

# Bridging Gaps in Online Learning: A Systematic Literature Review on the Digital Divide

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## Abstract

This study explores the evolution and challenges of the digital divide in online education, intensified by the COVID-19 pandemic's shift toward digital learning environments. A systematic literature review was conducted using three databases: Web of Science, Scopus, and the Education Resources Information Centre. The review focuses on identifying research designs, aims, and barriers within the literature from 2013 to 2023, highlighting the impact of the digital divide on access to educational technologies and digital literacy. A total of twenty-two articles were included in the dataset. The review reveals that despite advancements in online education technologies, significant disparities persist in access, digital skills, and educational outcomes, particularly affecting marginalized communities in both urban and rural settings. The study underscores the necessity for enhanced infrastructure, targeted educational policies, and inclusive teaching practices to bridge these gaps. Recommendations are provided for future research directions and practical implementations to mitigate the digital divide's impact on educational equity.

**Keywords:** digital divide, online learning, systematic literature review, educational equity, education and Technology

## 1. Introduction

### 1.1 Online Education

Bates (2015) states that the origins of online education can be traced back to early forms of distance learning pioneered by organizations such as the Open University, and that these early endeavors laid a solid foundation for transforming the educational paradigm. Initially characterized by correspondence courses and static online resources, online education has evolved significantly over the decades. One important milestone in this evolution is the emergence of complex virtual learning environments. Driven by continuous advances in information and communication technologies (ICT), these virtual platforms provide learners with immersive and interactive learning experiences comparable to traditional classroom environments (Weller, 2020). As Wiley and Hilton (2018) note, the rapid growth of online platforms and Learning Management Systems (LMS) has not only democratized access to education but also eliminated geographic barriers, significantly broadening educational opportunities for learners globally.

In addition, the online learning experience has been enriched by the integration of multimedia elements such as videos, simulations, and gamified content, catering to different learner styles and preferences (Anderson, 2004). This dynamic and interactive approach to education not only enhances learner engagement but also promotes deeper understanding and retention of knowledge (Means et al., 2009). The rise of Open Educational Resources (OER) has further contributed to the transformation of online education. Wiley and Hilton (2018) define OER as freely accessible and openly licensed educational materials that can be shared, reused, and adapted to the needs of learners. This spirit of openness and collaboration promotes the democratization of knowledge production and dissemination, enabling educators and learners to co-create, share, and collaborate on educational content.

Online education offers numerous advantages that transcend the limitations of traditional learning environments. Its flexibility allows learners to tailor their educational experience to their own schedules and preferences (Culduz,

2024). Furthermore, online education eliminates geographical barriers, granting learners access to a vast array of educational resources and expertise, regardless of their location (Allen & Seaman, 2017). In the current era of rapid technological advancement and socio-economic changes, online education holds significant importance. According to Ochieng and Waithanji (2023), online education provides marginalized individuals with access to quality education and training, thus promoting educational inclusion and equity. Additionally, online education fosters the development of critical thinking skills and digital literacy, which are essential in our increasingly complex and interconnected world (Marin & Castaneda, 2023). The evolution of online education reflects the convergence of technological innovation, pedagogical theory, and educational practice. From its early days as a form of distance learning to its current status as a global educational phenomenon, online education continues to reshape the educational landscape, offering new possibilities for teaching, learning, and collaboration in the digital age.

### *1.2 Digital Divide in Online Education*

Despite the significant transformative potential of online education, the digital divide remains a major obstacle to achieving equity in education. DiMaggio and Hargittai (2001) emphasize that the digital divide reflects substantial disparities in individuals' access to digital technology and Internet connectivity, perpetuating established socio-economic inequalities. This divide not only limits the full potential of online education but also hinders social mobility and economic empowerment (Warschauer, 2004).

Access disparities are a central element of the digital divide, marking the boundary between the 'digital haves' and the 'digital have-nots'. Van Dijk's (2005) study reveals the unequal distribution of digital infrastructure, with wealthy urban centers enjoying easy access to high-speed Internet connectivity, while rural and underserved areas are more likely to be poorly served. Such geographical disparities exacerbate social inequalities and deprive marginalized communities of access to basic education (Cruz-Jesus et al., 2016). The digital divide is not limited to the lack of technology and internet access; it also includes a lack of digital literacy, further worsening the plight of individuals from marginalized communities. Mossey and Manoharan (2019) state that digital literacy encompasses not only the technical skills required to navigate digital platforms but also the critical thinking skills to evaluate and utilize digital information. Individuals who lack digital literacy are often marginalized from the digital realm and struggle to fully integrate into the knowledge economy.

More importantly, the digital divide exacerbates the cycle of exclusion and marginalization, reinforcing existing gaps in educational attainment and socio-economic status. Warschauer and Matuchniak (2010) highlight that limited access to technology and internet connectivity constrains educational opportunities, particularly in resource-poor and marginalized communities. Consequently, individuals from disadvantaged backgrounds are often systematically excluded from the benefits of online education, further entrenching the cycle of poverty and social marginalization. In summary, the digital divide is a multifaceted challenge that involves not only issues of technological access but also encompasses digital literacy, geographic disparities, and socio-economic inequalities. These factors collectively impede the achievement of educational equity and social inclusion.

### *1.3 Factors Influencing the Digital Divide in Online Education*

The digital divide in online education is influenced by a variety of factors. Research has shown that students with strong social support networks are more likely to have access to the resources and assistance they need to better adapt to the online learning environment (Helsper & Van Deursen, 2017). This indicates that support from family, friends, and the community can significantly influence student engagement and learning outcomes in online education.

Furthermore, usage and affordability are also key factors. Hargittai's (2010) study found that differences in internet skills can lead to significant disparities in information access and use, which further exacerbates the unequal distribution of educational resources. Economic status likewise plays an important role in the digital divide. Anderson and Perrin (2018) noted that families with limited financial resources are more likely to suffer from inadequate technology access, which affects student learning outcomes.

In addition, the level of technological access is another determining factor. Van Deursen and Van Dijk's (2019) study suggests that the lack of a stable internet connection and modern learning devices significantly contributes to students' inability to fully engage in online learning. These technological barriers are particularly pronounced in rural or economically underdeveloped areas. These factors interact with each other to affect students' learning experiences and effectiveness in online education.

### *1.4 Research Questions*

An in-depth exploration of the digital divide in online education is critical to understanding and addressing

inequalities in access to and utilization of educational resources. Afzal et al.'s (2023) research highlights how socio-economic factors, geographic location, and technological infrastructure can combine to create a digital divide in online learning environments. By identifying the various barriers that marginalized groups encounter when accessing online education, educators and policymakers can develop more precise interventions aimed at promoting digital inclusion and ensuring equity in educational opportunities.

Furthermore, as Gupta and Verma (2024) highlight, in-depth analyses of the digital divide can reveal its multidimensional complexity, encompassing access, digital literacy, and educational achievement. By analyzing the complex interconnections and interactions between these factors, researchers can provide a strong basis for developing evidence-based strategies aimed at narrowing the digital divide and promoting educational equity in the digital age.

Table 1. A comparative analysis of related reviews

Author	Research Topics	Analyzed Dimension
Coleman	Remote education	1. Terminology and definition of digital exclusion 2. Terminology and definition of remote education
Ancheta-Arrabal et al.	Gender digital divide	1. Types of digital divide 2. The role of education in the digital divide
Maguraushe et al.	Shrinking the digital divide in online learning	1. Perceptions of students in learning online 2. Benefits of online learning 3. Challenges in learning online

Based on three systematic literature reviews on the digital divide and education (see Table 1), none of the current systematic reviews provide information on the research trends and theoretical stances in online education and the digital divide. Therefore, this study not only explores the research trends, theoretical foundations, research objectives, and designs in online education, but also pays special attention to the impact of these key factors on the digital divide. This research aims to bridge this gap by addressing the following research questions:

- 1) What were the research trends?
- 2) What theories were grounded upon or adopted?
- 3) What were the aims of these research?
- 4) What research designs were used?
- 5) What factors contribute to the digital divide in online education?

## 2. Methods and Materials

### 2.1 Systematic Searching Strategies

To ensure comprehensiveness, the scope of this study includes research conducted in K-12 education, higher education, vocational training, and adult continuing education settings. This scope was chosen to capture the ways in which the digital divide has manifested in different educational contexts. In searching for relevant articles, this study utilized the three systematic processes of identification, screening, and eligibility proposed by Shafri et al. (2021). By implementing these processes, the authors were able to comprehensively locate and synthesize studies, thus conducting a well-organized and transparent systematic literature review.

### 2.2 Identification

Based on the research questions posed, the study identified two main keywords: online education and digital divide. The researcher further enriched these keywords by searching for synonyms, related terms, and variants using online thesauri (e.g., deepl.com), referring to keywords used in previous studies, and consulting peers for their opinions. The combinations of these keywords were processed in two databases using search functions such as phrase search and Boolean operators: Scopus and Web of Science (see Table 2). The Education Resources Information Center (ERIC) was also included as it specializes in educational research.

Table 2. Search string used in the selected database

Database	String
Scopus	TITLE-ABS-KEY(("e-learning" OR "online learning" OR "online education" OR "distance learning" OR "remote education") AND ("digital divide" OR "digital inequality" OR "digital divide interventions"))
Web of Science	TS=("e-learning" OR "online learning" OR "online education" OR "distance learning" OR "remote education") AND ("digital divide" OR "digital inequality" OR "digital divide interventions"))

In addition, the search process included manual search techniques, with “hand-picking” conducted in the ERIC database. Based on the search results, a total of 1,767 potential articles were identified from the selected databases.

### 2.3 Screening

Screening is the second step in conducting a study, where articles are included or excluded based on specific criteria (see Table 3). In this process, the authors manually screened the articles with the assistance of Rayyan, a software tool that helps researchers screen titles and abstracts (Ouzzani, 2016). Given the rapid growth and changes in the field of online learning in recent years, some earlier studies may lack relevance to the current state of online learning technology. Therefore, this review limited the screening process to articles published between 2013 and 2023, ensuring a focus on the latest developments in online learning and the digital divide. Additionally, the authors only reviewed empirical studies that provided primary data. To avoid confusion, only papers written in English were considered in this review. Furthermore, only open-access studies were included for the convenience of the research. During this phase, 1,410 articles were excluded because they did not meet the inclusion criteria, leaving 357 articles available for evaluation in subsequent phases.

Table 3. Inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Studies focus on Online Learning	Focus on other educational modalities, such as traditional classroom-based instruction or hybrid models
Studies must explicitly address the concept of the digital divide in the context of online learning.	Not specifically examine or discuss aspects of the digital divide, or that only tangentially mention these issues without providing substantial analysis
Studies conduct on 2013-2023	2012 and earlier
Articles (with empirical data)	Review article, chapter in a book, book, conference proceeding, etc
Written in English	Written in other languages

### 2.4 Eligibility

Eligibility is the third step, where the authors manually checked the remaining articles to ensure they met all the criteria established after the screening process. This step involved reading the titles and abstracts of the articles. During this process, 313 articles were excluded for various reasons: focusing on online education and ICT rather than the digital divide, analyzing classroom settings of online education rather than perceptions of the digital divide, providing retrospectives instead of empirical evidence, being reviews rather than empirical studies, or lacking a clear methodology section, particularly those published as book chapters. Consequently, the number of articles that progressed to the quality assessment stage was 25 (see Figure 1).

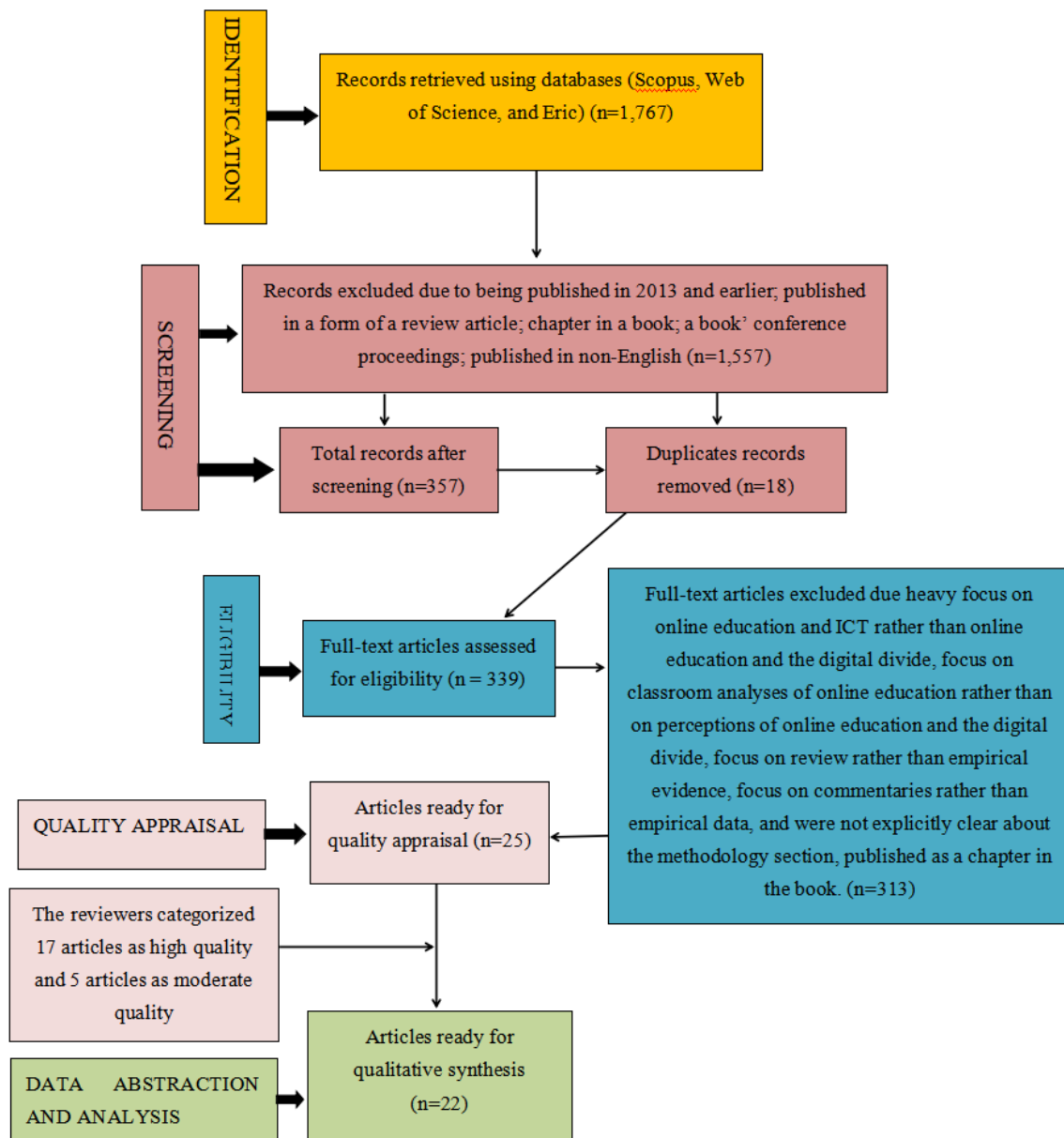


Figure 1. Flow diagram of searching process

### 2.5 Quality Appraisal

The aim of the quality assessment phase was to ensure that the methodological and analytical aspects of the selected studies were completed satisfactorily. To achieve this, the study utilized Hong et al.'s Mixed Methods Appraisal Tool (MMAT) (see Table 4). The MMAT allows researchers to assess systematic mixed-study reviews and covers the evaluation of five types of studies: qualitative studies, randomized controlled trials, non-randomized studies, quantitative descriptive studies, and mixed-methods studies (Hong et al., 2018).

Table 4. The criteria used to determine the rigor of the methodology and analysis used in the selected articles

Research Design	Assessment criteria
Qualitative	QA1—Is the qualitative approach appropriate to answer the research question?
	QA2—Are the qualitative data collection methods adequate to address the research question?
	QA3—Are the findings adequately derived from the data?
	QA4—Is the interpretation of results sufficiently substantiated by data?
	QA5—Is there coherence between qualitative data sources, collection, analysis and interpretation?
Quantitative (descriptive)	QA1—Is the sampling strategy relevant to address the research question?
	QA2—Is the sample representative of the target population?
	QA3—Are the measurements appropriate?
	QA4—Is the risk of nonresponse bias low?
	QA5—Is the statistical analysis appropriate to answer the research question?
Quantitative (non-randomised)	QA1—Are the participants representative of the target population?
	QA2—Are measurements appropriate regarding both the outcome and intervention (or exposure)?
	QA3—Are there complete outcome data?
	QA4—Are the confounders accounted for in the design and analysis?
	QA5—During the study period, is the intervention administered (or exposure occurred) as intended?
Mixed methods	QA1—Is there an adequate rationale for using a mixed methods design to address the research question?
	QA2—Are the different components of the study effectively integrated to answer the research question?
	QA3—Are the outputs of the integration of qualitative and quantitative components adequately interpreted?
	QA4—Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?
	QA5—Do the different components of the study adhere to the quality criteria of each tradition of the methods involved

With the assistance of the co-authors, the researcher carefully read each article, focusing on its methodological section and the analyses performed. Based on this review, all authors agreed that the selected articles met the minimum quality requirements in terms of methodology and analysis. A total of 22 articles met all criteria (see Table 5).

Table 5. Results of the quality assessment

Study	Research Design	QA1	QA2	QA3	QA4	QA5	Number of criteria fulfilled	Inclusion in the review
Hsieh (2017)	MX	C	√	√	C	√	3/5	√
Liu (2021)	QN(DC)	√	√	×	C	×	2/5	×
Zhao et al. (2023)	QN(DC)	√	√	√	×	√	4/5	√
Gan and Sun (2022)	QL	√	√	√	×	√	4/5	√
Jafar et al. (2023)	QN(DC)	√	√	√	×	√	4/5	√
Rofiah (2022)	MX	C	√	√	C	×	2/5	×
Asher (2021)	QL	√	√	√	√	√	5/5	√
Reynolds et al. (2022)	QL	√	√	√	√	√	5/5	√
Popyk and Pustułka (2023)	QL	√	C	√	√	√	4/5	√
Mathrani et al. (2022)	MX	C	√	√	C	√	3/5	√
Sun (2022)	QN(DC)	√	√	×	C	√	3/5	√
Frei-Landau and Avidov-Ungar (2022)	QL	√	√	√	√	√	5/5	√
Sosa (2021)	QL	√	√	√	√	√	5/5	√
Gu (2021)	QN(DC)	√	√	√	C	√	4/5	√
Gocotano et al. (2021)	MX	C	√	√	C	√	3/5	√
Jamil and Muschert (2023)	QL	√	√	×	√	√	4/5	√
Van De Werfhorst (2022)	QN(DC)	√	√	√	C	√	4/5	√
Guo and Wan (2022)	QN(DC)	√	√	√	C	√	4/5	√
Norman (2022)	QN(DC)	√	√	√	×	√	4/5	√
Nkoala and Matsilele (2023)	QL	√	√	√	√	√	5/5	√
Badiuzzaman (2021)	MX	C	√	×	C	√	2/5	×
Goin and Taylor (2021)	QL	√	√	×	√	√	4/5	√
Möhlen and Prummer (2023)	QL	√	√	√	√	√	5/5	√
Azubuike et al. (2021)	MX	C	√	√	C	√	3/5	√
Yajie (2023)	QN(DC)	√	√	√	C	√	4/5	√

## 2.6 Review and Coding Process

Based on the research questions, the researcher adapted or developed the following five coding schemes to better understand the selected articles: (1) Codes for bibliometric analysis. In reference to Zhang and Wang, and Spante et al., bibliometric information can be categorized by year of publication, journal of issue, discipline, and country (Zhang & Wang, 2021; Spante, 2018). (2) Codes for theories. According to Zydney and Warner, there are three types of theories, named grounded theoretical foundations, cited theoretical foundations, and theoretical foundations not provided (Zydney & Warner, 2016). (3) Codes for aims. Spante et al. proposed that the aim of educational research can be divided into practical didactical change, develop student competence, develop faculty competence, and develop educational system (Spante, 2018). (4) Codes for research design. Based on Luo et al., research design can be categorized into research type, research method, data collection method, and data analysis method (Luo, 2021). (5) Codes for factors. Drawing upon Barzilai-Nahon, these six factors relate to the digital divide: social and government constraints/support (SUP), affordability (AF), use, infrastructure access (INF), accessibility (ACC), and sociodemographic factors (SOC) (Barzilai-Nahon, 2006).

## 3. Results

### 3.1 Research Trends

The distribution of publication years is shown in Figure 2. It can be seen that the majority of papers were published between 2021 and 2023, with the highest number of publications occurring in 2023, totaling nine. This trend indicates that more scholars have been paying attention to this field during the COVID-19 pandemic.

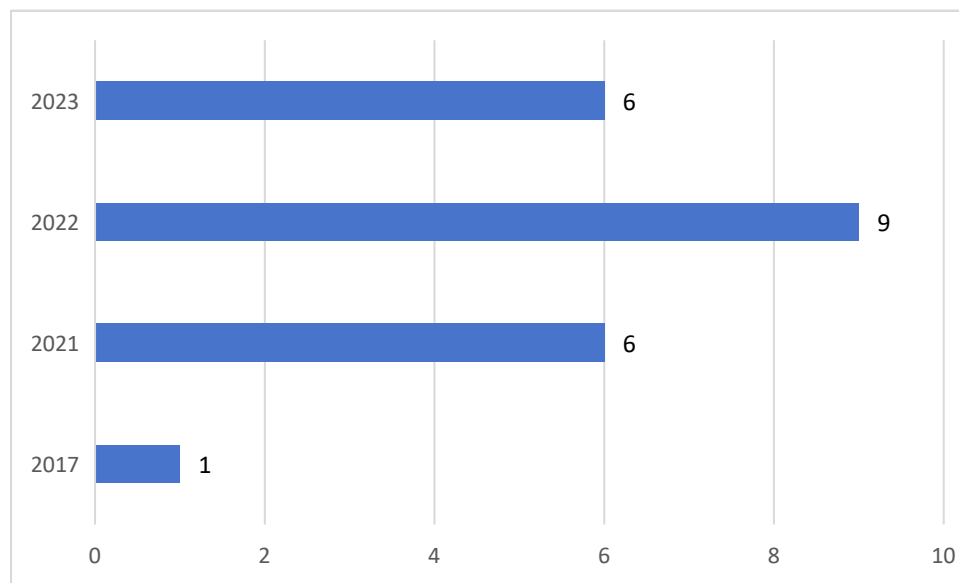


Figure 2. Number of published papers per year

The distribution of journals is diverse, including Sustainability (2), Applied Research in Quality of Life (1), Computers and Education Open (1), Computers in Human Behavior (1), Journal of Mathematics, Science and Technology Education (1), Frontiers in Public Health (1), Globalisation, Societies and Education (1), International Journal of Educational Research Open (1), International Journal of Environmental Research and Public Health (1), International Journal of Knowledge Management (1), International Journal of Learning, Teaching and Educational Research (1), International Journal of Multicultural Education (1), Journal of Affective Disorders (1), Journal of International Migration and Integration (1), Journal of Social and Economic Development (1), Journal of the Association for Information Science and Technology (1), Online Learning (1), SN Social Sciences (1), Social Inclusion (1), Teaching and Teacher Education (1), American Behavioral Scientist (1), and Technology in Society (1).

The level of education is shown in Table 6. The distribution is uneven across educational levels, with the majority concentrated in basic education (11) and higher education (9). Regarding countries, the top four most researched countries are China (6), the United States (4), India (3), and Pakistan (3), followed by others such as France,

Australia, Chile, Denmark, Finland, Germany, Italy, and South Korea.

Table 6. The level of education

Article	Basic Education	Intermediate Education	Higher Education	Professional Degrees	Continuing Education
ID1	√				
ID2			√		
ID3	√				
ID4			√		
ID5					√
ID6			√		
ID7			√		
ID8	√				
ID9	√				
ID10		√			
ID11	√				
ID12			√		
ID13			√		
ID14			√		
ID15	√				
ID16	√				
ID17	√				
ID18			√		
ID19			√		
ID20	√				
ID21	√				
ID22	√				

### 3.2 Theories

According to Zydney and Warner (2016), theories can be coded into three types: grounded theoretical foundations, cited theoretical foundations, and theoretical foundations not provided.

#### 3.2.1 Grounded Theoretical Foundations

Grounded theory refers to the explicit statement that a specific theory guides the research. As shown in Appendix A, eight of the 22 papers (36.4%) explicitly stated the theory used. These theories cover various fields such as economics, sociology, communication, and technology. This suggests that research on online education and the digital divide incorporates recent developments in contemporary economics, sociology, communication, and technology research. It also indicates that a solid understanding of theoretical paradigms is essential to bridging the digital divide in online education.

#### 3.2.2 Cited Theoretical Foundations

Of the 22 papers, four (18%) cited relevant theories to analyze the research, although these theories were not directly applied to the research design of the digital divide in online education. Among these theories, the three levels of the digital divide were cited most frequently (ID14, ID15, ID16). This demonstrates the multifaceted nature of the digital divide, recognizing that it is not only about physical infrastructure but also about how technology is integrated into the educational environment and how effectively individuals use it for learning. Additionally, one study cites Bourdieu's social capital theory to highlight how technological and social capital can help students cope with the challenges of the digital divide posed by online education (Gan & Sun, 2022).

#### 3.2.3 Theoretical Foundations Not Provided

Ten papers (45.5%) did not cite any theories to guide their research design but referred to terms closely related to specific theories. For example, Asher and Sunaina (2021) examined students' experiences of using technology for distance learning at two universities in the United States and Pakistan, which is closely related to the conceptualization of the technology acceptance model.

### 3.3 Research Aims

The aims of the studies are shown in Appendix B. Among all the studies, most were motivated by the development of the education system (10 papers), followed by the development of students' competencies (8 papers), and the development of faculty competencies and practical didactical changes in equal numbers (2 papers each). It is worth



noting that all the studies were investigative in nature, with no experimental studies included.

Studies aimed at developing the education system take a broader context to understand the digital divide in online education. For example, Hsieh et al. (2017) provide a strong strategy for developing Taiwan's education system by confirming the autocorrelation between the digital characteristics of online learning programs and the urban-rural education divide. Möhlen and Lisa-Katharina (2023) investigated various parallel discourses and visualizations in digital distance learning situations during the COVID-19 pandemic among vulnerable Austrian students, highlighting the absence or discrimination of guidelines and policies in the education system.

Papers that aim to develop student competence focus on the student population and explore the multiple levels at which the digital divide in online education exists from the student perspective. For instance, Popyk and Anzhela's (2023) research on the transnational transitions of immigrant schoolchildren in Poland reveals the overlapping nature of the immigrant experience, distance learning, and the digital divide in contributing to educational inequalities among immigrant schoolchildren in Poland. Jamil and Sadia's (2023) research blends the development of student competencies with the development of faculty competencies. They analyzed the ICT skills of teachers and students in Pakistani universities, highlighting the challenges faced by students in rural and remote areas regarding Internet access and virtual learning systems.

Research aimed at practical didactical change examines practical reform initiatives and provides a visual way of observing the digital divide in online education by discussing the results of these reforms. For instance, Jafar, Ananthpur, and Venkatachalam (2023) discuss Tamil Nadu's experience with continuing education during the epidemic, particularly how initiatives such as Calvi TV's television broadcasting programs for students have been effective in addressing the digital divide between rural and urban areas of the state. Furthermore, Goin and Taylor (2021) investigated how faculty adapted their courses during the rapid shift to online learning in 2020. Elements such as teachers' flexibility, reducing coursework to essential content, and personalization have been effective in mitigating the educational equity issues that emerged during the urgent transition to distance learning.

Papers aimed at developing faculty competence use teachers' in-depth narratives to demonstrate the widening or narrowing of the digital inequality gap in online education and how to effectively reduce the digital divide by improving teachers' abilities. For example, through interviews with K-12 public school teachers, Reynolds et al. (2022) explored how digital access and usage gaps in communities manifest into wider digital and social inequalities through educational technology, providing accompanying recommendations. Frei-Landau and Avidov-Ungar (2022) investigated the challenges of online learning encountered by female Bedouin pre-service teachers versus their Jewish counterparts, discussing possible ways to ensure equity in online teacher education from the perspective of the digital divide.

### *3.4 Research Design*

The research design was analyzed from four aspects, with the statistical results shown in Table 7. First, all studies were investigations rather than experiments (22). Secondly, qualitative designs were the most prevalent (10), followed by quantitative designs (8) and mixed research designs (4). Third, questionnaires (10) and interviews (10) were the main data collection methods. Finally, inferential statistics were the most commonly used statistical methods in quantitative designs (11).

Table 7. Classification of research design

Research Type	Total(%)	Research Method	Total(%)
Investigation research	22(100)	Qualitative research	10(45.4)
		Quantitative research	8(36.4)
		Mixed research	4(18.2)
Data collection method	Total	Data analysis method	Total
Questionnaire	10(45.4)	Descriptive statistics	5(22.7)
Interview	10(45.4)	Structural equation modeling	3(13.6)
Focus groups	2(9)	Grey relational analysis	1(4.5)
Course platform and official	1(4.5)	ANOVA	1(4.5)
Written reflections	1(4.5)	Qualitative material analysis	10(45.4)
Sound recording	1(4.5)	Chi-square analysis	1(4.5)
Knowledge test	1(4.5)	t-test	1(4.5)
Video	1(4.5)	Panel regression model	1(4.5)
		Regression analysis	1(4.5)
		Stepwise least squares regression analysis	1(4.5)
		Linear regression analyses	1(4.5)
		Linear multi-level regression analysis	1(4.5)
		Binomial logistic regression analysis	1(4.5)
		Multivariate logistic regression analysis	1(4.5)
		Probit regression models	1(4.5)

3.5 Factors

In terms of factors, six elements were identified (see Table 8): social and government constraints or support, use, affordability, infrastructure access, accessibility, and sociodemographic factors (Barzilai-Nahon, 2006). It is worth noting that some studies identified more than one influencing factor. From the figure, it can be concluded that infrastructure and sociodemographic factors are the main influences on the digital divide in online education. Additionally, the digital divide in online education for people with disabilities is most easily overlooked.

Table 8. Factors of the digital divide

	SUP	USE	AF	INF	ACC	SOC
ID1		√		√		
ID2	√	√	√	√		
ID3	√					√
ID4		√		√		
ID5				√		√
ID6		√		√		√
ID7						√
ID8			√	√		√
ID9	√		√	√		√
ID10						√
ID11						√
ID12	√			√		
ID13				√		√
ID14	√		√	√		
ID15		√				√
ID16				√	√	√
ID17					√	√
ID18				√		
ID19		√		√		
ID20	√		√	√		
ID21						√
ID22						√

Note. SUP = social and government constraints/support; USE = use; AF = affordability; INF = infrastructure access; ACC = accessibility; SOC = sociodemographic factors.

3.5.1 Social and Government Constraints/Support

Social and government constraints or support refer to the various factors within society and governmental policies that either hinder or facilitate individuals’ access to and use of digital technologies, such as the Internet (Curtin, 2001; Barzilai-Nahon & Barzilai, 2005). Six (ID2, ID3, ID9, ID12, ID14, ID20) of the 22 papers explored social

and government constraints or support. For example, Jamil and Muschert (2023) noted that during the epidemic, thousands of students in Pakistan needed to rely on government-provided Internet services to access online courses and educational content.

### 3.5.2 Use

The concept of ‘use’ encompasses a range of dimensions including the frequency of engagement, duration of time spent online, underlying purposes driving interactions, proficiency levels of users, and the autonomy individuals wield in their media consumption habits (Crump & McIlroy, 2003; Warschauer, 2002). Six of the 22 papers (ID1, ID2, ID4, ID6, ID15, ID19) researched use. For example, through a study of students in seven countries, Van De Werfhorst, Kessenich, and Geven (2022) concluded that students’ ICT use was a significant factor in the digital divide in online education during the COVID-19 pandemic.

### 3.5.3 Affordability

Affordability directly impacts individuals’ and communities’ access to essential digital resources. It encompasses multiple layers: the physical layer, involving accessible infrastructure facilitating internet connectivity; the logical layer, comprising affordable applications and software necessary for meaningful digital engagement; and content, ensuring diverse and relevant online information and services are within reach (Alliance for Affordable Internet, 2021). Five of the 22 papers (ID2, ID8, ID9, ID14, ID20) studied affordability. For instance, Möhlen and Prummer (2023) found that the implementation of digital distance learning was hampered by a severe lack of digital equipment for teachers during school closures, thus undermining inclusive education during digital distance learning.

### 3.5.4 Infrastructure Access

Infrastructure access refers to the ability of individuals or communities to connect to and utilize various components of information and communication technology (ICT) infrastructure. This encompasses a range of factors, including communication channels and their capacity, the availability of computers and internet-enabled devices per capita, the density of accessible websites, and the number and nature of internet service providers (ISPs) serving a particular population. The presence of governmental incumbents or private entities in the ISP landscape also plays a significant role in shaping access. Fourteen of the 22 papers (ID1, ID2, ID4, ID5, ID6, ID8, ID9, ID12, ID13, ID14, ID16, ID18, ID19, ID20) investigated infrastructure access. For instance, Gocotano et al. (2021) discovered that many students in mountainous areas do not have access to Wi-Fi modems due to inadequate internet signals, and a significant number of respondents reported poor internet connectivity. This finding suggests that online learning is more feasible for students living in urban areas or places with stable networks, whereas for students in remote areas or places with unstable networks, infrastructure access remains an unbridgeable gap.

### 3.5.5 Accessibility

Accessibility, particularly concerning disabled and special needs populations, is often neglected, highlighting the widening gaps in addressing the requirements of individuals with physical disabilities and other special needs. Two of the 22 papers (ID16, ID17) examined accessibility. Norman et al. (2022) investigated the access and connectivity of online learning for vulnerable students in basic education, revealing the digital divide in their use and utilization of technology and suggesting effective emergency teaching and learning strategies.

### 3.5.6 Sociodemographic Factors

Sociodemographic factors encompass a broad range of characteristics that shape the composition and dynamics of human populations. These factors include socioeconomic status, gender, age, education level, geographic dispersion, ethnic diversity, race diversity, religiosity, and language. Collectively, these factors provide insights into the social and economic structure of communities, influencing various aspects of life including access to resources, opportunities, and services. Fourteen of the 22 papers (ID3, ID5, ID6, ID7, ID8, ID9, ID10, ID11, ID13, ID15, ID16, ID17, ID21, ID22) researched sociodemographic factors. For instance, Guo and Wan (2022) examined the digital divide in online learning in China during the COVID-19 pandemic. They showed that while online learning mitigated the negative impact on learning for ‘poor’ students, the offline benefits varied for students from different social backgrounds. In particular, children from advantaged social groups were more likely to maintain their attainment during the pandemic, while their disadvantaged peers were more likely to experience a drop in attainment.

## 4. Conclusion and Discussion

A systematic literature review on the digital divide in online education highlights the rapidly growing academic interest in this field, particularly evident from the increase in the number of publications in 2023. This trend

underscores the urgency and relevance of addressing digital inequalities exacerbated by the epidemic, aligning with the global momentum to drive the digital transformation of education.

#### *4.1 Important Factors Affecting the Digital Divide*

Through a systematic literature review, this study analyzes in detail the research trends, theoretical foundations, research objectives, and designs in online education, with a special focus on the key factors affecting the digital divide. The findings suggest that technological access and sociodemographic factors are the main influences on the digital divide in online education.

These findings are consistent with those of Anderson and Perrin (2018). Their study showed that low-income families often lack the necessary technological devices and internet connectivity due to limited financial resources, resulting in poorer performance in online education compared to students from higher-income families. Similarly, Van Deursen and Van Dijk (2019) found that lack of technological access directly affects student learning outcomes and educational equity.

Sociodemographic factors, such as family income, parents' education level, and region of residence, also significantly impact online education participation and effectiveness. Hargittai (2010) noted that students from lower-income families often lack the necessary technological equipment and support due to limited financial resources, leading to poorer performance in online education compared to their higher-income counterparts. Additionally, research by Robinson et al. (2015) suggests that parents' education levels largely influence the home learning environment and the quality of instruction students receive, which directly impacts their online learning outcomes.

These findings emphasize the importance of addressing the digital divide caused by technological access and sociodemographic factors in the drive for universal access to online education.

#### *4.2 Integration of Theoretical Foundations*

This study observed that 36.4 percent of the studies explicitly adopted theoretical frameworks from the fields of economics, sociology, communication, and technology studies, reflecting a deeper understanding of the complexity of digital divide issues. This interdisciplinary integration not only provides rich theoretical support for academic research but also enhances the practicality and applicability of the research results in policy formulation. However, nearly half of the studies lacked a clear theoretical foundation, suggesting a need for greater emphasis on the construction and application of theoretical frameworks in future studies to improve the depth and breadth of research.

#### *4.3 Diversity in Educational Stages and Geographical Distribution*

In terms of educational stages, most studies focus on basic education and higher education, reflecting the profound impact of the digital divide on these two stages of education. Addressing the digital divide in basic and higher education is crucial for promoting social equity and sustainable development, given the importance of these stages in individual growth and social development. Additionally, the wide geographical distribution of the literature, encompassing countries such as China, the United States, India, and Pakistan, highlights the global and universal nature of the digital divide issue. This geographical diversity provides an opportunity to understand digital divide issues from various perspectives and contexts.

#### *4.4 The Multidimensional Nature of the Digital Divide*

The digital divide is not only reflected in gaps in physical infrastructure but also involves multiple dimensions of digital skills, technology adoption, and the integration of educational practices. This study found that teacher competence and self-efficacy profoundly affect online learning outcomes (Asher & Sunaina, 2021). According to Yang and Du (2024), teachers with high self-efficacy are likely to create more effective online learning environments, demonstrating resilience and an enhanced ability to engage students. This is critical to addressing the digital divide, as it affects not only the quality of online instruction but also student engagement and learning outcomes on digital platforms. Teacher resilience and emotion regulation also play important roles in managing online teaching stressors, which can impact the quality of education (Reynolds et al., 2023). The ability to effectively regulate emotions contributes to maintaining a positive learning environment and is associated with reduced burnout and increased job satisfaction, which directly impacts student learning experiences and outcomes in the online environment.

Furthermore, intrinsic motivation and parental support have been identified as key factors influencing student engagement and success in online learning (Zhao et al., 2022). According to Aboobaker and Muneer (2022), motivation is a key driver of learning behaviors and performance, and intrinsic motivation is positively correlated

with learning outcomes. Parental support further reinforces this by providing the necessary encouragement and resources required for successful online learning (Chen & Tu, 2021). This study also reveals that additional family responsibilities, such as caring for younger siblings, often negatively impact girls' educational participation (Mathrani, 2022). This suggests that education policies need to take these family responsibilities into account and aim to provide additional support to ensure that all students, particularly those from disadvantaged backgrounds, have equitable access to learning opportunities. These findings emphasize the need to consider a combination of dimensions and factors when addressing the digital divide.

#### *4.5 Implications and Recommendations*

Based on the above discussion, we propose the following practical implications and policy recommendations: First, training and support for teachers should be strengthened to enhance their online teaching competence and emotional resilience, enabling them to better cope with the challenges posed by the digital divide. Second, education policies should focus on the needs of disadvantaged groups and provide necessary support and assistance to students facing socioeconomic disadvantages or increased family responsibilities. In addition, future research should further explore the mechanisms of interaction between teacher competence, self-efficacy, and student achievement, and the applicability of these mechanisms in different cultural contexts. Finally, attention should be paid to gender equality issues to mitigate the negative impact of gender roles and family responsibilities on students' educational participation and success.

In summary, the issue of the digital divide in online education is a complex and urgent problem that requires in-depth research and practical exploration from multiple perspectives and levels. By strengthening the integration of theoretical frameworks, paying attention to the diversity of educational stages and geographical distribution, deeply understanding the multidimensional characteristics of the digital divide, and proposing targeted practical implications and policy recommendations, we can make positive contributions to narrowing the digital divide and promoting educational equity and sustainable development.

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#### **Authors' contributions**

Conceptualization, Qingqing Tang; methodology, Qingqing Tang and Syafila Kamarudin; software, Qingqing Tang; validation, Qingqing, Syafila Kamarudin, Saiful Nujaimi Abdul Rahman and Xin Zhang; formal analysis, Qingqing Tang; investigation, Qingqing, Syafila Kamarudin, Saiful Nujaimi Abdul Rahman and Xin Zhang; resources, Qingqing Tang; data curation, Qingqing Tang; writing—original draft preparation, Qingqing Tang; writing—review and editing, Syafila Kamarudin; visualization, Qingqing Tang; supervision, Syafila Kamarudin; project administration, Qingqing Tang and Qingqing Tang. All authors have read and agreed to the published version of the manuscript.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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No additional data are available.

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