RESEARCH ON DIGITAL DIVIDE AND EDUCATIONAL EQUITY: A BIBLIOMETRIC PERSPECTIVE

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Schools today face practical dilemmas: how to integrate technology in an inclusive way, how to prepare teachers to overcome digital divides, and how to ensure that innovations serve all students, rather than a privileged minority. Using bibliometric research, an analysis of the scientific research that debates this topic is carried out. The results of this research are not only academic, but also action-oriented, providing guidance and proposals for educational institutions, decision-makers and practitioners. By correlating bibliometric evidence with thematic comparisons, the study identifies concrete areas where digital interventions can reduce inequalities in classrooms, curricula, and teacher professional development.

Keywords: education, digital divide, educational equity

JEL Classification Codes: I21, I22, I28, H52, O15

INTRODUCTION

Access to technology has become a necessity for quality education anywhere in the world. But even in a world that seems completely digitized to so many, there is still a significant digital divide between societies, disproportionately affecting marginalized communities, especially in remote areas of low-income countries. This problem further deepens inequalities in education and perpetuates cycles of poverty in less developed regions.

The digital divide around the world has profound implications for education, affecting everything from access to learning resources to the quality of educational outcomes. These outcomes include unemployment rates, poverty rates, pressure on the regional environment, access to healthcare, and the potential for adequate education for the next generation. Understanding these outcomes is crucial for developing effective gap bridging strategies (Outreach, 2024).

Educational equity ensures equitable access for all students to the resources and support they need to succeed, regardless of their background or circumstances. It is about tailoring support to individual needs, not treating everyone equally, in order to reduce performance gaps and promote equal opportunities for all students (OECD, 2025).

In 2023, 55% of people in the EU aged 16-74 had at least basic digital skills in general. There were significant disparities in the EU, with rates ranging from 83% in the Netherlands to 28% in Romania.

The level of formal education has an impact on the digital skills levels of individuals. The gap in basic digital skills between people with a high level of education (80%) and those with zero or low formal education (34%) in the EU was 46 percentage points (pp). The largest gaps were recorded in Portugal (66 pp), Greece (63 pp) and Malta (59 pp). In contrast, the

smallest gaps were recorded in Estonia (12 pp), Finland (14 pp) and Lithuania (22 pp), (Eurostat, 2024).

The study aims to provide a detailed perspective on bibliometric analysis research on access to technology, the digital divide and educational equity. The aim of this research is to identify the long-term impact of access to technology on student performance worldwide. By identifying the measures currently taken, along with the potential issues of this topic, all stakeholders involved, including academia, can set directions to properly balance the adoption of technology in the academic curriculum and provide an appropriate environment for students.

1. LITERATURE REVIEW

In the context of digitalization generated transformations, investments in education are an essential factor to reduce digital divide and promote educational equity, since an equilibrate distribution of resources between different levels of education contributes to ensure equal access to learning opportunities and reduces socio-technological disparities between students. According to Figure 1 at EU level there are significant differences across investments between levels of study, which highlights distinct national priorities and potential inequalities in accessing educational and technological resources. This variation may suggest that educational equity not only depends on the total volume of financing but also the modality in which these investments are targheted to support digital inclusion and equality of chances.

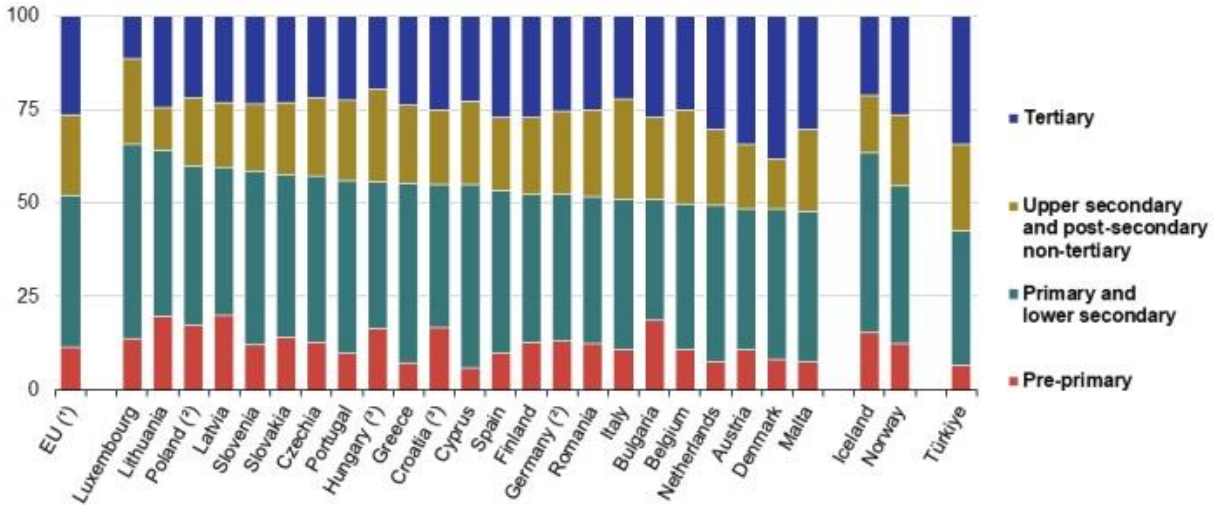

Figure 1. Methodological structure for bibliometric analysis of studies related to the digital divide and educational equity, the impact of technology on students

Source: Eurostat, 2022

Recent literature shows that the *digital divide* can no longer be reduced to the simple access/non-access dichotomy. Theoretical reviews in education highlight the existence of interconnected levels: (1) infrastructure and connectivity; (2) digital skills, uses and trust; (3) outcomes achieved through the use of technology (school performance, civic participation, well-being) — and highlight persistent conceptual confusions (interchangeably used terms: 'digital skills', 'computer and information literacy', 'digital literacy'), which make it difficult to compare studies and target interventions (Mirazchiyski, 2025). The same literature draws attention to the fact that although the issue of access has attenuated in many contexts,

differences "beyond access" (skills, uses, outcomes) remain central to understanding technology-induced educational inequalities (Mirazchiyski, 2025).

A substantive strand concerns the relationship between digital infrastructure and socio-economic outcomes (including innovation), with the potential for ambivalent effects: in the absence of a fair distribution of infrastructure and complementary capabilities, digital investments can generate *a digital dividend* only for groups already advantaged and a *digital divide* accentuated for the others. The analysis in the Journal of Innovation & Knowledge shows that differences in digital infrastructure can widen the innovation gap between regions/organizations if they are not doubled by human capital development and inclusion policies (Du & Wang, 2024). For education, the implication is that the facilities and connectivity of schools/communities must be correlated with digital literacy programs and targeted support for vulnerable groups, otherwise digitization replicates pre-existing stratifications (Du & Wang, 2024).

At the intersection of *the digital divide* and the current wave of artificial intelligence (AI), research shows the risk of an *AI divide*. A study published in *AI and Ethics* introduces the concept of "digital confidence" as an essential psychological link between current technological experiences and attitudes towards AI; lower scores are associated with gender, age, lower income, and reduced access, which may limit the benefits of AI for the same groups already exposed to digital exclusion (Bentley et al., 2024). For education systems, this means that adopting AI without explicit inclusion measures (training, accessible design, fair assessment) risks deepening inequities (Bentley et al., 2024).

On the educational policy side, the role *of assessment* is central to modelling equity: a synthesis in *Education Sciences* argues that assessment practices can both perpetuate and correct inequities—depending on the extent to which they recognize cultural, linguistic and learning style diversity, avoid "one-size-fits-all" approaches, and use formative feedback for differentiated support (Levy-Feldman, 2025). In a digital context, this involves designing technology-assisted assessments to minimize bias (linguistic, cultural, access) and provide reasonable accommodations (accessibility, multimodal support) (Levy-Feldman, 2025).

At the level of teachers' practices and perceptions, a qualitative study in *The Educational Review, USA* (China) shows that teachers and administrators see technology as a level of *equity* (access to resources, personalization, efficiency), but also points to the risk of reinforcing socio-economic differences if the infrastructure is not equitable and if there is a lack of support for pedagogical integration (Tang, Ren & Zhao, 2024). This confirms that "digital equity" also requires investment in pedagogical capabilities (continuing education, mentoring, communities of practice), not just in hardware/software (Tang, Ren & Zhao, 2024).

Interventions to reduce the digital divide and promote educational equity combine macro policies (infrastructure, costs, local relevance) with micro practices (tutoring, assessment, differentiated support). A case study from Gujarat shows that a regional college reduced exclusion through affordable fees, programs anchored in the local economy, bilingual teaching, and community partnerships (Shahbazyan & Bogusz, 2022), and research on academic tutoring points to the tutor–student relationship, personalization, and formative feedback as levers of equity, although implementation is limited by conceptual ambiguities and resources (Sipińska & Sadowska, 2022); together, these support policies that combine access and contextual relevance with teacher training and inclusive assessments.

Van Dijk (2005) addresses the digital divide by including dimensions related to skills, use and social outcomes. In addition, according to Warschauer (2004) digital equity is not achieved only through the availability of technology, but through the development of students' digital skills and its integration into relevant educational contexts. These perspectives are fundamental to the present work, allowing the interpretation of the results in light of how the

scientific literature addresses the relationship between digital access, technology use and educational equity.

2. METHODOLOGY

Nowadays the importance of technology can not be overseen. It is part of many aspects related to human life and also, adopted in more and more fiels. In education technology plays a key role, eventhough digital equity can be identified in different geographical areas all over the globe. This paper aims to address the following research question:

" Which are the main trends, research themes and collaboration networks identified in the specialized academic literature between 2019-2023 concerning the relathionship between education, digital divide, technologu and educational equity?"

To carry out this analysis, keywords were used to cover the subject, addressing the two main concerns of this research, as follows: the digital divide and educational equity. To cover them, specific criteria have been used, which is outlined below.

To ensure transparency and methodological rigor, the dataset was checked by testing the sensitivity of keywords and validating the results obtained. The co-occurrence and co-authorship networks generated in VOSviewer were interpreted in relation to the research question and the defined conceptual dimensions. The 2019–2023 interval was selected to capture recent trends in the literature on digital equity in education, a period marked by the intensification of the use of technology and significant changes in educational practices.

Inclusion criteria:

- All studies that addressed the following two directions were selected:
  - (Education AND Digital divide AND Technology AND Student) OR
  - (Education AND Educational equity AND Technology AND Student)
- Only studies from the last 5 full years, i.e. 2019 – 2023, were selected.
- All Article OR Proceeding Paper OR Review article research was selected.
- All studies fall into the categories: Education Educational Research, Education Scientific Disciplines, Educational Psychology or Education Special, all of which are related to the field of Education.
- All studies that have been written and published in English, being an international language.

Exclusion Criteria:

- Other databases
- The articles published in 2024, as the data was extracted when it was still in progress.
- Articles before 2019, because this topic is of high interest, and the purpose is to provide topical data.

The selected keywords provided a sample of 1,255 results from the Web of Science Main Collection. By filtering only after the last 5 full years, the initial sample was reduced to 657. After filtering and including the specified type of studies, 649 papers resulted. This number dropped to 389 after choosing the education category. The final sample, which includes all inclusion criteria, including English, is 350. All these documents were exported as tab-delimited files, in .txt format, as complete records and references cited and analyzed using the VOSviewer tool, version 1.6.20. A model of this research is shown below in Figure 2.

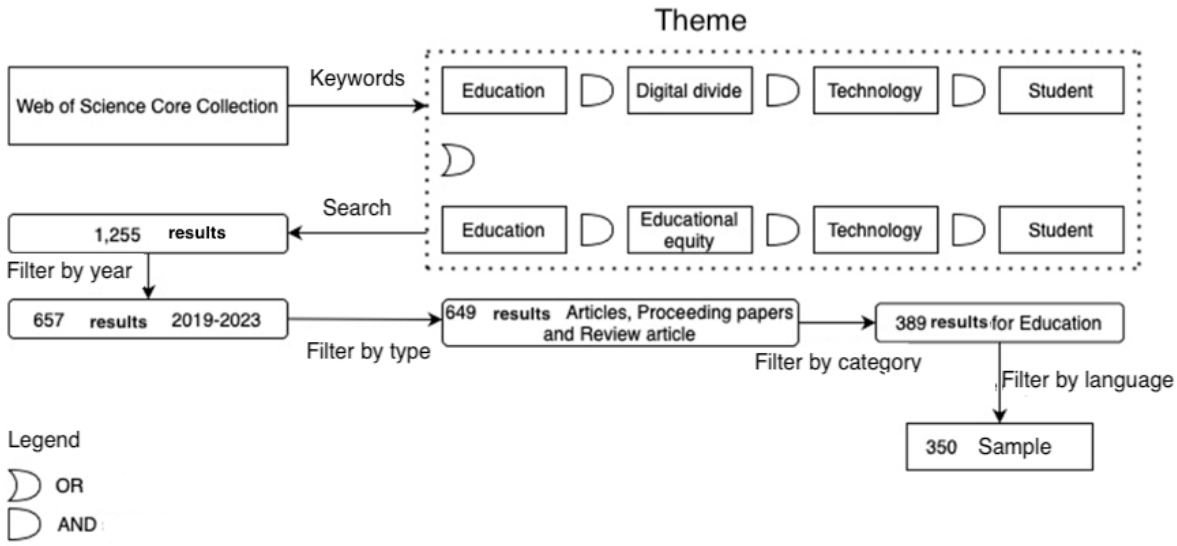

Figure 2. Methodological structure for bibliometric analysis of studies related to the digital divide and educational equity, the impact of technology on students

Source: Authors' contribution

Subsequently, using the articles included in the resulting database, an analysis of them was carried out, from the point of view of the subject addressed.

3. RESULTS AND DISCUSSION

The field of education has embraced technology in recent years, and studies on its adoption and impact have increased in number. Researchers are concerned about this topic, as can be demonstrated from their published papers (Figure 3). If in 2019, before the COVID-19 pandemic, there were only 85 papers addressing these two themes, of the digital divide and educational equity in terms of access to technology for student performance, and even fewer studies before, in 2023 210 studies are carried out on these topics. Therefore, this area is still an ongoing one, with a lot of potential for research, measures that can be proposed and effects that can be studied.

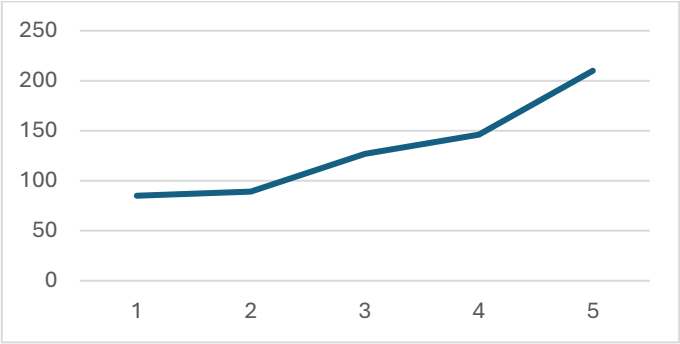

Figure 3. Studies published between 2019 and 2023 related to the digital divide and educational equity of students

Source: Authors' contribution

The first analysis carried out is of the Co-authorship and authors type, and the maximum number of authors per document is set at 25. If the minimum number of documents is 1 and the

citations for one author is 2, out of 138 authors, 81 meet the thresholds. Some of the 81 elements are not connected to each other, the largest set of connected elements consists of 12 (Figure 4). The work of these 12 authors has more citations and a greater total strength of the links, reflecting the impact and importance of their findings. Since the connection between the authors is barely visible, this may mean that their preference was to analyze this topic on their own, without relying on or being able to collaborate with others who share the same interest. Several compact clusters are observed, indicating the existence of stable research teams addressing similar themes within the field of "digital divide" and "educational equity". At the same time, the distances between clusters suggest limited connectivity between some groups, which may reflect thematic fragmentation or differences in approach within existing research. The network thus highlights the need for more extensive collaboration between authors and for strengthening knowledge exchange across subfields.

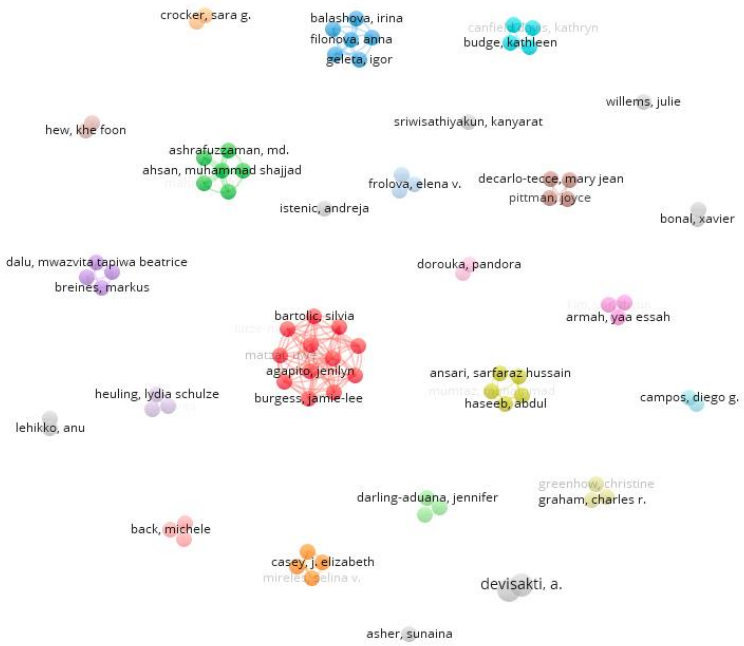

Figure 4. Authors who addressed the topic of the digital divide and educational equity of students

Source: Authors' contribution

Another type of analysis was carried out, entitled co-occurrence, first of all for all keywords, having the maximum number of occurrences of a keyword 3. Out of the total of 285 keywords, 20 reach the threshold (Figure 5). If the maximum number of occurrences of a keyword is 2, only 51 reach the threshold (Figure 6). As seen in Figure 5, there are 4 main clusters for representative keywords: the yellow one related to the digital divide, the red one associated with higher education and students, the blue one related to technology, equity and performance, and the green one represented mainly by digital technologies and access. They are all connected to each other, amplifying the strong relationship between them. This also suggests research trends and key themes, keyword patterns for this topic, which can help create a map for the conceptual structure of this topic. The keywords with the most occurrences are, in this order: digital gap – 23 (total link strength 43), technology – 12 (total link strength 32),

higher education – 11 (total link strength 26), covid-19 – 8 (total link strength 21), education – 7 (total link strength 20), students – 7 (total link strength 19), gap – 6 (total link strength 17), Access – 6 (total link strength 15), online – 4 (total link strength 15), performance – 4 (total link strength 11).

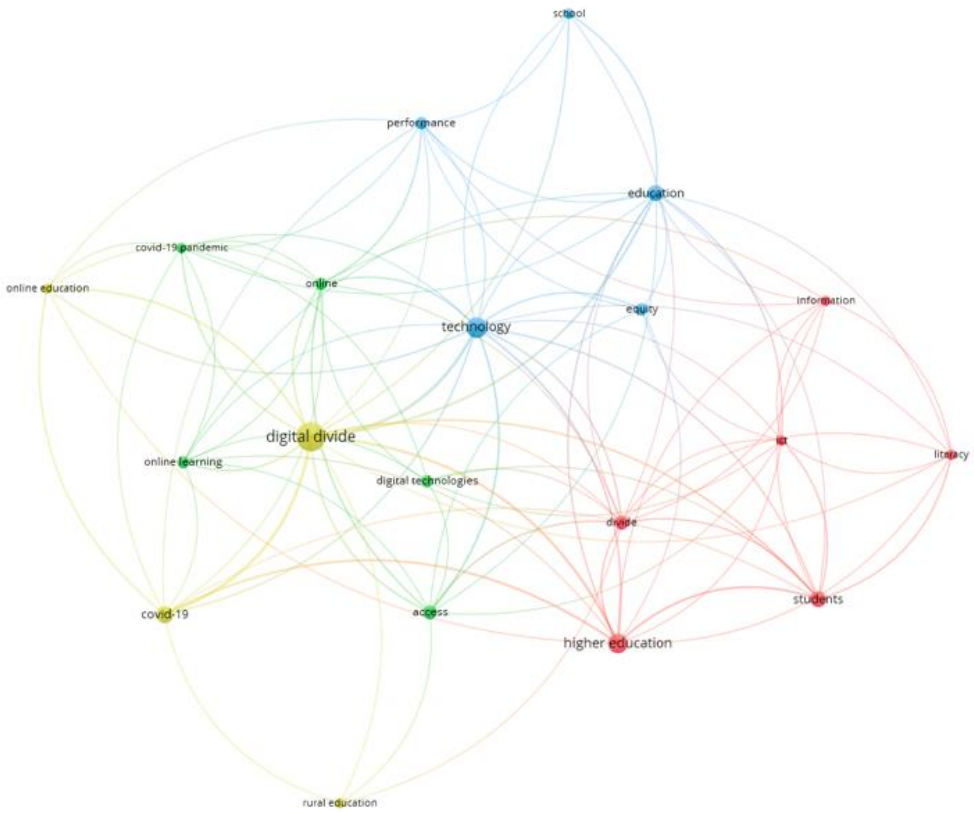

Figure 4. Main cluster of keywords that addressed the topic of the digital divide and student educational equity

Source: Authors' contribution

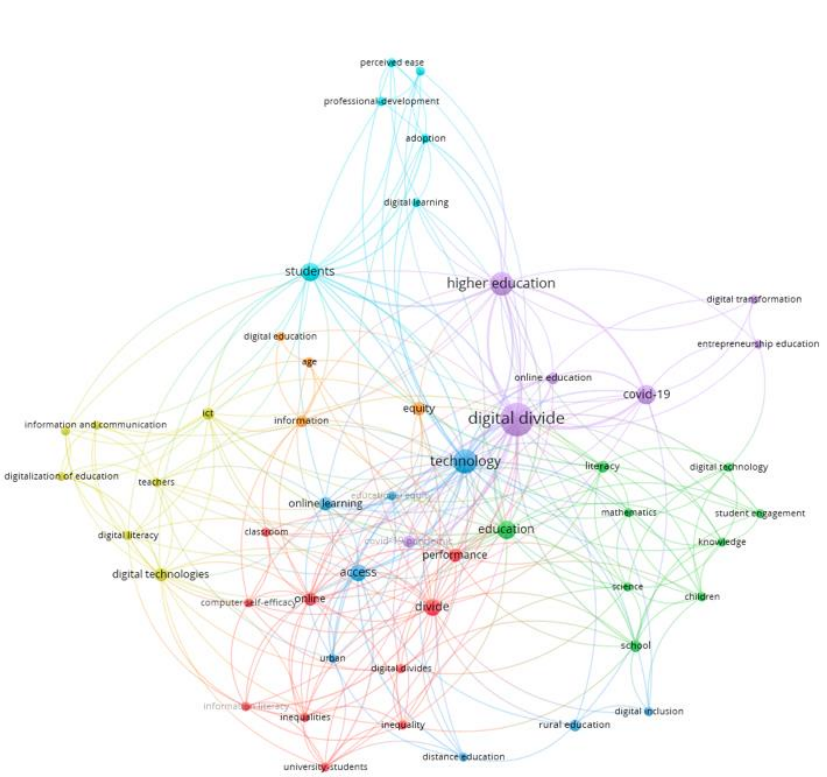

Figure 5. Secondary cluster of keywords that addressed the topic of the digital divide and student educational equity

Source: Authors' contribution

Unlike bibliometric analyses that have been conducted and address topics in this area, the current study adds value by explicitly focusing on the intersection between the digital divide and educational equity for students. Its contribution lies in identifying recent bibliometric trends (2019–2023), and integrating them into an interpretive conceptual framework, structured around four analytical dimensions—contextual influences, implications, divergent outcomes, and convergent outcomes. Thus, the study provides a critical synthesis of the specialized literature, strengthening the understanding of how unequal access to technology influences educational equity and suggesting future research directions.

The analysis of convergences and divergences identified in the literature highlights how structural inequalities continue to influence digital access and educational equity. Convergent results show a consensus on the essential role of digital skills, technological infrastructure and institutional support in reducing educational gaps. In contrast, divergent results reflect differences in context (economic, geographical and political) that determine significant variations in the impact of technology on educational equity. These findings suggest that the digital divide is not just a problem of technical access, but a systemic one, linked to the social structure and educational policies that can amplify or diminish existing inequalities.

Contextual influences, such as the level of economic development, educational policies, and digital infrastructure, determine the degree to which technology can support educational equity. These factors shape access to digital learning resources and opportunities.

The resulting implications suggest the need for educational policies aimed at reducing digital barriers and promoting inclusion, through balanced investments in infrastructure, digital skills training, and equitable access to technology for all students.

Convergent results

A strong convergence in the literature is the recognition that access itself is not sufficient to ensure equitable learning outcomes. Studies in various contexts demonstrate that access to materials must be accompanied by a pedagogy of support and institutional mediation. For example, research on MOOCs concludes that open access does not automatically translate into equitable participation unless the design explicitly addresses barriers (Lambert 2020). Similarly, analyses of remote students in rural and urban areas in South Africa (Lembani 2020) and household inequalities in Spain (González-Betancor 2021) confirm that contextual supports are needed for technology to improve performance. In low-resource contexts, adoption is shaped by perceptions of utility and compatibility rather than just infrastructure (Isaac 2019), reinforcing the idea that access is multidimensional.

Another area of agreement lies in the role of pedagogy and design. Classroom-level interventions show consistent positive effects when technologies are intentionally aligned with learning objectives. Collaborative digital storytelling improves writing skills (Tanrikulu 2022), immersive VR strengthens historical understanding (Taranilla 2022), gamified reading environments improve motivation and results (Li 2021), and virtual classroom environments promote creativity (Wannapiroon 2022). These reflect Leedahl's (2019) findings on intergenerational reverse mentoring, which not only improved technological skills among older adults, but also cultivated communication and teaching skills in students. Collectively, these studies confirm that technology offers fair gains when integrated into coherent pedagogical frameworks.

The literature also converges on the importance of teachers' capacity and institutional conditions. Studies on Distance Teaching in Emergencies (Ezra 2021; Lie 2020; Jacques 2021; Vijayan 2021) reflects this, showing that inequalities during the pandemic have been amplified by limited teacher training, high workload, and inadequate institutional support. Together, these findings reinforce that equity in student performance requires parallel investments in teachers and schools.

Finally, the conceptual and analytical contributions highlight the consensus on the centrality of equity in digital educational frameworks. Greenhow (2022) identifies equity as one of the five pillars of online learning, while Frolova (2020) and Akour (2022) point out that digitalization and digital transformation involve changes in governance and pedagogy with distributive consequences. Analyses of artificial intelligence in education (Pham 2022) and the maker movement (Schad 2020) similarly warn that without ethical and resource considerations, benefits risk being unevenly distributed.

Divergent results

Despite these convergences, the literature differs in the assessment of emerging platforms and technologies. Hu (2021), drawing on PISA data, reports that certain uses of social media can improve digital reading performance, while Krutka (2019) argues that the same platforms incorporate systemic inequalities and need to be addressed in school curricula. Similarly, studies on artificial intelligence oscillate between optimism and caution: Yan (2023) and Pham (2022) highlight the promise of personalization and empowerment of students, while Tsai (2020) and Emenike (2023) warn of risks related to agency, transparency, and integrity. These divergences suggest that the results of technology are not inherent in the tools, but conditioned by the pedagogical framework and governance structures.

There are also differences in how equity is conceptualized. In some contexts, equity is primarily material, defined in terms of devices and connectivity (Lembani 2020; Isaac 2019), while in others it is cultural and social, related to inclusion, identity and belonging. Reviews of the cultural richness of the community (Denton 2020), studies on STEM capital (Moote 2020), and investigations into the persistence of gender and minorities in engineering (Campbell-Montalvo 2022) emphasize that equitable outcomes require addressing structural exclusion and promoting environments that respect identity.

Contextual influences

The findings vary depending on the geographical and socioeconomic context. In high-income countries, the focus is increasingly on issues of identity, participation, and capital (Moote 2020; Campbell-Montalvo 2022; Denton 2020), while in low- and middle-income backgrounds, basic access and perceptions of utility remain critical (Isaac 2019; Lembani 2020). COVID-19 studies provide further evidence that existing inequalities are exacerbated by crises: children with disabilities and their families faced disproportionate barriers (Ezra 2021), while teachers struggled to adapt under pressure (Lie 2020). These contextual variations underline that the digital divide is multi-layered, encompassing material, cultural and institutional dimensions.

Implications

Taken together, the comparative results suggest three general perspectives. First, pedagogical alignment is decisive: when technology is coherently integrated into teaching, positive outcomes consistently occur (Leedahl 2019; Tanrikulu 2022; Taranilla 2022; Li 2021; Wannapiroon 2022). Second, structural conditions mediate impact: household resources, teacher training, and institutional support determine whether technologies reduce or replicate inequalities (Lembani 2020; González-Betancor 2021; Saikkonen 2021; Ezra 2021; Lie 2020). Third, emerging technologies have a dual effect: they create opportunities for personalization and empowerment (Yan 2023; Pham 2022; Hu 2021), but poses risks of exploitation and exclusion if governance and critical pedagogy are absent (Krutka 2019; Tsai 2020; Emenike 2023). Thus, although the field converges on the transformative potential of digital technologies, it diverges in terms of how this potential is realized in practice. Finally, the comparative results show that fairness is not guaranteed by the technology itself, but must be actively pursued through design, governance and systemic support.

7. CONCLUSIONS

Bibliometric and comparative analyses highlight the significant strengths of existing research on access to technology, the digital divide, and educational equity, while exposing persistent limitations and gaps that require attention.

An obvious strength is the diversity of methodologies used in the field. Quantitative studies, such as those using PISA datasets (Hu 2021), large-scale surveys among teachers (Saikkonen 2021), and adoption models in developing contexts (Isaac 2019), provide strong evidence of population-level correlations and patterns. These are complemented by qualitative and mixed-methods studies, including case studies on distance learning in South Africa (Lembani 2020), investigations into collaborative digital storytelling (Tanrikulu 2022), and immersive VR implementations (Taranilla 2022). The combination of approaches offers both breadth and depth, allowing for a richer understanding of how technology influences equity and performance.

Another strength is the range of contexts represented. The literature covers both high-income contexts, where issues related to identity, cultural capital, and inclusion dominate (Moote 2020; Campbell-Montalvo 2022; Denton 2020), as well as low- and middle-income contexts, where infrastructural and perceptual barriers remain critical (Isaac 2019; Lembani 2020). This diversity allows for comparative perspectives on how the digital divide manifests itself differently in global contexts.

Cornland also demonstrates strength in conceptual and synthetic contributions. The frameworks provided by Greenhow (2022), Frolova (2020), and Akour (2022) anchor empirical work in a broader understanding of equity and pedagogy, while systematic analyses (Schad 2020; Lambert 2020; Pham 2022) consolidates the scattered evidence and identifies the key variables that drive the results. These contributions increase coherence in a fragmented area.

Despite these strengths, several gaps appear. First, there is a relative lack of longitudinal studies that track the effects of access to technology and equity interventions over time. Most jobs provide snapshots rather than a sustained analysis of the long-term impact on performance.

Second, geographical imbalances persist. Although there is strong representation from North America and Europe, studies from the Global South remain underrepresented, except for isolated contributions (Isaac 2019; Lembani 2020). This risks over-generalizing findings from well-resourced contexts to contexts with different challenges.

Third, there is a notable gap in intersectional equity analyses. While some works explore gender and minority experiences in STEM (Campbell-Montalvo, 2022; Moote 2020), few studies systematically investigate how multiple axes of inequality – such as gender, class, disability, and geography – interact in shaping digital access and outcomes.

Fourth, emerging technologies such as artificial intelligence and learning analytics are often examined in terms of promise or conceptual risk (Tsai 2020; Pham 2022; Emenike 2023; Yan 2023), but empirical studies on their impact at the classroom level remain scarce. This creates a discrepancy between theoretical discourse and applied evidence.

Finally, while the literature recognizes the importance of policy and governance in shaping equity outcomes (Frolova 2020; Akour 2022; Krutka 2019), few articles explicitly assess the effectiveness of concrete policy interventions. There is limited evidence on which regulatory or institutional frameworks most effectively mitigate inequalities.

Addressing these gaps requires more long-term, comparative and intersectional studies, especially in underrepresented regions. Future research should also go beyond the documentation of divisions and move towards evaluating solutions and interventions that demonstrably close equity gaps. Moreover, as artificial intelligence and data-driven technologies proliferate, empirical work needs to reach the level of conceptual debates to ensure that these innovations are integrated responsibly and fairly.

Comparative analysis of the literature reveals that the digital divide and educational equity are shaped by a complex interplay between access to materials, pedagogical design, teacher capacity, institutional support and broader policy frameworks. While many studies state that technology can increase student engagement and performance, they also warn that without intentional strategies, digital innovations risk reinforcing existing inequalities.

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