores niveles de competencia digital percibida en el aprendizaje técnico y la enseñanza que los profesores de más edad. Aquellos con menos experiencia docente también mostraron más competencias técnicas en la preparación de recursos, el diseño de procesos y la reserva de prácticas. Sin embargo, el estudio carece de una exploración más profunda de la expresividad profesional relacionada con la comparación de la competencia digital de los profesores en activo y en formación.

3) Este estudio tiene una limitación para investigar cómo los actuales cursos de formación en TIC impactan en las actitudes e intenciones de comportamiento de los profesores en formación y en servicio hacia el uso de las TIC, así como en el impacto en los resultados de aprendizaje.

Como líneas de trabajo futuro, destaca la posibilidad de medir el impacto en los resultados del aprendizaje de los profesores en activo y en formación a través de un diseño cuasi-experimental pretest-postest con un muestreo aleatorio y un grupo de control sin intervención. Además, podría aplicarse un estudio longitudinal para analizar la evolución de los niveles de competencia digital docente de los profesores en activo durante el curso de formación propuesto. Asimismo, podría aplicarse otro estudio longitudinal para investigar cómo influye el curso de formación en TIC en el trabajo futuro de los profesores en activo a la hora de transferir las competencias en TIC y su integración en la enseñanza desde la formación inicial a la práctica en el aula.

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