REVIEW ARTICLE

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Digital transformation and digital literacy in the context of complexity within higher education institutions: a systematic literature review

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The incessant changes in technology generate new products and services, presenting multiple opportunities for the complex educational environment. Consequently, higher education institutions must be attentive to these changes to ensure that students have the knowledge and skills necessary for the work environment. This research aimed to identify studies related to digital transformation and digital literacy in higher education institutions through a systematic study of literature. The search resulted in 830 articles published in the Scopus and Web of Science databases from 2015 to 2022. Quality questions, inclusion and exclusion criteria were applied where 202 articles were selected for the study. The results show (a) interest of educational institutions in empirical studies where technologies are incorporated for didactic purposes, (b) challenges of opportunity in training programs to develop digital competences of teachers and students, (c) little interest in the development of media literacy, (d) the methodological aspects of the studies allow exploring new perspectives of digital transformation in higher education. This article may be of interest to academics, decision-makers and trainers of future professionals to introduce educational technology into learning processes in line with the complex demands of the world of work and society.

Introduction

At the end of the twentieth century, the emergence of the internet led to organizations' digital transformation from analogous to digital information ("digitization"), followed by the incorporation of information technologies into business processes ("digitalization") (Verhoef et al., 2019). Several authors make no distinction between digitalization and digital transformation (Hess et al., 2016; Tratkowska, 2020; Xiao, 2020). Verhoef et al. (2021) propose that digital transformation goes further; its impact generates new business models and value creation. Organizations' various areas are influenced and committed to change to remain relevant (Anderson and Ellerby, 2018). For this study, the term "digital transformation" (DT) was used.

Digital transformation goes beyond just incorporating technologies. An example of this is to consider that digital technologies and automation demand that the workforce develop digital

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skills and human-centered skills (Digital Transformation Expert Panel, 2021), which impacts aspects such as culture, processes, as well as the strategy of the organization (Fischer et al., 2020) consequently the organization must make the necessary adjustments for its effective implementation. These impacts reach all business lines including higher education.

Higher education institutions, in particular, must be attentive to the changes in the environment and society to ensure that students have the knowledge and skills demanded. Morin (2019, 2020) invites us to think of complexity as a challenge of contemporary thinking, which requires a reform of our way of thinking, since classical scientific thinking was previously built on three foundations: order, separability and reason, but developments in science have undermined these foundations. In this sense, high-level competences such as reasoning for complexity become indispensable in the formation of critical, systemic, scientific and innovative thinking (Ramírez-Montoya et al., 2022; Vázquez-Parra et al., 2022). Complex environments require active (Patiño et al., 2023), collaborative (Romero-Rodríguez et al., 2022), open education (Suárez-Brito et al., 2022) and digital technology systems (George-Reyes et al., 2023; Ponce et al., 2022). Because of this, education systems around the world have made various efforts to address the influence of digital technologies and DT, such as UNESCO's 'Working Group on Education on Digital Skills and Work' (UNESCO, 2017), the "Bologna Digital 2020" report in Europe (Rampelt et al., 2019), the "Outline of China's National Plan for Medium and Long-term Educational Reform and Development (2010–2020)" of the Chinese government (Xiao, 2020), and the Digital Educational Agenda ADE.mx in Mexico (SEP, 2019). Likewise, this transformation has triggered the development of topics of interest that intertwine education with technology as proposed by González-Pérez et al. (2019) (Table 1):

Currently, skills performed in digital environments have been added to the basic skills performed in analog environments. Digital literacy involves mastering software and hardware, development, analysis, and interaction with digital content (Chetty et al., 2018). Skills such as problem-solving and applying technology were derived from digital technologies (UNESCO, 2017), and are considered essential for workers to adapt to digital transformation (Digital Transformation Expert Panel, 2021). As new technology becomes available to users, it demands from them continuous learning to remain relevant.

Due to the above, it is worthwhile to research the use and impact of technologies in the educational field on the delivery of content, pedagogical practices, and evaluation and management of learning (Williamson and Hogan, 2020), as well as its impact on users, teachers and students. Systematic studies of related literature are scarce, during this investigation, we found four reviews ranging from 2020 to 2021; they focused on the development of digital skills of students (Starkey, 2020), or university professors (Bilbao Aiastui et al., 2021), on digital competence assessment processes and methods in higher education (Sillat et al., 2021), and one focused on media literacy (Manca et al., 2021). This study contributes to the subject by integrating digital transformation practices in education, as well as studies on digital competencies of students and teachers, which are key roles of higher education institutions.

This article aims to identify recent studies (2015–2022) related to the issues of digital transformation and digital literacy in higher education institutions through a systematic study of literature. The study seeks to answer what educational trends higher education institutions are using, as well as what studies they have carried out in this regard, and the opportunities they have identified to advance in digital transformation and digital literacy. This study can serve as a basis for higher education institutions interested in exploring educational innovations to identify these implementations and their outcomes and seek inter-institutional collaborations with common interests.

Methodology

The study was conducted through a systematic literature review (SLR) based on the guidelines proposed by Kitchenham and Charters (2007, p. 11), "a means to identify, evaluate and interpret relevant research on a particular topic". The phases to carry out the study were adapted from Kitchenham et al. (2010) and are described as follows:

- Phase 1 Planning: The research starts from the objective of analyzing studies related to the topics of digital transformation and digital literacy in higher education institutions. A series of questions were defined to guide the review; these questions were derived from the integration of elements that would contribute to identify trends in digital transformation, research methods and instruments used in assessing such practices, as well as opportunities for future research; such findings would be useful to other researchers interested in the subject (Kitchenham and Charters, 2007) (Table 2).
- Phase 2 Execution: The articles were selected using inclusion criteria such as the publication period between 2015 and 2022, studies in higher education institutions, focus on students and professors, and empirical research or mixed studies. Articles not arbitrated or published in languages other than Spanish and English were excluded (Table 3).
The search was conducted based on the above criteria in the Scopus and WoS databases (Table 4). 202 studies met the specified criteria (Fig. 1).
- Phase 3 Results: The results of each research question were analyzed to determine the educational trends higher

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Table 1 Specific emerging issues in the use of educational technology.

Categories

- Digital pedagogies: adapting pedagogical and technological resources to each area of knowledge. An example is b-learning, an environment with multimedia technologies.
- Technology models: integrating innovation models with technology, such as smart innovation systems and research-based design.
- Adaptive technologies: introducing new e-learning systems that adapt to the new needs of society and foster adaptive learning and educational systems (e.g., e-portfolios and Web 2.0).
- Open technologies: enable open access to disseminate open knowledge, including open platforms, repositories, open resources, MOOCs, and open science.
- Smart technologies: using smart tools and devices, such as Big Data, data mining, data analytics, cloud technologies, cloud computing in educational contexts, and m-learning.
- Disruptive technologies: involving new processes and services with leapfrog technologies, such as augmented reality, sensory stimulation, abstract imagery, and virtual and remote laboratories.

education institutions incorporate, the studies they have carried out in this regard, and the opportunities to advance in digital transformation.

Results

Results are presented based on the research questions. For data analysis, Excel and Power BI were used. The database is available at the following link: https://doi.org/10.6084/m9.figshare.21972170.v2.

RQ1 What are the trends and topics addressed in the articles? The trends identified were determined based on the emerging themes of educational technology by González-Pérez et al.

(2019), highlighting digital pedagogies (166 articles), which "link pedagogical and technological supports to adapt to each area of knowledge" (González-Pérez et al., 2019, p. 189). Examples include implementing the "blended learning" strategy (Power and Kannara, 2016; Tang and Chaw, 2016; Wang et al., 2022) and studies on digital skills (Ting, 2015; Tømte et al., 2015; Torres-Gastelú et al., 2019) and media competencies (Koc and Barut, 2016; Jormand et al., 2022) Second place went to adaptive technologies (21 articles) that "introduce systems that adapt to the needs of society and encourage learning" (González-Pérez et al., 2019, p. 189). Examples are the use of Web 2.0 tools (Sichel et al., 2019), e-portfolio (Carl and Strydom, 2017), e-Learning (Divya and Mohamed Haneefa, 2018; Feriady et al., 2020), adaptive systems (Murray and Pérez, 2015), and social networks (Amaro-Jiménez et al., 2016; Robles Moral and Fernández Díaz, 2021).

To a lesser extent, the rest of the trends were found in 6 articles on technological models (Andrew et al., 2018; Bond et al., 2018; Kör et al., 2017) and open technologies (Cronin, 2017; Paskevicius and Irvine, 2019; Spieler et al., 2020). Finally, there were articles on disruptive technologies that use extended reality resources (Astudillo Torres, 2019; Bucea-Manea-Țoniş et al., 2020) and smart technologies for mobile learning (Pinto Molina et al., 2019) (Fig. 2).

The analysis of the author's keywords highlighted the issue of digital competence and digital literacy (de Ovando Calderón and Jara, 2019; Liu et al., 2020; Oria, 2020) and, to a lesser extent, digital teaching and media literacy (Tetep and Suparman, 2019; Sánchez-Caballé and Esteve-Mon, 2022) Also notable were keywords regarding technology in these topics (Roa Banquez et al., 2021; Rodríguez-Hoyos et al., 2021) (Fig. 3).

RQ2 What are the trends in research methods observed in the articles? Studies on digital literacy and digital transformation increased in the last three years; in 2022, it rose 53% compared to the previous year. The most commonly used research method (56%) was quantitative (Guillén-Gámez and Peña, 2020; Kim et al., 2018; Miguel-Revilla et al., 2020). Qualitative methods were found in similar proportions (Kajee, 2018; Önger and Çetin, 2018), and mixed methods (Pozos Pérez and Tejada Fernández, 2018; Techataweewan and Prasertsin, 2018) (Fig. 4).

Also, the highest number of articles was found in Spain, which represents 32% of the total, and shows an interest in digital transformation and digital literacy issues in higher education

Table 2 Research questions.

Research questions	Possible responses
RQ1 What are the trends and topics addressed in the articles?	Digital pedagogies Technological models Adaptive technologies Open technologies Smart technologies Disruptive technologies
RQ2 What are the trends in research methods observed in the articles?	Mixed methods Qualitative method Quantitative method
RQ3 What are the main findings in digital transformation and digital literacy?	Content creation Digital skill level Educational technology
RQ4 What are the authors' recommendations for future studies?	Larger scale Literacy Longitudinal studies New instruments Technology
RQ5 What are the opportunities identified in the studies?	Training programs Use of educational technology Improving learning design Security & Privacy Open practices
RQ6 What are the stated limitations in digital literacy studies involving digital transformation?	Sample Feasibility Technological problems Instruments

### Table 3 Inclusion, exclusion and quality criteria.

Inclusion	Exclusion	Quality criteria
Studies in the Scopus and WoS databases.	Studies on subjects other than students or teachers.	Coherence between the objective, method, and results.
Studies in higher education institutions.	Studies in languages other than Spanish and English.	
Studies published between 2015–2022. Empirical or mixed studies.	Conference papers, books, articles not arbitrated.	

Table 4 Search strings in Scopus and WOS.

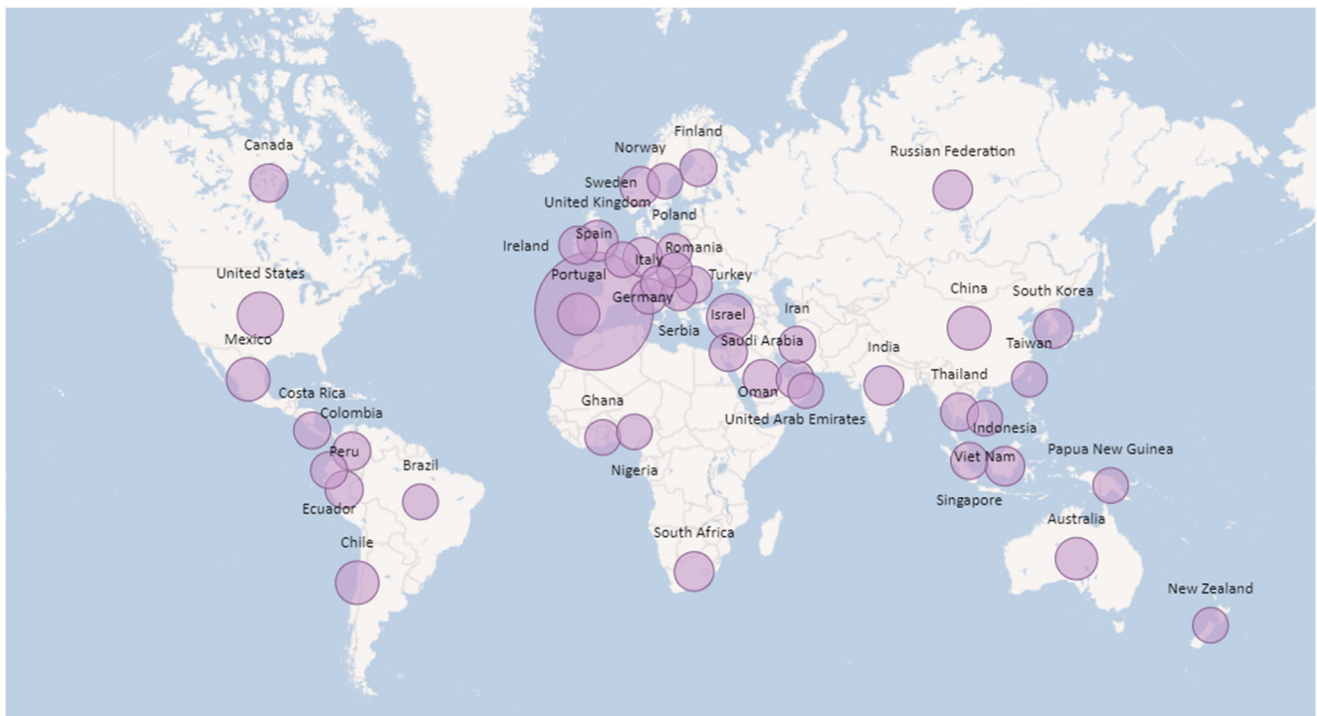| Scopus	WoS
TOPIC: (("digital transformation" OR "digital*")) AND TOPIC: (("university" OR "higher education" OR "tertiary education")) AND TOPIC: (("model" OR "framework" OR "system")) AND TOPIC: (("media literacy" OR "digital competenc*" OR "digital literacy"))	"digital transformation" OR "digital*" (Topic) AND "university" OR "higher education" OR "tertiary education" (Topic) AND "model" OR "framework" OR "system" (Topic) AND "media literacy" OR "digital competenc*" OR "digital literacy" (Topic) and Article or Review Article (Document Types) and English or Spanish (Languages)
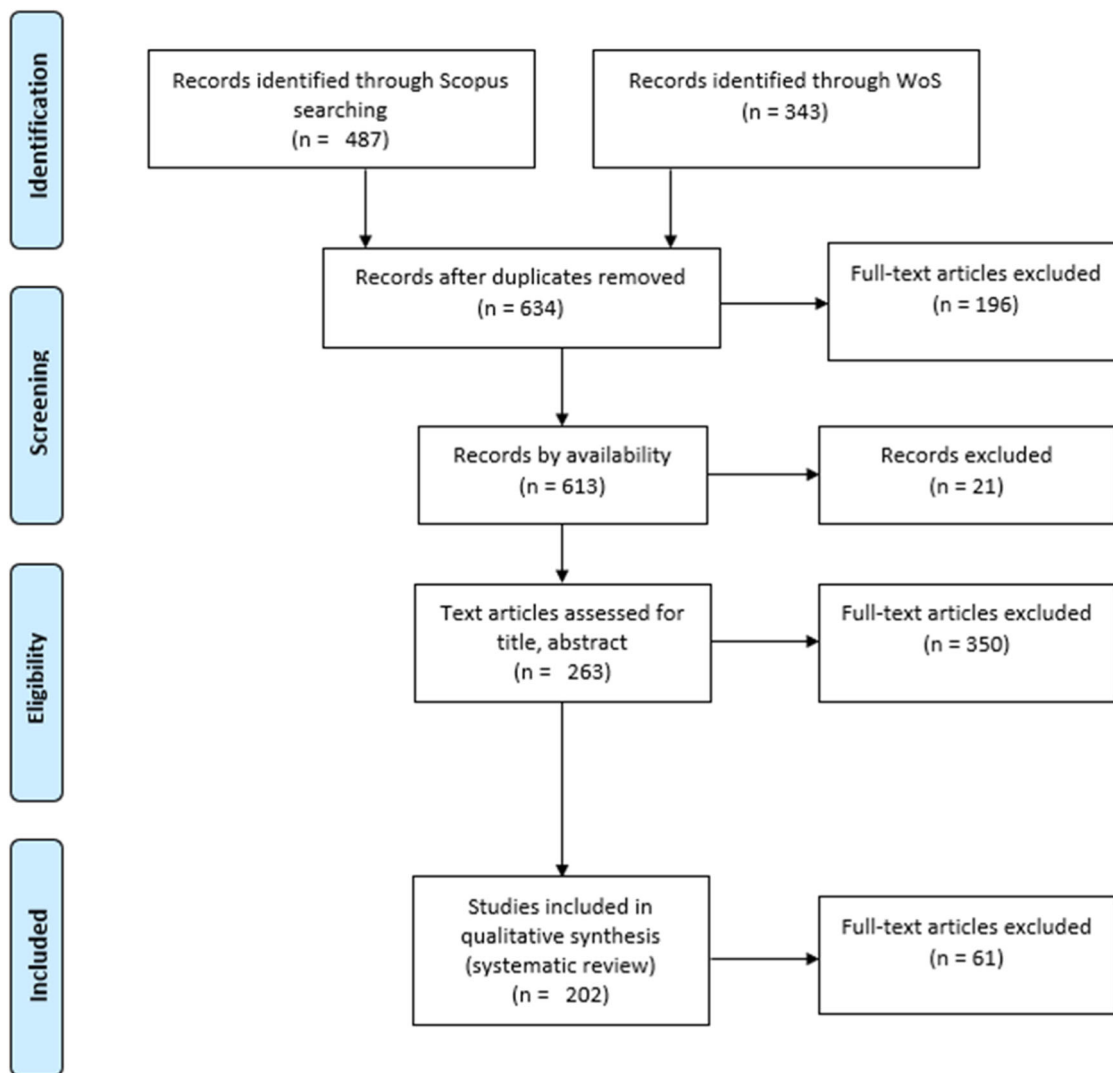
Fig. 1 Flow diagram. The flowchart presents the process of classifying the articles based on inclusion and exclusion criteria and the resulting number of articles. The flowchart was adapted from Moher et al. (2009).
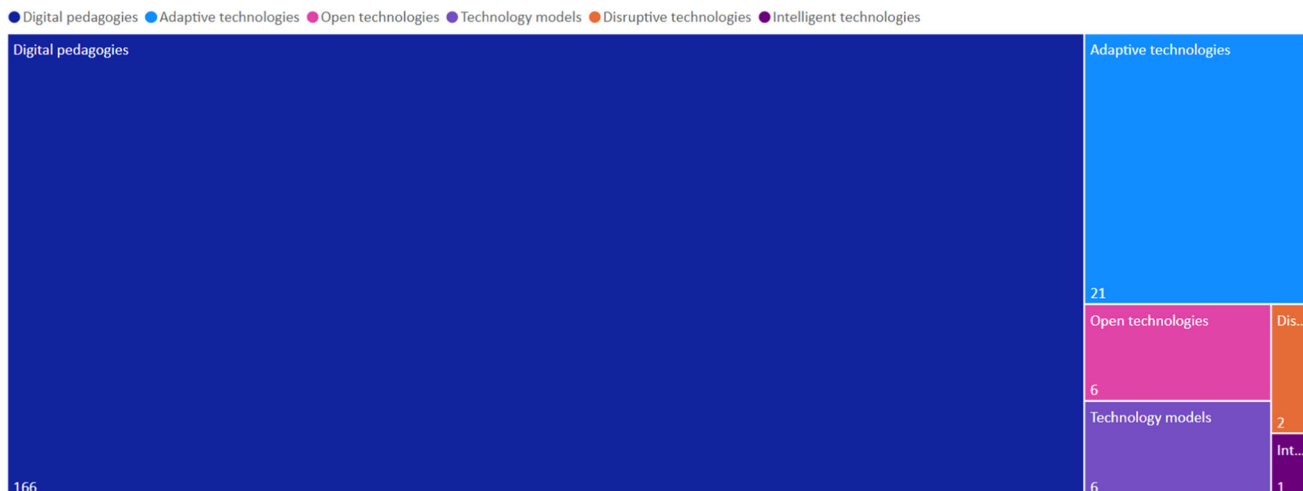
Fig. 2 Trends addressed by the articles. The rectangles show the proportion and number of published articles classified according to specific emerging issues in the use of educational technology as proposed by González-Pérez et al. (2019).

Fig. 3 Authors' keywords analysis in a word cloud. Main keywords identified in the reviewed articles.

Fig. 4 Trends in research methods. Number of published articles during 2015–2022 classified by research method, qualitative, quantitative or mixed method.

institutions; followed by Turkey with ten, the United States with nine, and Chile, China and Mexico with seven research papers each (Fig. 5).

RQ3 What are the main findings in digital transformation and digital literacy? The principal findings center on studies on the level of digital skills, and use of educational technology (Fig. 6). The most significant number of articles (121) focuses on digital competency (Blayone, 2018; Hong and Kim, 2018; Torres-Coronas and Vidal-Blasco, 2015; Zhao et al., 2021). The use of educational technology involves 2.0 technologies (Novakovich,

2016), virtual communities (Robin Sullivan et al., 2018), online education, or e-Learning (Aznar Díaz et al., 2019; Hamutoğlu et al., 2019; Gumede and Badriparsad, 2022). Regarding media literacy, it was found in eight articles (Altamirano Galván, 2021; Brown et al., 2016; Koc and Barut, 2016; Jormand et al., 2022; Leier and Gruber, 2021; Olivia-Dumitrina et al., 2019; Reyna and Meier, 2018; Robles Moral and Fernández Díaz, 2021). Two additional issues identified were environmental protection (Amador-Alarcón et al., 2022) and educational process (Makarova et al., 2021) both of interest to today's situation faced by higher education institutions.

Fig. 5 Location of the studies by country. Proportion of published articles distributed by country.

RQ3: What were the main findings?	Digital pedagogies	RQ1: What are the trends and topics addressed in the articles?				
		Adaptive technologies	Open technologies	Technology models	Disruptive technologies	Intelligent technologies
Digital skill level	121	3		1		
Educational technology	38	15	6	5	2	1
Media literacy	5	3				
Environmental protection	1					
Educational process	1					

Fig. 6 Main findings addressed in the literature review. Trends, topics and main findings from the reviewed articles.

RQ4 What are the authors' recommendations for future studies? And RQ5 What are the opportunities identified in the studies? By correlating these two questions, we identified four opportunities regarding digital literacy and digital transformation (Fig. 7); first, that higher education institutions have training programs for both students and teachers to help them develop digital skills (Igbo and Imo, 2020; Martzoukou et al., 2020; Sandí Delgado, 2020), media skills (López-Meneses et al., 2020; Reyna and Meier, 2018; Romero-Rodriguez et al., 2016), and critical thinking (Kocak et al., 2021; Nagel et al., 2022; Vetter and Sarraf, 2020). Second, that the development of skills requires to enhance learning design by incorporating new didactic strategies, and educational technologies in academic programs (Boulton, 2020; del Prete and Almenara, 2020; Foster, 2020; Liesa-Orús et al., 2020; McGrew et al., 2019), and that the impact of these changes improves learning (Castellanos et al., 2017; Dafonte-Gómez et al., 2018; Sosa Díaz and Palau Martín, 2018).

On the other hand, methodological recommendations for future studies included incorporating new instruments and variables to collect more information (Kamardeen and Samaratunga, 2020; Khalil and Srinivasan, 2019; Varga-Atkins, 2020; Vetter and Sarraf, 2020). Others pointed to increasing the sample size (Amhag et al., 2019; Kolodziejczyk et al., 2020; Munoz-Repiso and del Pozo, 2016; Pozo-Sánchez et al., 2020). To a lesser extent, longitudinal studies were recommended to test the

models used (He et al., 2018; Johnston, 2020). In addition, we found that 28% of the studies did not include recommendations, and 31% did not include opportunities for future studies.

RQ6 What are the stated limitations in digital literacy studies involving digital transformation? The limitations indicated in the studies refer primarily to the small sample size (45%) (Arango et al., 2020; Romero-Tena et al., 2020; Tugtekin and Koc, 2020). To a lesser extent, limitations were found with the instrument used to carry out the study (Heuling et al., 2021; Nikou and Aavakare, 2021; Sánchez-Caballé and Esteve-Mon, 2022). Problems with the technology used was another limitation highlighted in eight studies (Castellano, 2016; Pozo-Sánchez et al., 2020). Finally, seven studies reported limitation regarding its feasibility (Dafonte-Gómez et al., 2018; Fázik and Steinerová, 2020; Kerr et al., 2019) and one on the low response obtained (Myyry et al., 2022); 36% of the studies did not include limitations (Fig. 8).

Discussion

Incorporating educational trends and new technologies in the educational environment has highlighted the need to continue developing skills that allow their adoption by teachers and students. The interest in digital pedagogies and the study of digital competencies
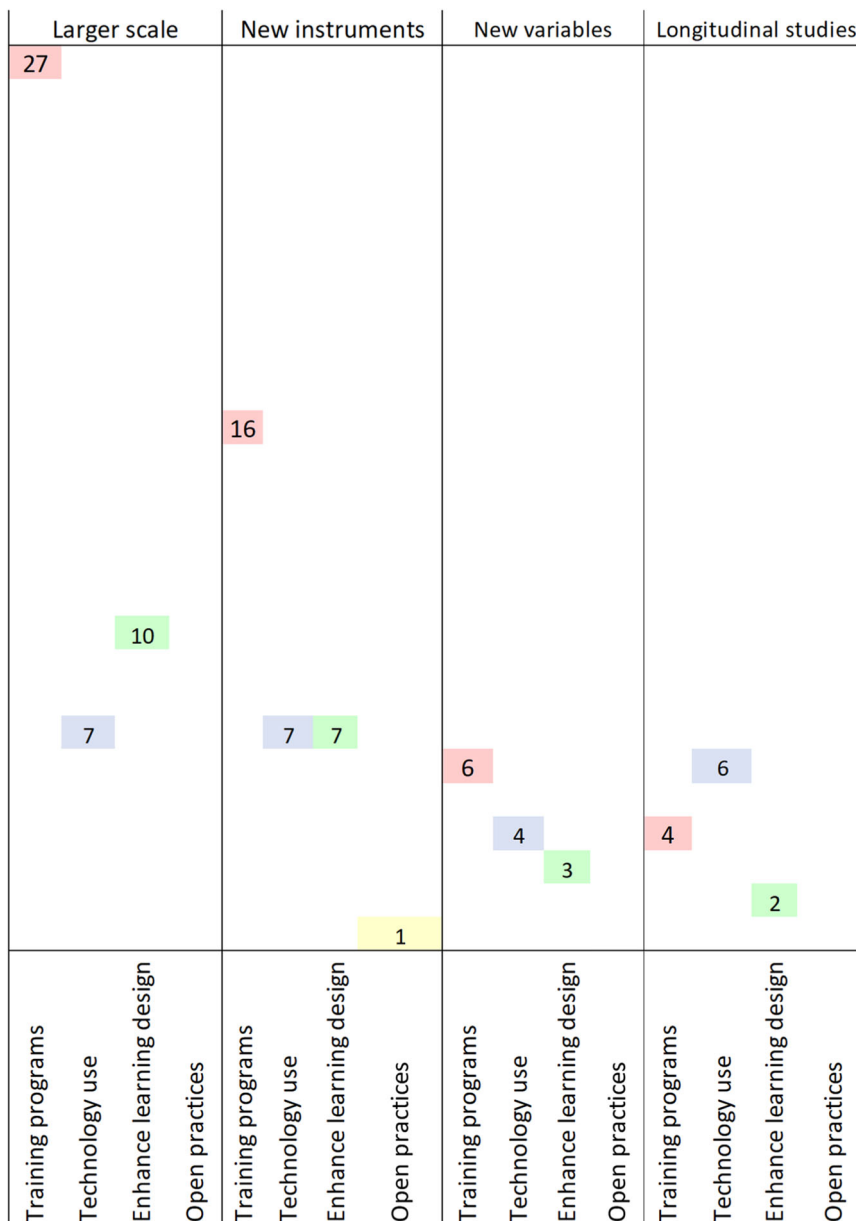
Fig. 7 Recommendations and opportunities for future studies. Frequency of recommendations and opportunities for future studies.
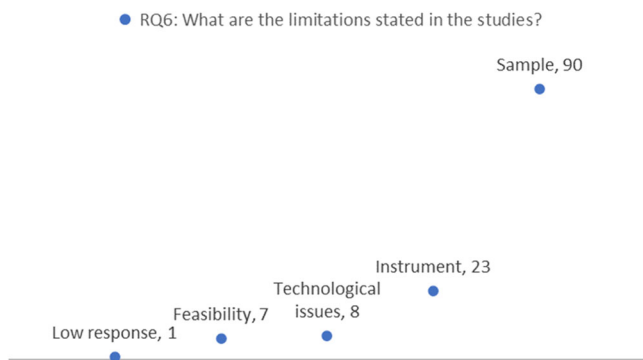
Fig. 8 Limitations identified in the studies. Frequency of limitations found in the reviewed articles. The figure does not include data from articles that did not specify the limitations (36%).

were relevant trends among higher education institutions aiming to use adaptive, intelligent, open, or disruptive technologies and technological models (Fig. 2). The transition from the analog to the digital world in both processes and products of organizations is part of their journey towards digital transformation (Hess et al., 2016; Tratkowska, 2020). It also includes organizational and cultural changes among users and operators (Anderson and Ellerby, 2018). However, we must point out that technology is not the end in itself but should be a means to facilitate learning.

Therefore, studies employing the scientific method where the benefit can be determined are relevant, and those that examine areas of opportunity by adopting technologies in the learning process. In the last three years, empirical studies on incorporating educational innovations in teaching practice in higher education institutions increased, most applying mainly quantitative methods (Figs. 4 and 5). Spain is the country that stands out with the most studies (64). In some cases, the impetus for these efforts has

come from the establishment of educational strategies at the national (SEP, 2019; Xiao, 2020) and regional level (Rampelt et al., 2019). These studies denote international interest in the influence of digital transformation, and digital literacy on the educational process.

Digital technology skills and knowledge are hallmarks of the twenty-first-century generations. Digital literacy and educational technology accounted for 95% of the study findings, and only 4% focused on media literacy. Required job competencies include software and hardware skills, critical thinking, information analysis, and the ability to create and communicate content (Chetty et al., 2018; Silva et al., 2021; UNESCO, 2017). "Workers who can combine 'human' skills like empathy, cooperation and negotiation with cognitive skills such as problem-solving, will thrive in an economy that increasingly relies on both types of skill" (Digital Transformation Expert Panel, 2021). As the work environment and education continue to evolve along new technologies.

In addition to the conceptual components, the methodological aspects of the studies allow exploring new perspectives of digital transformation in higher education. In the studies reviewed, 44% of the recommendations concerned using new instruments, and exploring new variables, while 56% were about sample size increase and longitudinal studies (Fig. 7). Although they have not been conceived or designed for the educational field, the technologies are embedded today in the learning process (González-Pérez et al., 2019). Studies on their adoption allow testing and validating methodologies and instruments to have reliable data for their implementation (García-Ruiz et al., 2014). Though used simultaneously by teachers and students, the adoption of technology may require the implementation of different strategies or approaches to meet the needs of each group.

The ability to learn and unlearn is being tested by constantly introducing technologies into human activities. The opportunities reported by the studies coincide with the need for institutions to have training programs to develop skills for larger groups (27%). In the case of students, other topics of interest are the use of technology, enriched learning experiences, and security and privacy issues (Fig. 7). Organizations' digital transformation strategy must consider the training of their members and their users because the skills required for the job become increasingly specialized (Anderson and Ellerby, 2018; Hess et al., 2016; Verhoef et al., 2019). In order to get the best out of educational technology, users are required to have a minimum level of digital literacy (Kerr et al., 2019). Higher education institutions are a fertile place to continue studies on digital transformation and the development of digital literacy of their members.

Therefore, empirical studies on the experiences and challenges faced by higher education institutions in adopting technologies in the learning process and strategies implemented to train teachers and students are relevant. The limitations reported in the studies focused on methodological issues, with the sample size being the most crucial aspect to consider (45%). These studies were carried out in groups managed by the researcher, making it difficult to project the results. The systematic literature review methodology emphasizes the analysis of variables to answer research questions so that similarities and differences among studies can be identified (Kitchenham et al., 2010; Kitchenham and Charters, 2007). Inter-institutional collaboration can contribute to achieving results that help find joint strategies to promote the adoption of educational innovations and the development of competencies in both teachers and students.

Limitations. This study was limited to trends in higher education institutions in a specific period of time (2015–2022). Another limitation was the selection of two databases, Scopus and Web of Science, which although they include high-impact journals, articles from other databases were not considered; future research can continue the timeline and include other systems and databases.

Conclusions

The digital transformation of higher education institutions goes beyond its impact on administrative and operational processes. The study showed that teachers have incorporated educational trends, new pedagogies and technologies for didactic purposes, and this has highlighted the need to develop the level of digital literacy of both teachers and students. Higher education institutions, as trainers of future professionals, must acknowledge the need for digital transformation and act upon to develop strategies so students and teachers are prepared for the demands of the workplace.

The pandemic spurred the urgency of developing digital skills for both teachers and students. Technologies they used for socializing and leisure became necessary tools for study and work. Higher education institutions are conducting studies on their experiences of adopting educational technologies and the impact on their users. Although related empirical studies on media literacy were scarce, since it is linked to the use of technology, future studies have an opportunity to assess how it develops in the following years. These should examine teachers' and students' performance, their critical capacity as media users, and content creators.

The development of teachers' digital competencies involves not only the mastery of technology but also the improvement of their teaching practice with the appropriate pedagogical use of technology to contribute to student learning. There are opportunities for higher education institutions in measuring digital competencies to find strengths and weaknesses to focus their training programs. The same applies to students, who should be provided with the relevant training for the development of digital skills and prevent the lack of these from becoming an obstacle to their performance in the classroom.

This study aimed to identify the state of digital transformation and digital literacy in higher education institutions and their impact on students and teachers. Digital transformation and new technologies are generating complex environments that demand the development of digital and high-level skills. Technological progress provides opportunities to enhance the learning process. Research must continue to assess the performance and students' learning gains. This study can serve as a basis for higher education institutions interested in exploring educational innovations to identify these implementations and their outcomes and seek inter-institutional collaborations with common interests.

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