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Review Article

Digital Competence of Students in Higher Education: A Systematic Review (2019-2023)

Yang Yang[1,2], Tien Tien Lee[1, 3]* and Yi Zhang[2]

[1]*Faculty of Social Sciences & Liberal Arts, UCSI University, 56000 Cheras, Kuala Lumpur, Malaysia*
[2]*School of Information and Business Management, Chengdu Neusoft University, 611844 Chengdu, Sichuan, China*
[3]*Department of Chemistry, Faculty of Science and Mathematics, Universiti Pendidikan Sultan Idris, 35900 Tanjong Malim, Perak Darul Ridzuan, Malaysia*

ABSTRACT

The effective use of digital technology enables students to confidently navigate tasks in daily life, work, and academia. The growing prevalence of generative Artificial Intelligence (AI) tools underscores the urgent need for higher education institutions to enhance students' digital competence. This systematic review was conducted using the PRISMA method, 42 articles were selected from Scopus and Web of Science from 2019 to 2023, aiming to provide an overview of research trends on university students' digital competence. Through thematic analysis, this study revealed four key research themes: digital competence evaluation, relationship studies, comparative studies, and strategies for improvement. The onion framework of digital competence that emerged from this study effectively illustrates the progression from core to specialized competencies. The authors advocate that targeted intervention strategies are essential to effectively improving students' digital competence. It is recommended that universities embed digital competence into educational philosophy, adopt interdisciplinary approaches, and incorporate it into curriculum design to comprehensively enhance students' digital competence and support their career development.

Keywords: Digital competence, higher education, onion framework, systematic review, university students

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E-mail addresses:
1002265931@ucsiuniversity.edu.my (Yang Yang)
lee.tt@fsmt.upsi.edu.my (Tien Tien Lee)
zhangyi@nsu.edu.cn (Yi Zhang)
*Corresponding author

INTRODUCTION

The advancement of digital technologies, coupled with numerous studies, has emphasized the importance of digital competence. As an essential skill for current

and future citizens, digital competence is indispensable in the digital age (Ferrari, 2013). To navigate daily work, education, employment, and entertainment with greater confidence, a certain level of digital competence is essential for citizens (Saltos-Rivas et al., 2021). Recently, there has been a surge of interest in research on digital competence, particularly within the higher education sector. Researchers are increasingly focused on examining the digital competence of university students, aiming to enable them to capitalize on the opportunities offered by digitization.

Digital competence extends beyond the mere acquisition of technical knowledge or specific skills. It encompasses strategies and values essential for effective and ethical engagement with digital technology (Pais, Quiroz, & Carrasco-Manríquez, 2023). In the educational context, digital competence includes students' abilities to utilize technology to access and consume information. It also involves students' use of technology to process, acquire, and evaluate information. Furthermore, digital competence entails the capacity to use digital technology for creating and communicating information (Hatlevik & Christophersen, 2013). In this study, digital competence refers to the cognitive skills required to actively and creatively use ICT, emphasizing applying these skills in various scenarios to support lifelong learning and active digital citizenship.

Initially, many studies concentrated on defining concepts such as digital literacy, digital skills, and digital competence (Spante et al., 2018), recognizing these as distinct but complementary concepts applicable in different contexts. In recent years, digital competence has gained increasing prominence in the education sector. During the COVID-19 pandemic, numerous studies focused on evaluating digital competence (Cerny, 2021; Zare et al., 2023) and exploring the relationships between digital competence and other variables (Heidari et al., 2021). The development of digital competence assessment frameworks has also emerged as a significant area of research, with many studies dedicated to creating and validating reliable and valid instruments (Saltos-Rivas et al., 2022). In higher education, scholars have primarily focused on the digital competence of students and teachers, with particular attention to students from diverse backgrounds (Zhao, Llorente, & Gómez, 2021). Recently, scholars have also investigated strategies for enhancing university students' digital competence. According to Mogas et al. (2023), students can get a lot better at using technology by using relevant digital resources like e-portfolios or mobile devices in teaching methods (Agila-Palacios et al., 2021).

Digital competence is intricately linked to students' academic pursuits and daily lives. Kim et al. (2018) discussed how acquiring digital competence can increase students' willingness to use technology. Those with higher levels of digital competence tend to experience greater success in digital learning environments (Bergdahl et al., 2020). This competence can directly or indirectly affect their academic engagement. During crises like the COVID-19 pandemic, universities that prioritize digital competence and

offer efficient, user-friendly platforms can significantly enhance students' academic engagement (Heidari et al., 2021). Moreover, students with strong digital competence can access critical information and services, perform online transactions, explore new technologies, and strengthen social relationships with friends and family. Digital competence also provides university students with more opportunities for career development or further academic pursuits (Vodă et al., 2022).

Between 2019 and 2023, numerous studies have explored digital competence among university students. However, there are limited systematic reviews on this topic. Existing systematic reviews have focused on definitions, theoretical frameworks, and research methodologies (Van Laar et al., 2017). While these studies have been confined to these three aspects, there has been no development in additional fields. Given this gap, re-examining the research on digital competence over the past five years and identifying new fields of study is significant for scholars. It can highlight evolving trends in research topics, identify the instruments used to evaluate digital competence and explore strategies for enhancing the digital competence of university students. Therefore, this systematic review aims to address the following three research questions by examining articles on the digital competence of university students published between 2019 and 2023.

1. What are the themes in research on digital competence among students in higher education?
2. What are the features of instruments used to evaluate students' digital competence in higher education?
3. What strategies are being implemented by higher education institutions to enhance students' digital competence?

METHODOLOGY

This systematic review is conducted by following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines (Moher et al., 2010), focusing on the digital competence of university students from 2019 to 2023. A systematic review involves identifying, selecting, and critically appraising relevant research on a clearly defined topic using a systematic and explicit approach and subsequently collecting and analyzing data from previous studies. The rationale for selecting this methodology lies in its ability to facilitate an accurate and reliable synthesis of the literature. In this review, we systematically analyzed articles about the digital competence of university students. The article search was conducted using the PRISMA method, which ensures clarity and transparency in the reporting of the systematic review process.

Database Selections

In this systematic review, the Scopus and Web of Science databases were chosen to search for the required thematic articles. Scopus and Web of Science are recognized as primary databases for international interdisciplinary academic literature (Chadegani et al., 2013). To narrow the

search scope, the title must include "digital competence," the topic must include "higher education," "universities," or "colleges," and "students" or "learners" while excluding titles, abstracts, and keywords that contain "faculties," "educators," "teachers," or "professors." The search string for each selected database is as follows:

- TITLE ("digital competence")
- AND TITLE-ABS-KEY ("higher education" OR universit*)
- AND TITLE-ABS-KEY (studen* OR learne*)
- AND NOT TITLE (facult* OR educato* OR teache* OR professo*)
- AND NOT ABS (facult* OR educato* OR teache* OR professo*)
- AND NOT KEY (facult* OR educato* OR teache* OR professo*)

Inclusion and Exclusion Criteria

The research selection process is iterative and incremental, divided into several stages, and involves different activities. The initial search results included 204 articles. To screen for suitable studies, the following inclusion and exclusion criteria were established to select studies relevant to answering the research questions (Table 1). Initially, 204 articles were reviewed according to predefined inclusion and exclusion criteria, leading to the identification and removal of 23 duplicate articles. Additionally, 129 articles that did not meet the inclusion criteria were excluded. Experts then conducted further readings and quality reviews of the remaining 52 articles to ensure that the selected ones met the necessary standards to effectively address the research questions.

Quality Assessment

Articles that met all the inclusion criteria and did not match the exclusion criteria underwent a comprehensive review to ensure they met the specified quality standards. The selected articles were submitted to three experts for independent quality assessment. As noted by Chowdhury et al. (2024), spreadsheets are a convenient tool for classifying and analyzing data in biometric research and literature reviews. Therefore, the experts utilized Microsoft

Table 1
Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
The participants were students who studied in higher education institutions.	The participants include primary, secondary, and high school students, as well as teachers and other faculty members working in higher education institutions.
Published between 2019 and 2023.	Not published between 2019 and 2023.
Peer-reviewed full-text research papers.	Not peer-reviewed full-text research papers.
Written in English.	Written in other languages.
Empirical studies.	Literature review, commentaries or meta-analysis paper.

Table 2
Quality assessment criteria

Questions of quality assessment criteria	
1.	Is the research topic related to the digital competence of university students?
2.	Are the research objectives clearly defined?
3.	Are the research questions or hypotheses specified?
4.	Is the instrument clearly described and based on the design?
5.	Is the study sample clearly described?
6.	Are the research results adequately addressed in these studies?
7.	Are the conclusions clearly described and based on the results?
8.	Do the authors address the limitations of the study?
9.	Are suggestions made for improving digital competence in higher education?
10.	Are future research directions suggested?

Source: Zhao, Llorente, & Gómez (2021)

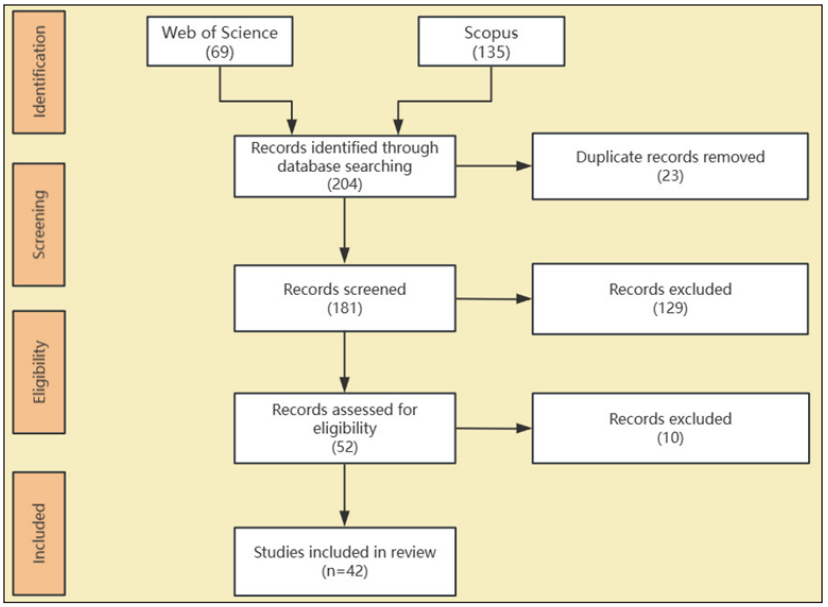

Figure 1. PRISMA flow of data extraction procedure

Excel spreadsheets to collect and organize data from the reviewed articles. The articles' quality assessment criteria include 10 questions that focus on the description of university students' digital competence, research objectives, research questions, research design, research instruments, research sample, research conclusions, research limitations, recommendations for future development of students' digital competencies, and future research directions (Table 2). Each question is evaluated based

on the clarity, relevance, and specificity of the responses in each article. Each question has three possible answers coded "Yes" (1 point), "No" (0 points), and "Partially" (0.5 points). The experts evaluated the articles based on the 10 questions listed in the criteria (Table 2). To be included in the final selection, an article must receive a score of 7.5 or higher from all three experts, which is the threshold for the selection of the article (Zhao, Llorente, & Gómez, 2021).

Three experts spent a month evaluating the quality of the 52 articles. Finally, 42 articles were selected for analysis, allowing the research questions to be addressed. The data extraction process is illustrated using the PRISMA flow diagram (Moher et al., 2010) in Figure 1.

RESULTS

Research Themes on Digital Competence

In the selected 42 articles, an evident trend is the increasing depth and specificity of research themes. These articles can be categorized into four primary themes: evaluating digital competence, relationship study, comparative study, and improving digital competence (Figure 2). Articles that focused on the evaluation of digital competence constitute the largest segment, representing 26%. This highlighted that the evaluation of students' digital competence has remained a significant research theme over the past five years. Additionally, there is a clear trend of increasing relationship studies, with an increasing number of variables influencing digital competence being validated, such as self-efficacy, time management, career adaptability, computer safety, and self-organization. This highlights a growing trend toward a more comprehensive understanding of digital competence, compared to the findings of Zhao, Llorente, and Gómez (2021), which included only two variables: digital information learning and digital readiness.

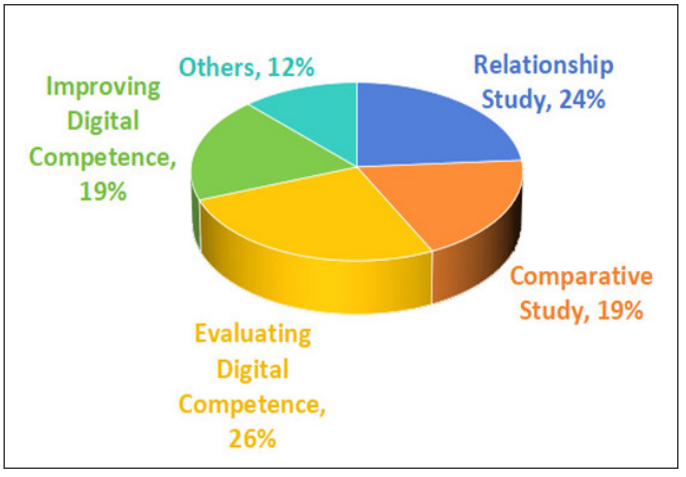

Figure 2. Different themes of research on students' digital competence

Evaluating Digital Competence

Among the 42 selected articles, the evaluation of university students' digital competence is the most prevalent topic, with a total of 11 articles (Table 3). Four articles examined students' self-perceived digital competence, while the remaining seven evaluated it based on various respondent backgrounds. These backgrounds include non-technical students, communication program students, public administration students, law students, students with disabilities, physiotherapy students, and online learners. Over the past five years, the scope of evaluating digital competence among different types of university students has expanded, reflecting a trend toward greater diversity compared to previous periods.

Relationship Study

Ten articles explored the relationship between digital competence and other factors (Table 3). Four articles highlighted the significance of digital informal learning, indicating a strong research focus on the interplay between it and digital competence. Two articles examined self-efficacy as one of the variables, discussing how digital competence correlates with students' learning efficiency. Other variables related to digital competence include time management, career adaptability, and factors from the Decomposed Theory of Planned Behavior (DTPB) model (He et al., 2020; Taylor & Todd, 1995), self-organization, the ability to learn, seek help, learn independently, and various learning approaches. It indicates that students' digital competence is interconnected with multiple variables, which collectively impact their academic performance (Wang et al., 2021).

Comparative Study

Eight articles conducted comparative analyses of digital competence under varying conditions (Table 3). Three of these studies focused on temporal comparisons,

Table 3
Different themes about digital competence

Themes	Sub-themes	References
Evaluating digital competence	General students' self-perceived digital competences	Guevara-Otero et al. (2023) Leví-Orta et al. (2020) Martzoukou et al. (2020) Zhao, Gómez, et al. (2021)
	Students study non-technical program	Tóth et al. (2022)
	Students in the communication program	Crawford-Visbal et al. (2020)
	Students in public administration	Budai et al. (2023)
	Students study in law-related courses	Martzoukou et al. (2022)
	Physiotherapy students	Røe et al. (2023)
	University students with disabilities	Cabero-Almenara, Gutiérrez-Castillo, Palacios-Rodríguez, & Guillén-Gámez (2023)
	Online learners	Vishnu et al. (2022)

Table 3 *(continue)*

Themes	Sub-themes	References
Relationship Study	The relationship between digital competence, digital informal learning, and academic engagement	Heidari et al. (2021)
	The relationship between digital competence, digital informal learning, and technology expectancy	He & Li (2019)
	The relationship between digital competence, digital informal learning, and DTPB factors	He et al. (2020)
	The relationship between digital competence, career adaptability, digital informal learning, and academic performance.	Zhou et al. (2023)
	The relationship between digital competence, time management, and self-efficacy	Galindo-Domínguez & Bezanilla (2021)
	The relationship between digital competence, computer anxiety, and self-efficacy	Katsarou (2021)
	The relationship between digital competences, self-organization, and independent learning abilities influences digital learning	Scheel et al. (2022)
	The relationship between digital competence, help-seeking, and learning agency influence university students' well-being during the pandemic by reducing cognitive load and burnout	Wang et al. (2021)
	The relationship between digital competence on perceived stress, burnout, and well-being	Kumpikaitė-Valiūnienė et al. (2021)
	The relationship between digital competence and different learning approaches	Niu et al. (2022)
Comparative Study	Different time frame: 2018–2020	Cerny (2021)
	Different time frame: during the COVID-19	Zare et al. (2023)
	Different time frame: before and during the COVID-19 pandemic	Burgos et al. (2023)
	Different countries: Belgium and Romania	Vodă et al. (2022)
	Different countries: Spain and Latin America	Pérez-Escoda et al. (2021)
	Different countries: Italy and Spain	López-Meneses et al. (2020)
	Different schools: university students from technical-vocational secondary education (TVSE) and scientific-humanistic secondary education (SHSE)	Pais, Véliz-Campos, & Quiroz (2023)
	Different competence: students have had to repeat a year or not	Cabero-Almenara, Gutiérrez-Castillo, Guillén-Gámez, & Gaete-Bravo (2023)
Improving digital competence	E-portfolios	Mogas et al. (2023)
	Electronic resource "Oracle"	Tolmachev et al. (2022)
	Digital tools	Araújo-Vila et al. (2020) Baranovska et al. (2023)
	Digital tools and social networks	Rodríguez-Moreno et al. (2021)

Table 3 *(continue)*

Themes	Sub-themes	References
	Gamification teaching method	Humeniuk et al. (2022)
	Project-Based Learning (PBL), Case-Based Learning (CBL)	Agila-Palacios et al. (2021)
	Blended learning course	Sánchez et al. (2022)
Other Studies	Digital safety competences	Pais, Quiroz, & Carrasco-Manríquez (2023)
	Environmental protection	Amador-Alarcón et al. (2022)
	The internet used to classify digital competence	Martinez-Lopez et al. (2020)
	Identify latent classes among university students based on their digital competence levels	Burgos-Videla et al. (2021)
	Instrument of SDiCoS	Tzafilkou et al. (2022)

specifically utilizing the COVID-19 pandemic as a critical segmentation point. Another three studies compared the digital competence of university students across different countries, thus employing macro-level conditions as the research premise. Additionally, two studies examined micro-level conditions, such as the differences in digital competence among first-year university students from diverse secondary education backgrounds and the impact of academic year repetition on digital competence. Over the past five years, comparative studies of university students' digital competence have explored both macro and micro-level factors, with a pronounced emphasis on macro-level conditions. This trend highlighted the significance of broader contextual factors in understanding and evaluating digital competence among university students.

Improving Digital Competence

Eight articles have discussed the use of various teaching resources and methods to enhance the digital competence of university students (Table 3). Five studies have explored the impact of different digital resources, such as e-portfolios, electronic resources "Oracle," digital tools, and social networks, on improving students' digital competence. Three studies have highlighted the effectiveness of targeted teaching methods, including gamification, project-based learning, case-based learning, and blended learning courses, in enhancing digital competence. Since the onset of COVID-19, there has been increased attention from researchers on improving students' digital competence.

Other Studies

A small number of articles address various specialized research topics (Table 3). Two articles focus on sub-digital competence, such as digital safety competence and environmental protection. Over the past five years, research on students' digital competences has increasingly focused on specific competence areas, reflecting a trend

towards more in-depth analysis of aspects of digital competence.

Two articles categorized university students based on their levels of digital competence, one into three categories and the other into four categories. The researchers recommended developing tailored training programs to enhance digital competence for students at different levels (Burgos-Videla et al., 2021).

Another article developed a digital competence assessment instrument specifically for university students (Tzafilkou et al., 2022). An analysis of 42 articles revealed that 15 of these studies employed instruments designed to assess the digital competence of university students, all of which were developed before 2019. Over the past five years, researchers have paid limited attention to the development of new digital competence instruments tailored for university students.

The Features of the Digital Competence Instrument

The selection criteria mandated empirical studies and a comprehensive reasoning process, leading to the evaluation of university students' digital competence in all 42 articles. Most of the articles used digital competence assessment tools as their main idea, and they looked at different aspects of digital competence (Figure 3). Approximately 12% (n = 5) of the studies did not explicitly state the evaluation dimensions. Instead, the studies provided questions only. Additionally, researchers typically classify about 5% (n = 2) of the studies as having a single dimension, as they concentrate on a specific subdomain

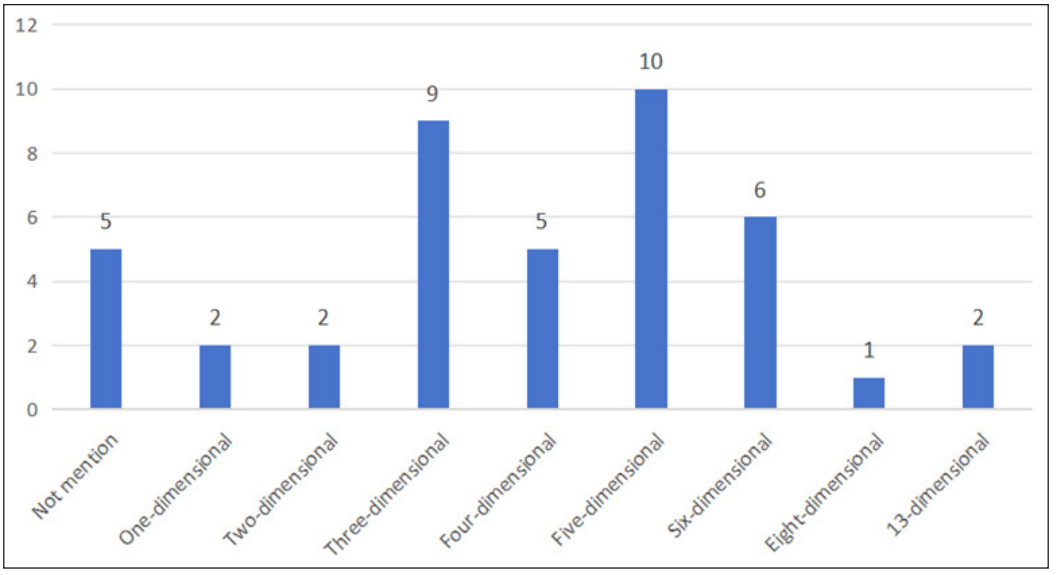

Figure 3. Instruments with different dimensions

of digital competence. Furthermore, three studies integrated different digital competence assessment frameworks from previous research, resulting in instruments with as many as eight or 13 dimensions. The five-dimensional instrument is the most used, appearing in about 24% (n=10) of the studies. Overall, the instruments primarily concentrated on three to six dimensions. These instruments exhibit both similarities and differences in their content across the various dimensions (Appendix 1).

Common Features

The DigComp Framework, developed by the European Union, emerged as the most frequently cited instrument, explicitly mentioned in 17 studies, including six mixed studies and one qualitative study. However, it is to be noted that the dimensions of the instrument were often modified. The DigComp Framework provided a unified vision of the necessary skills for addressing various aspects of digital challenges. Its objective is to establish a common language applicable to diverse tasks, including policymaking, goal-setting, planning, evaluating, and monitoring education (Pais, Quiroz, & Carrasco-Manríquez, 2023). "University students' Basic 2.0 Digital Competence" (COBADI) Framework, which is registered in Spain, is also frequently cited and explicitly mentioned in five studies, including a mixed study. COBADI primarily measures the digital competence of information search, management, and communication in the perceptible Web 2.0 (Martinez-Lopez et al., 2020). Additionally, some studies referenced specialized evaluation instruments tailored to the themes of the articles and the characteristics of the research subjects. Some of the tools that were used to look at informal learning were the Technological Skills (TS), Cognitive Skills (CS), and Ethical Knowledge (EK) questionnaires (Heidari et al., 2021). The Digital Literacy Questionnaire for Language Learners (DLQ-LL) was used to test language learners' digital skills (Katsarou, 2021), and the Digital Competence Profiler (DCP) was used to test online learning (Kumpikaitė-Valiūnienė et al., 2021).

The most common dimensions used to measure university students' digital competence in the 42 articles were information and data literacy, communication, and collaboration (Appendix 1). This shows that these skills are seen as the basis of digital competence (Guevara-Otero et al., 2023). Digital content creation also emerged as a critical dimension, consistently appearing across multiple frameworks, reflecting the importance of skills in creating and managing digital content (Crawford-Visbal et al., 2020). The emphasis on technological skills and cognitive skills within these multidimensional frameworks suggests that both technical proficiency and cognitive abilities are essential in navigating the digital environment. These skills are often integrated with information processing and problem-solving competence, forming a comprehensive approach to understanding and applying digital technology (He & Li, 2019). Additionally, security and ethical

knowledge were prominently featured, particularly in more advanced frameworks, highlighting the critical importance of safe practices and ethical behavior within digital contexts (He et al., 2020; Røe et al., 2023). The fact that educational and learning-related parts are included, like ICT used in university learning (Burgos-Videla et al., 2021), digital literacy tests (Katsarou, 2021), and educational parts (Humeniuk et al., 2022), shows how important it is to improve digital competence in school settings.

Differences and Unique Features

Firstly, it is important to highlight the variation in the number of dimensions across frameworks, ranging from a single dimension to as many as thirteen. This variation indicates differing levels of depth and complexity in how digital competence is conceptualized and understood across studies and frameworks. Frameworks with fewer dimensions generally concentrate on core competence, while those with more dimensions encompass a broader and more detailed spectrum of skills and knowledge areas.

Secondly, there is a differential emphasis on specific competence. Higher dimensions more frequently highlight skills like critical thinking, problem-solving, and creativity, indicating their integral role in advanced levels of digital competence. Additionally, some instruments introduce specialized skills, such as digital innovation and digital citizenship, which are absent in lower-dimensional frameworks. The fact that attitudes toward ICT tools are included in digital competence measures shows the importance of this dimension. This is especially true for more complex instruments. These elements are critical as they influence an individual's acceptance and effective use of technology (Tóth et al., 2022; Zhao, Gómez, et al., 2021).

Thirdly, interdisciplinary and personalized development is a distinctive feature of higher dimensions. These instruments often incorporate personal development components and interdisciplinary elements, such as the integration of education and engineering (Humeniuk et al., 2022), emphasizing that digital competence extends beyond technical skills to include the holistic development of individuals across various disciplines and contexts (Martzoukou et al., 2022; Tolmachev et al., 2022).

Strategies to Enhance Students' Digital Competence

There are eight of the 42 selected articles focused on various methods for enhancing students' digital competence (Table 3). Five articles explored the application of digital resources, while three implemented targeted teaching methods to improve digital competence. In the discussion sections of some articles, it was suggested that establishing digital skills courses, such as ICT courses, is the most efficient way to enhance students' digital competence (Agila-Palacios et al., 2021; Burgos-Videla et al., 2021). However, it is also noted that digital skill courses alone are insufficient. A comprehensive digital reform of the entire academic program is necessary,

integrating programming and algorithmic thinking throughout the curriculum to foster enduring competencies (Cerny, 2021). While some articles emphasized the importance of enhancing the digital competence of university students, they did not specify methods. Others explicitly stated that improving university students' digital competence should be a focus of future research (Martzoukou et al., 2022; Zhou et al., 2023).

Digital Resources

The selected articles indicated that enhancing university students' digital competence can be effectively achieved using various digital resources and tools. For instance, the use of e-portfolio evaluations has been shown to facilitate the development of digital and autonomous skills, thereby enriching the overall learning process (Mogas et al., 2023). Tolmachev et al. (2022) employed an Information Digital Resource (IDR) model to demonstrate that the electronic resource "Oracle" effectively supports the development of digital competence among business school students. Similarly, Baranovska et al. (2023), through instructional experiments, showed that the integration of digital tools within a holistic pedagogical approach significantly enhances the digital competence of future philologists. Additionally, the effective use of social networking platforms can improve students' communication and collaboration skills within digital environments (Rodríguez-Moreno et al., 2021).

Targeted Teaching Methods

Three studies have recommended the implementation of targeted teaching methods to enhance students' digital competence. Humeniuk et al. (2022) pointed out that using the Gamification of Learning theory in schools can get students more involved and help them learn how to use technology well. Similarly, Sánchez et al. (2022) reported that the blended learning method effectively improves students' digital competence by requiring them to interact with various digital resources and tools throughout the learning process, thereby enhancing their digital competence. Agila-Palacios et al. (2021) investigated Problem-Based learning (PBL) and Case-Based learning (CBL) as ways to teach and compare how they affected students' digital competence by redesigning the course. This comparison demonstrated that redesigning existing pedagogical methods is a prevalent strategy for advancing the digital competence of university students.

DISCUSSION

This systematic review examines the research themes, features of instruments, and strategies for improving the digital competence of university students over the last five years. Since 2013, digital competence has witnessed a significant surge in academic interest (Spante et al., 2018). Scholars from various countries have examined digital competence from diverse perspectives, covering a wide range of topics. Before 2017, a significant number of studies focused on digital competence

definition (Van Laar et al., 2017). However, the advent of the COVID-19 pandemic in 2019 and the subsequent shift toward online learning have underscored the critical importance of digital competence, particularly in its impact on students' academic performance when interacting with other variables (Kumpikaitė-Valiūnienė et al., 2021). During the pandemic, students were exposed to more informal learning scenarios, making digital competence a key factor in the effectiveness of informal learning, which aligns with the findings of He and Li (2019). Another emerging trend is the growing intersection between digital competence and career development. With the widespread integration of digital technology across various industries, digital competence has become a critical factor in personal career advancement (Zhou et al., 2023). Consequently, university students must prioritize the enhancement of their digital competence as part of their career planning. This focus enables them to adapt to the rapidly evolving demands of the job market and capitalize on emerging career opportunities (Baranovska et al., 2023).

The evaluation of university students' digital competence has emerged as a key research focus over the past five years. Academic background has been identified as a primary determinant of the disparities in digital competence among students. Specifically, differences in educational backgrounds contribute to varying levels of digital competence, with first-year students from Scientific-Humanistic Secondary Education (SHSE) exhibiting higher digital competence compared to Technical-Vocational Secondary Education (TVSE; Pais, Véliz-Campos, & Quiroz, 2023). Additionally, students' disciplinary fields significantly influence their digital competence. For instance, students pursuing technical degrees often had greater exposure to technological literacy, aligning with the findings of Sánchez-Caballé et al. (2021). Conversely, students in non-technical fields, such as law, have been reported to possess digital innovation skills at a more basic level (Martzoukou et al., 2022). Furthermore, access to digital resources is a critical factor affecting the level of digital competence among students. Students who attend universities equipped with advanced digital facilities or that offer diverse digital courses tend to demonstrate greater efficiency in their studies. This observation is consistent with He et al. (2020).

Currently, university students exhibit a high level of awareness regarding their technical skills, particularly in the use of digital tools for information retrieval and communication. However, their awareness of digital content creation, digital security, and problem-solving remains relatively underdeveloped (Budai et al., 2023; Guevara-Otero et al., 2023). On a positive note, students have demonstrated a strong awareness of the environmental implications associated with the use of various digital devices. Amador-Alarcón et al. (2022) emphasized the necessity of adopting effective measures and attitudes to fully and optimally engage with the digital environment. Consequently, it

is imperative to implement effective strategies for managing electronic waste while leveraging digital tools to promote sustainable development (Amador-Alarcón et al., 2022).

Evaluating students' digital competence necessitates the use of specialized digital assessment instruments. Among the 42 selected empirical research studies, a variety of instruments were employed. The findings indicated that the scope of digital competence extends far beyond the traditional concept of digital literacy. The onion framework for digital competence in this paper was modified from Saunders' framework (Saunders et al., 2019). This framework (Figure 4) illustrates the progressive relationship between core competence and specialized competence within digital competence. As the levels progress from the innermost to the outermost layers, the complexity and specialization of these competences increase incrementally.

The onion framework of digital competence places information and data literacy, communication, and collaboration at its core, symbolizing their fundamental role in digital competence (Guevara-Otero et al., 2023). These competences were most frequently discussed in the 42 articles reviewed (Figure 4). In academic settings, students must first develop strong information and data literacy to effectively collect and analyze information. Subsequently, they must leverage communication and collaboration to share this information with team members and engage in meaningful collaborative discussions (Burgos et al., 2023). Digital content creation, problem solving, and security are in the second

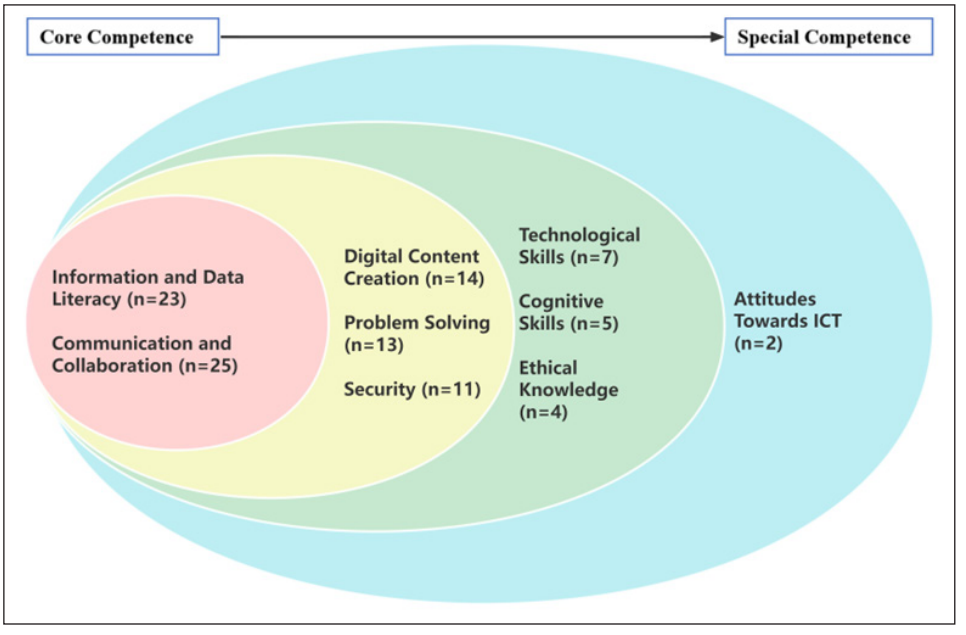

Figure 4. Onion framework of digital competence (*Source*: Adapted from Saunders et al., 2019)

layer, suggesting that once basic digital competencies are established, students can advance these skills. Technological skills, cognitive skills, and ethical knowledge are in the third layer, indicating that a higher level of technical and cognitive ability is needed for creating high-quality digital content (He et al., 2020). The placement of security and ethical knowledge across layers emphasizes the importance of safe practices and ethical behavior in digital environments. These competencies often require advanced skills and sensitivity for effective navigation. In digital environments, students need technological skills to protect personal data and ethical knowledge to ensure their actions align with moral standards (Budai et al., 2023). Attitudes towards ICTs are in the outermost layer, suggesting that individuals' attitudes towards digital technologies influence their use and development of these competences. A student's attitude towards ICT tools affects their frequency and effectiveness in using them. Students who are open to and positive about new technologies are more likely to actively learn and acquire new skills, continually enhancing their digital competence (Tóth et al., 2022). Digital competence has become a multidimensional concept, with these dimensions collectively forming essential components of 21st-century skills (Van Laar et al., 2017).

Enhancing the digital competence of university students can be achieved through various approaches, with the utilization of digital resources being one of the most frequently cited methods. These resources encompass a wide array of digital tools and platforms, including digital learning. Mastery of these tools and platforms can significantly bolster students' digital skills, as they offer abundant learning and practical opportunities that enable students to acquire and refine digital competence in practical contexts (Araújo-Vila et al., 2020; Tolmachev et al., 2022). Through these platforms, students can access up-to-date knowledge and technologies, conduct self-assessments, and engage in interactive learning experiences. This not only enhances their digital competence but also fosters independent learning abilities and self-organization skills within the digital environment (Scheel et al., 2022). The adoption of innovative teaching methods is another crucial aspect of current curriculum reforms in higher education aimed at enhancing students' digital competence. Methods such as gamification and blended learning emphasize active student participation and practical application (Humeniuk et al., 2022; Sánchez et al., 2022). These pedagogical methods encourage students to apply digital skills in real-world scenarios, thereby enhancing their overall digital competence.

Providing specialized digital courses is a direct and effective strategy for improving the digital competence of university students (Cerny, 2021). Such courses may cover a range of topics, including basic computer operations, internet security, data processing, advanced programming, artificial intelligence, and data analysis. However, while these specialized courses

are beneficial, it is essential to integrate digital competence into various academic disciplines and courses (Galindo-Domínguez & Bezanilla, 2021). This integration enables students to comprehend and apply digital technologies within diverse disciplinary contexts. Moreover, as noted by Burgos-Videla et al. (2021), higher education institutions should develop tailored training programs based on the varying levels of students' digital proficiency. This differentiated instructional approach enhances students' digital competence by providing foundational training for those with lower levels of competence and advanced courses for those with higher levels. These personalized programs ensure that all students achieve the maximum possible improvement in their digital competencies.

CONCLUSION

In the digital age, digital competence is essential for both personal and professional development, extending beyond technical staff to become a critical skill for everyone. This is particularly evident in higher education, where students' digital competence significantly influences their academic performance and future career prospects (Zhou et al., 2023). This systematic review aimed to assess the research on university students' digital competence from 2019 to 2023. Using the PRISMA method, 42 articles were selected from Scopus and Web of Science databases, based on specific inclusion and exclusion criteria, to address three key research questions. First, the research themes on digital competence have diversified, including digital competence evaluation, relationship study, comparative study, and strategies for improvement. Second, various instruments were used to evaluate digital competence, with both commonalities and differences among them. Third, the most common strategies to enhance digital competence involve the use of digital resources and the development of targeted teaching methods. Overall, research on university students' digital competence has gained significant attention over the past five years, driven by the COVID-19 pandemic and ongoing technological advancements. Future research should focus on holistic approaches, integrating digital competence into broader educational frameworks and practices.

Implications of the Study

Implications for Practice

This systematic review offers a comprehensive analysis of research on university students' digital competence. The findings highlighted the growing importance of digital competence in higher education. By examining 42 articles, this review provides valuable insights into the strengths and weaknesses of students' digital competence, serving as a benchmark for educators, policymakers, and researchers. These insights are crucial for informing educational policy, curriculum design, and targeted teaching interventions, ensuring effective resource allocation and improved digital competence among students.

The study of digital competence assessment instruments enables scholars to gain deeper insights into their underlying content and methodologies, providing a solid foundation for selecting the most appropriate tools. The evaluation outcomes from these instruments revealed which educational practices and curriculum content are most effective in enhancing students' digital competence. These findings informed the optimization of curriculum design and instructional strategies, aligning them more closely with students' learning needs and the evolving demands of the labor market. A comprehensive understanding of these instruments allows educators to accurately identify the specific competencies measured by each instrument and ensure that all essential dimensions are thoroughly assessed. Furthermore, recognizing the distinctions among various instruments enables educators to select the most suitable assessment framework based on their educational context and pedagogical objectives.

Implications for Theory

Recent studies over the past five years have revealed that the DigComp and COBADI frameworks are the most used tools for assessing digital competence. The original DigComp framework comprises five dimensions and 21 indicators. However, many studies have extended this framework by adding new dimensions, thereby broadening the scope of digital competence and advancing theoretical developments in its assessment. Similarly, the COBADI framework, initially structured with three dimensions, has been expanded to four in subsequent research, offering new insights into digital competence frameworks. A review of 42 studies highlights that the dimensions of digital competence have evolved to become more precise and comprehensive. The use of these modified assessment tools allows for a more accurate evaluation of university students' digital competence levels.

Limitations

This systematic review is limited to research on the digital competence of university students from 2019 to 2023. The focus was specifically on the term "digital competence", excluding related terms like "digital literacy" and "digital skills". This choice reflects the terminology commonly used in European contexts, where "digital competence" is prevalent (Zhao, Llorente, & Gómez, 2021). As a result, many selected articles feature European authors, though this should not imply that other regions disregard the importance of digital competence. It simply reflects regional research trends.

The review exclusively examined the digital competence of university students, deliberately excluding studies on teachers and other groups. However, the digital competence of university teachers significantly impacts students, making it a vital area for future research. Additionally, this review does not cover the digital competence of middle or primary school students, despite its potential influence on their future academic opportunities.

Understanding the digital competence of middle school students is crucial, as it plays a key role in their educational pathways and success.

Recommendations for Future Research

Despite extensive research on digital competence and its relationships with various variables over the past five years, further exploration is needed to uncover additional variables that could deepen our understanding of these connections. While many studies have assessed students' digital competence, the dimensions used are often broad and general. Few studies have explored specific aspects, such as digital competence related to environmental protection. Future research should focus on these sub-dimensions to accurately evaluate competence levels in particular areas, offering more detailed insights and a comprehensive understanding of digital competence in various contexts. The onion framework of digital competence can serve as a valuable tool for future researchers by providing a comprehensive and precise perspective on the layered structure of digital competence, ranging from core competence to specialized competence.

Moreover, there is a relative scarcity of research on strategies to enhance university students' digital competence. Although many studies acknowledge the importance of improving digital competence, they often lack comprehensive solutions. Some studies have used qualitative methods to examine the impact of digital resources and innovative teaching methods, but these approaches alone are insufficient. Future research should integrate digital competence into teaching concepts, projects, and curricula within higher education. This holistic approach is essential for effectively enhancing students' digital competence, ensuring they are well-prepared to meet the demands of the digital age.

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APPENDIX 1

Different dimensions of selected instruments

Types	Dimensions	References
One dimension	• Communication and collaboration • Safety Area	AgilaPalacios et al. (2021) Pais, Quiroz, & CarrascoManríquez (2023)
Two dimensions	• ICT knowledge and usage for social communication and collaborative learning • ICT for information search and processing	GuevaraOtero et al. (2023)
	• Use of digital tools as part of university learning • Use of consumer, learning and visualization technologies as part of university learning	AraújoVila et al. (2020)
Three dimensions	• Technological skills (TS) • Cognitive skills (CS) • Ethical knowledge (EK)	Heidari et al. (2021) He et al. (2020) He & Li (2019) Sánchez et al. (2022)
	• Competence in the use of ICT for the search and management of information • Competence in the use of ICT in social communication • The university's virtual tools and social communication	MartinezLopez et al. (2020) LópezMeneses et al. (2020)
	• Office technology • Communication • Extension of informatics tools	Zare et al. (2023)
	• Information and data literacy • Communication and collaboration • Digital content creation	CrawfordVisbal et al. (2020)
	• Social DC • Informational DC • Epistemological DC	KumpikaitėValiūnienė et al. (2021)
Four dimensions	• Competences in knowledge and use of ICT in social communication and collaborative working • Competences in knowledge and use of ICT for information search and processing • Interpersonal competences in the use of ICT in the university context • Virtual and social communication tools are used in the University	Burgos et al. (2023) BurgosVidela et al. (2021)

	• Subjectpedagogical element of the digital component	Humeniuk et al. (2022)
	• Engineering and computer competencies	
	• Common User component of ICT competence	
	• General pedagogical component of ICT competence	
	• Motivationalvalue component (MVC)	Tolmachev et al. (2022)
	• Cognitive component (CC)	
	• Activity component (AC)	
	• Personality development component (PDC)	
	• Computing and digital skills	Katsarou (2021)
	• Use of digital technologies	
	• Digital literacy test	
	• Factors affecting the use of digital technologies for language learning	
Five dimensions	• Information and data literacy	GalindoDomínguez & Bezanilla (2021)
	• Communication and Collaboration	PérezEscoda et al. (2021)
	• Digital content creation	Cerny (2021)
	• Security	Vishnu et al. (2022)
	• Problem solving	Zhou et al. (2023)
		Pais, VélizCampos, & Quiroz (2023)
		Røe et al. (2023)
		Budai et al. (2023)
	• Availability of technical equipment	Tóth et al. (2022)
	• Attitude towards the use of digital technologies	
	• Level of technical skill	
	• Ability to concentrate and multitask in education	
	• Learning materials	
	• Availability of ICT resources	Zhao, Gómez, et al. (2021)
	• Potential for digital competence	
	• ICT and digitalrelated training	
	• Selfperception in digital competence	
	• Attitude towards ICTs	
Six dimensions	• Communication and collaboration digital skills	Vodă et al. (2022)
	• Creative digital skills	
	• Critical digital skills	
	• Information digital skills	
	• Problemsolving digital skills	
	• Technical digital skills	

	• Technological literacy • Search and information processing • Critical thinking, problemsolving and decision making • Communication and collaboration • Digital citizenship • Innovation and creativity • Search, find, access (SFA) • Develop, apply, modify (DAM) • Communicate, collaborate, share (CCS) • Store, manage, delete (SMD) • Evaluate (EV) • Protect (PR) • Information and data literacy • Communication and collaboration • Digital content creation adopted • Safety and security adopted • Problemsolving • Analyzing and reflecting	CaberoAlmenara, GutiérrezCastillo, GuillénGámez, & GaeteBravo (2023) CaberoAlmenara, GutiérrezCastillo, PalaciosRodríguez, & GuillénGámez (2023) RodríguezMoreno et al. (2021) Tzafilkou et al. (2022) Scheel et al. (2022)
Eight dimensions	• Information and data literacy • Communication and collaboration • Digital content creation • Safety • Solving problems • Critical attitude • Development of digital competence • Selfperception measuring the relevance of promoting digital competence	Mogas et al. (2023)
13 dimensions	• Everyday participation as a digital citizen • ICT proficiency in completing different task • ICT productivity • Information identification in different contexts • Information literacy skills • Digital creation skills • Digital research skills • Digital communication skills • Digital innovation • Digital learning and development • Digital abilities to complete academic work • Digital identity management • Digital wellbeing	Martzoukou et al. (2020) Martzoukou et al. (2022)