RESEARCH ARTICLE

Gender digital divide in education 4.0: A systematic literature review of factors and strategies for inclusion

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Abstract
The gender digital divide (GDD) is a phenomenon that refers to the inequalities and differences between men and women in accessing the digital ecosystem in various environments, such as the scenarios of Education 4.0. Bridging the GDD in access, use, and appropriation of technologies would promote the digital inclusion in spaces traditionally dominated by men. A systematic literature review was conducted using seven databases, considering Scopus and Web of Science. Through this, the factors with the most significant impact on the widening of this type of gap were identified. The findings suggest that the elements that limit the GDD are (a) access and use of technologies, (b) social barriers, and (c) gender stereotypes and roles. On the other hand, factors that need to be considered for the digital inclusion of women were identified as follows: (a) the mode of interaction with technologies, (b) digital competencies in Education 4.0, (c) the mode of technology-mediated teaching and learning, (d) digital competencies in the workplace, and (e) digital participation. It is concluded that more digital inclusion strategies are needed to reduce the GDD, thus requiring greater participation from society and universities to achieve digital equity.

KEYWORDS
digital inclusion, Education 4.0, gender digital divide, higher education, women
Incorporating technology into society has facilitated various activities related to telecommunications, healthcare, transportation, commerce, education, and nearly all social practices, thus impacting individuals' economic and cultural development. However, it has also been argued that technology has widened the digital divide (Chang, 2018; Van Dijk, 2020). This concept refers to unequal access to the Internet and digital devices that enable communication and information exchange in various social spaces as well as inequalities in technology use among traditionally excluded population groups, such as individuals with disabilities, functional illiteracy, and women (Berrio et al., 2017; Lythreatis et al., 2022).

The digital divide concept emerged in the 1990s during the post-industrial era and the Technological Revolution in the United States and Europe (Norris, 2020). The digital divide can be seen as a fracture or separation between those who have access and skills to use Information and Communication Technologies (ICT) and those who do not effectively. This division can be caused by socioeconomic, cultural, or educational factors, contributing to social exclusion and inequality in the information society. Furthermore, it refers to the access to technology and the ability to use and leverage it (Hamburg & Lütgen, 2019).

On the other hand, the gender gap refers to the situation in which women have fewer opportunities than men to develop equally in different areas (Davies, 2011; Warrington & Younger, 2000). This phenomenon is evidenced by the limited presence of women in high-tech positions or leadership roles in technology-based companies (Windley & Pan, 2020).

Currently, various gender gaps limit women compared to their male counterparts in various spheres, such as education, work, society, or the digital world (Cimpian et al., 2020; Olarte, 2017). In education, the gender gap has been observed for several decades, and differences in performance and learning styles between female and male students have been identified (Bertocchi & Bozzano, 2020; Vantieghem et al., 2014). In the digital world, for example, the digital divide restricts women more deeply than men due to the gender roles and stereotypes established by Western society (Acilar & Sæbø, 2023; Acosta-Velázquez and Pedraza-Amador, 2020).

The gender digital divide (GDD) represents a digital inequality among women in terms of access, use, and utilization of ICT due to their role in society and social expectations of male and female ICT use (Kristal & Yaish, 2020; Perifanou & Economides, 2020). This divide can manifest in different forms, such as ease of access to the Internet, ownership of technological devices, training in digital skills, participation in technology-related fields, and equitable representation in the tech industry (Banerjee, 2019). This phenomenon can be exacerbated or mitigated depending on nationality, social class, race, access to education, qualifications, age, and social status of women, who may face barriers or inequalities in accessing, using, and benefiting from ICT compared to men (De Andrés et al., 2020).

Various studies have highlighted the main differences and inequalities of the GDD in various areas, including the education sector (Alozie & Akpan, 2017; Bala & Singhal, 2018). Other authors have analyzed gender differences in digital skills exhibited by women and men in higher education (Ancheta et al., 2021; Palomares et al., 2021), the barriers that limit women's access to careers in Science, Technology, Engineering, and Mathematics (STEM) due to the presence of gender stereotypes and roles (Bala & Singhal, 2018), and the disadvantages that women face when entering fields with high demand for digital skills (Del Valle, 2020; Krchová & Höesová, 2021; Mushtaq & Riyaz, 2020). It has even been argued that the digital divide is a risk factor for women's social security, as it hinders the growth of the digital economy due to the lack of skilled workers, reduces company profits, and deteriorates social well-being (Kislyakov & Shmeleva, 2018).

As a result of the social complexity brought about by the development of 21st-century technologies and the emergence of Education 4.0, characterized by disruptive practices such as artificial intelligence, machine learning, and algorithm application (Chaka, 2020), the gaps in the equitable use of technology have also widened (Singh et al., 2023). This has led to an increase in the digital divide,
negatively affecting people's access to emerging job markets and innovative learning opportunities, as well as limiting access, use, and appropriation of complex learning environments based on augmented reality, virtual reality, data analytics, and blockchain among others (Miranda et al., 2021).

In the educational context, the GDD is represented by the lack of educational materials with a gender perspective (Pedraza Bucio, 2021; Wong & Kemp, 2018), disinterest of girls and young women in the digital world (Yu, 2018), professional vocations related to technology (Liu et al., 2022), and false identification of spaces such as computer labs as exclusive to males (Afiani, 2018). Another critical factor influencing the GDD is the lack of digital competencies and skills that limit women in all areas of their lives (Ahmad et al., 2019).

In this context, it is urgent to reduce the GDD so that both men and women can participate equitably in complex job and educational scenarios to address the demands of an ever-changing digital ecosystem (Kerras et al., 2020; Masdoki & Din, 2021). However, this requires improving digital infrastructure and literacy and addressing social and cultural paradigms related to gender profiles necessary to be part of Education and Industry 4.0 (Noguez et al., 2021). Therefore, this research was carried out with the following question: What is the pattern of the GDD and women’s digital inclusion (WDI) publications that determine the trends in research on the complex digital ecosystem of Education 4.0?

2 | METHOD

A systematic literature review (SLR) was conducted using the following databases: Dialnet, ERIC, Google Scholar, ProQuest, Scielo, Scopus, and Web of Science (WoS) to identify contributions related to the topic of GDD in the context of Education 4.0 and thus gain a comprehensive understanding of the studied phenomenon's evolution over time (Donthu et al., 2021). Therefore, the work represents a bibliometric process that applies mathematical and statistical methods to analyze scientific literature and its authors, investigate and analyze patterns related to scientific production, and contribute to the emergence of new conceptual structures (Baena et al., 2022).

The research can be classified as descriptive since it involves gathering information to conduct an analysis, in this case, a bibliometric analysis of a social phenomenon that describes the situation of GDD and its impact on women (Shields, 2020). To find information in the databases, terms such as “gender digital divide,” “complexity,” and “Education 4.0” as well as similar terms were used. Figure 1 provides a detailed overview of the methodology used.

After the methodology was defined, the stages for conducting the study and the timeframe analysis (2017–2021) were determined, considering the proposal by Kitchenham (2004), Kitchenham and Charters (2007), and Petersen et al. (2015) as well as the works of Velázquez-Durán and Ramirez-Montoya (2018), Ruiz and Glasserman (2021), and García and Ramírez (2019) as guidance for organizing the stages of the research. Figure 2 presents the stages, and the following paragraphs describe each.

2.1 | Phase 1: Objective

The objective of the SLR was to analyze the pattern of publications on the GDD to identify the elements that restrict women's access to the complex digital ecosystem of Education 4.0. The initial literature mapping revealed a limited scientific production, as only 87 papers were found, which were categorized into three research fields: (a) multidisciplinary in the area of social sciences (44.82%), (b) education (39.08%), and (c) sociological studies (16.09%). These studies were classified into eight topics: (a) gender inequalities and/or differences (n = 24), (b) education (n = 13), (c) digital and social inclusion (n = 13), (d) empowerment/work or professional development (n = 12), (e) digital
FIGURE 1 The method applied for data treatment.

competencies/skills ($n = 9$) (10.34%), (f) digital literacy ($n = 8$), (g) gender strategies/public policies ($n = 5$), and (h) technological resources/technology ($n = 3$).

2.2 | Phase 2: Research questions

The initial mapping allowed us to continue the research and formulate the research questions shown in Figure 2. The purpose of formulating these questions was to guide a more detailed analysis of publications that promote the study of the GDD and WDI in Education 4.0.

2.3 | Phase 3: Database selection

Seven databases were chosen for the study: Dialnet, ERIC, Google Scholar, ProQuest, Scielo, Scopus, and WoS. Emphasis was placed on using Scopus as it is considered one of the largest and most prestigious citation and peer-reviewed literature databases (Ball, 2021).

2.4 | Phase 4: Method of analysis

Flow diagram of the screening process (PRISMA) method (Page et al., 2021) was selected in this study. It involves identifying and selecting scientific documents, following a curation process
according to several quality criteria, establishing eligibility criteria, and finally, creating a database that was analyzed to achieve the research objective. Figure 3 presents the structure of the method, and the following paragraphs provide details of each step.

The first step in this stage consisted of a search in the databases using the selected keywords, identifying 260 articles. The papers were then selected by applying the following inclusion and exclusion criteria:

- Research articles, scientific dissemination articles, systematic literature reviews, methodological articles, and meta-analyses were included.
- Editorials, errata, articles unrelated to the study topic, and duplicate documents were excluded.

The quality criteria were established that the articles should be published between 2017 and 2021, should be accessible in full text, and focus on the complexity of Education 4.0. The next step involved reading the abstracts of the selected documents and reviewing the topics and subtopics to select papers that addressed the research question. After applying this filter, 73 documents were obtained.

The following step was to read the full text of the 39 articles to select the most relevant ones for the study topic. The following classification was obtained: (1) digital literacy, (2) gender inequalities...
and differences, (3) digital competencies and skills, (4) higher education 4.0, (5) women's empowerment, (6) strategies to reduce the digital divide, and (7) digital and social inclusion.

The screening process resulted in a total of 31 articles, which were assigned sequential numbers and entered into a bibliographic database with the following fields: (a) author(s), (b) title of the work, (c) year, (d) document type, (e) journal or publisher, (f) authors' country, (g) institutions or organizations, (h) DOI, (i) APA-style bibliographic data, (j) abstracts, (k) keywords, (l) language, and (m) access type. The information is available in the following link: Database A.

### 2.5 Phase 5: SLR elaboration

This section presents the results of the SLR in the same order as the research questions were formulated.

#### 2.5.1 Q1. What kind of studies related to the GDD and WDI have been conducted from 2017 to 2021?

We coded the most relevant studies on the topic; the final classification included 18 codes to identify the frequency of the most pertinent issues in the 31 papers through MAXQDA 2022 (see Figure 4).
After analyzing the frequencies of the most pertinent issues by codes, it was observed that “WDI to promote interaction and use of ICT” was explored with the authors' highest interest (90.3%). On the other hand, the second and third highest frequencies are related to Education 4.0, as “WDI to develop digital skills in Education 4.0” (71%) and “WDI to promote ICT-mediated teaching/learning” (67.7%) have high incidence percentages. Other studies analyzed WDI to develop digital skills (61.3%) as well as WDI to develop digital work skills (61.3%). The codes related to GDD with

**Figure 4** Classification of GDD and WDI by codes. GDD, gender digital divide; WDI, women’s digital inclusion.
the highest frequencies are “access and use of 4.0 technologies” (54.8%) and “social gaps” (54.8%), followed by “stereotypes and gender roles” (48.4%). To sum up, selected studies focused on diverse variables related to the GDD and WDI (see Figure 5).

2.5.2 | Q2. Which countries were the most analyzed in the studies?

Studies analyzed the GDD and WDI in different countries. We observed that 11 papers analyzed the phenomenon from a global perspective. On the other hand, some papers studied the GDD in some regions or different countries, such as the sub-Saharan African region [2], the Indo-Pacific region [28], European Union countries [4] and [25], Latin American countries [6] and [14], and South Asian countries [26]. Other papers investigated the topic in more than two countries (n = 5). The results showed that the most analyzed countries were Spain (n = 11), Mexico (n = 6), Ecuador (n = 5), Poland, Czech Republic, Slovakia, and Colombia (n = 4), with the same number of studies. We recognized that the studies were mainly conducted in Latin America and Europe (see Figures 6 and 7).

2.5.3 | Q3. Where were the studies conducted?

To identify the contexts studied in the 31 papers, we classified all the sceneries into four: (a) society (social context), (b) Education 4.0, (c) society and work, and (d) work. The results showed that studies were primarily performed in social contexts (45.16%) (n = 14). The second context was education 4.0 (25.81%) (n = 8). Furthermore, some studies analyzed gender differences and inequalities in social and work contexts (19.35%) (n = 6). However, other studies only focused on the labor context (9.68%) (n = 3). Indeed, it can be recognized that the GDD is a phenomenon that is mainly immersed in society. However, the analysis showed that the phenomenon is also located in education and work, as visualized in Figure 8.

Additionally, the articles were classified into four types of studies: (a) context analysis, (b) data analysis, (c) literature review (systematic mapping, SLR, and meta-analysis), and (d) the development of a framework or model. We recognized that the studies mainly focused on analyzing the

![Figure 5](image-url)

**Figure 5** Code frequencies of GDD and WDI. GDD, gender digital divide; WDI, women's digital inclusion.
contexts with a total of 19 papers (61.29%). Moreover, we registered five data analyses in the papers (16.13%) and five literature reviews (systematic mapping, SLR, and meta-analysis) (16.13%). Finally, only two papers focused on the development of a framework or model (6.45%). To sum up, the studies mainly focused on analyzing the phenomenon, and only two papers developed a
framework or model. We concluded that there are a few interventions or implementations to reduce the problem of GDD (see Figure 9).

In Figure 10, we categorized the types of studies from the 31 papers into (a) quantitative studies, (b) qualitative studies, (c) mixed studies, and (d) conceptual research. The results clearly showed that quantitative studies are highly predominant (45.16%) \( (n = 14) \). Secondly, the studies focused on conceptual research (35.48%) \( (n = 11) \). The following type of study is qualitative studies (12.90%) \( (n = 4) \). The final position was for mixed studies (6.45%) \( (n = 2) \). To summarize, quantitative approach and conceptual research are the most common type of study, while an open window to analyze the subject in qualitative and mixed studies is registered (see Figure 10).

**Figure 8** Classification of studies by contexts.

**Figure 9** Classification of studies by types of studies.
2.5.4 | Q4. What kind of populations did the studies explore?

The population explored in the studies was classified into six groups: (a) women, (b) women and men, (c) students, (d) adolescents, (e) kids, and (f) students and teachers. The results showed that 11 papers only focused on women (35.48%), while other 11 studies analyzed women and men's interaction in the digital world in the same papers (35.48%). We observed that the studies mainly focused on adult/old participants \((n = 22\) papers/70.96%), while childhood was the least analyzed \((3.23%)\) \((n = 1)\).

On the other hand, youth was the second most analyzed population considering two groups: (a) adolescents \((6.45%)\) \((n = 2)\) and (b) the group of students \((16.13%)\) \((n = 5)\) because students are in the youth criterion. By analyzing Education 4.0, five studies addressed the impact of GDD on students \((16.13%)\), while only one research considered both educational actors (teachers and students). Figure 11 presents the complete distribution of the studies by population.

2.5.5 | Q5. What findings have emerged from the studies?

The majority of the studies concluded that women's digital participation had been limited due to barriers that arise in social spaces where they operate as students or workers, such as limited access to...
digital literacy and the absence of Education 4.0 technology such as virtual or augmented reality scenarios (63.3%).

Other studies recognize that the GDD level has expanded due to technology's penetration in educational and work environments (43.3%). Paradoxically, it has been considered that the increasing access to technology has been used to promote women's participation in activities related to Industry 4.0 (40.4%). Studies have also shown that digital inclusion through technology has increased women's participation in the educational, social, work, economic, and business spheres. However, technology access and appropriation must be facilitated to enhance efficiency in using digital devices and applications in the Education 4.0 ecosystem (16.7%).

Furthermore, the articles acknowledge that the GDD has limited women's development in society (30.0%) and their opportunities to reach leadership positions in work and business (26.7%). It was also noted that the GDD affects not only digital, social, work, and financial inclusion but also replicates digital segregation due to the persistence of gender stereotypes, such as the assumption that women cannot pursue studies in STEM fields or prefer professional training in social sciences (30.0%) (see Figure 12).

On the other hand, studies have reported that the GDD is exacerbated due to beliefs related to the idea that women are excluded from digital learning experiences because they prefer activities with other women who are not interested in technology (23.3%). An important finding relates to representative actions of digital harassment and violence against women (16.7%). In the same proportion, gender differences have been analyzed regarding positive or negative attitudes toward using technology (16.7%) and the lack of digital skills and competencies that limit women's access to STEM ecosystems (20%) (see Figure 13).

2.5.6 | Q6. What future research is proposed by the studies?

To analyze the research context of the GDD, a categorization of the studies into three main lines of future research was developed using MAXQDA 2022. The classification of future research can be observed in the following diagram (see Figure 14).
The results showed the frequency of the classified codes for future lines of research. Firstly, digital literacy for women in non-formal education (40.0%) and formal education (32.0%) was indicated as a priority line. On the other hand, studying digital literacy for finance and women's
employment was not considered an urgent research line (DL in finances and employment = 12.0%). On the other hand, the importance of developing models/curricula that include a gender perspective was identified as a priority line, firstly to develop digital skills that allow women to effectively engage in the educational and work fields of Education 4.0 (STR to develop digital skills = 32.0%), and secondly, to participate in sustainable digital spaces (WDI for sustainability = 20.0%).

Another emerging line is investigating women's participation in activities facilitating access to STEM. Although it was only identified in 8.0% of the articles, there is a need to expand this field of research to contribute to knowledge about how the GDD can be reduced through the inclusion of women in Education 4.0 (BDG1 = 16.0%), employment (BDG2 = 12.0%) as well as the development of instruments to evaluate the GDD in university and work (INS/IND = 16%) (see Figure 15).

3 | DISCUSSION

According to specialized literature on reducing and eventually eliminating the GDD, WDI is necessary to ensure access to technology, enhance their digital skills in Education 4.0, and improve their teaching/learning practices by incorporating them into digital ecosystems. The literature review demonstrated that key elements to reduce the GDD are WDI for interaction with technology (90.30%), WDI in digital skills in Education 4.0 (71.0%), and WDI in teaching/learning mediated by technology (67.7%). The studies emphasize the importance of digital inclusion as a critical factor in bringing the digital divide and digital literacy is another critical factor to guide women's interaction in digital ecosystems.

On the other hand, this research confirmed that the sociocultural context is inherent in all human activities, as culture shapes beliefs and behaviors and “normalizes” them through repetition. Educational processes must consider promoting equitable opportunities for digital literacy training to reduce the digital divide. In this regard, social and cultural factors directly influence the GDD, as social gaps (54.8%) and gender stereotypes and roles (48.4%) were consistent themes in the studies. Therefore, these two variables represent an opportunity gap that still permeates women's lives in various areas, such as education and training. This can be seen in career choices, as women tend to concentrate on fields related to social and human sciences while leaving science and technology education to men (Ancheta et al., 2021).

Thus, it is imperative to address society's limitations on women due to their role in the social structure as Bala and Singhal mentioned (2018). The segregation of women nowadays influences social interaction and is reflected in various social roles, such as students or workers. Therefore, it is

![Figure 15](image-url)  
**Figure 15** Code frequencies of future research.
necessary to enhance women's technological skills and provide them with technological education (Ahmad et al., 2019). In this context, the significance of women's education and digital literacy becomes evident to eliminate the persisting digital gender gaps (Singh et al., 2023).

The analysis also shows a focus on analyzing and seeking to address this phenomenon in these two settings. The interests and attitudes of young women play a decisive role in reducing or increasing the GDD (Yu, 2018). Future research should explain how these interests and attitudes emerge and transform to bridge the various gaps. As it was recognized, the research studies revealed that women have different interests and attitudes toward the use of technology (41.9%).

It was also recognized that these gender differences perpetuate the GDD in younger generations, as they directly influence their interaction in digital ecosystems within their education (71%). Young people maintain continuous and autonomous use of new technologies, but digital divides depending on various factors such as age, education level, sociodemographic situation, and gender persist (Acilar & Sæbø, 2023; Acosta-Velázquez and Pedraza-Amador, 2020). Therefore, more studies are needed to analyze the various factors that influence and perpetuate the GDD and other digital divides among the younger generations immersed in digital ecosystems.

4 | CONCLUSIONS

To sum up, bridging the GDD requires a comprehensive approach that addresses technological and sociocultural aspects. Promoting WDI, strengthening digital literacy, and encouraging participation in emerging fields such as Education 4.0. Additionally, gender stereotypes and roles deeply ingrained in society must be challenged to achieve WDI. These conclusions provide a solid foundation for future research that contributes to bridging the GDD, and promoting equal opportunities in the digital environment.

Therefore, this SLR identified vital factors contributing to the widening of this divide, such as limited access and use of technology, gender stereotypes and roles ingrained in society, economic barriers, and the selection of traditionally male-dominated careers. Therefore, the results of this study highlight the importance of considering these factors and promoting WDI in emerging digital ecosystems, as proposed by Bikos et al. (2018).

Despite the efforts made in digital inclusion strategies, it is concluded that they have not been sufficient to reduce the GDD. As mentioned in various studies, greater participation from society and universities is required to achieve digital equity, as women's participation in digital environments is not equal and fair (Alozie & Akpan, 2017; Banerjee, 2019; Hamburg & Lütgen, 2019). It is necessary to address technological and access barriers and the sociocultural challenges that perpetuate gender inequalities in the digital environment, as the GDD has a negative impact on women's academic, economic, and social development. Moreover, this phenomenon limits their participation in emerging educational and workspaces, restricts access to innovative learning opportunities, and hinders their integration into fields that demand digital skills. Additionally, the GDD replicates gender stereotypes and obstructs the development of female leadership in the workplace, as the digital environment has become a reflection of social structures and the issues that exist within society (Bala & Singhal, 2018).

Finally, it is essential to acknowledge that this study presents some limitations. Firstly, the selection of studies was focused on a specific timeframe, considering that the GDD is an ongoing issue. This temporal limitation could affect the relevance of our findings as the problem evolves. Additionally, it is necessary to consider the language limitation, as a significant portion of the reviewed literature is based on publications in English and Spanish from specific countries. Therefore, the results may only be universally applicable in some contexts or geographical regions. Nevertheless, this study can be considered a valuable starting point for further research despite these limitations. Likewise, the provided results can help educational institutions understand the underlying causes of the problem and guide their efforts toward specific areas.
For future research, three priority lines of investigation were identified. Firstly, strengthening women's digital literacy in formal and non-formal contexts is emphasized. Therefore, studies proposing models and curricula with a gender perspective are recommended. In addition to addressing the lack of access to and use of technology, it is necessary to propose content and digital spaces encouraging women's participation in STEM fields within universities and the industry. Lastly, it was also identified that women's digital literacy is a future line of research to promote their digital inclusion in diverse digital settings. A change is required in both formal and informal educational environments to foster digital skills development and women's participation in Education 4.0 and the workforce.

DATA AVAILABILITY STATEMENT
The data that support the findings of this study are openly available in Google Drive at URL http://dx.doi.org/10.13140/RG.2.2.20456.65288/1.

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