

Mapping the intellectual landscape of research on the digital divide and digital education transformation: A bibliometric analysis

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Abstract: Digital education has emerged as a cornerstone of modern learning, expanding opportunities for access, innovation, and inclusiveness. However, persistent inequalities in connectivity, resources, and skills continue to reinforce a digital divide that shapes who benefits from these opportunities and how educational transformation unfolds. This study investigates the intellectual development of research on digital education with particular attention to the digital divide and its pedagogical, technological, and equity-related dimensions. Using a descriptive and explanatory bibliometric methodology, it analyzes highly cited Scopus-indexed publications spanning 2001 to 2025. Bibliometric tools, including co-word analysis and thematic mapping, were employed to uncover dominant trends, conceptual shifts, and underexplored areas. The findings reveal an evolution from broad themes such as digital divide, e-learning, ICT, and education (2001–2021) toward more specific concerns with digital inequality, digital learning, and digital literacy (2022–2025). This shift underscores the growing emphasis on structural barriers, technological fairness, and the implications of remote and hybrid learning. The thematic map further identifies digital divide and e-learning as well-developed motor themes, ICT and education as foundational but less conceptually advanced, online education and parental engagement as niche yet enduring, and WiMAX and professional development as declining. By providing a longitudinal and strategic overview, this study enriches academic discourse and highlights critical gaps in digital fairness, technological inclusiveness, and pedagogical transformation. Reliance on peer-reviewed Scopus data ensures methodological rigor and offers insights into the evolving landscape of digital education scholarship.

Keywords: Digital divide, Digital learning, Digital education, Digital education transformation, E-learning, ICT, Bibliometric analysis

1. Introduction

Digital education has emerged as one of the most transformative forces in contemporary learning, with the potential to democratize knowledge, expand access, and reshape pedagogical practice. From classrooms in developed countries embracing sophisticated online platforms to institutions in low-resource contexts grappling with limited connectivity, the shift toward digital education reflects both promise and profound inequality. While digital tools enable continuity of learning, they also expose and magnify persistent gaps in infrastructure, digital literacy, and socioeconomic opportunity (Pedulla et al., 2010; Mpungose, 2020). These disparities underscore the central challenge of the digital divide: rather than being merely a technical or logistical issue, it is a multidimensional phenomenon shaping educational inclusion and exclusion worldwide.

The dynamic between digital education and the digital divide is therefore not peripheral but foundational to debates about equity, innovation, and systemic transformation. Socioeconomic background continues to dictate who gains meaningful access to digital learning, with students from marginalized communities often facing structural barriers that limit both engagement and skill development (Andreas et al., 2025; Nautwima et al., 2023; Yang et al., 2022). Similarly, institutional readiness is uneven, with many universities and colleges still struggling to transition fully to digital education due to insufficient planning, capacity gaps, and weak stakeholder engagement (Akour & Alenezi, 2022; Asa et al., 2024; Milezi et al., 2023). The COVID-19 pandemic made these challenges starkly visible: in South Africa, the rapid pivot to emergency remote teaching was described as both necessary and exclusionary, benefiting only those students with stable internet access and adequate devices (Mpungose, 2020; Nautwima & Asa, 2022).

Globally, studies in teacher education further confirm that pre-existing inequalities were deepened during the crisis, as digital disparities reinforced social and educational divides (Frei-Landau & Avidov-Ungar, 2022). Governance and

policy responses have attempted to bridge these gaps, with frameworks for digital inclusion and e-governance emphasizing accountability, accessibility, and infrastructure investment (Chohan & Hu, 2022). However, persistent policy misalignment, fragmented implementation, and uneven resource distribution continue to constrain the transformative potential of digital education. As a result, the transition remains contested, uneven, and deeply shaped by the interplay of technological, policy, and socioeconomic factors.

Despite the rapid expansion of scholarship on digital education, existing reviews often remain fragmented, focusing narrowly on specific tools, pedagogical innovations, or national contexts, without providing a structural overview of how the digital divide shapes the field's intellectual trajectory. Narrative reviews, while insightful, are insufficient for capturing the scale and thematic evolution of a literature that now spans two decades and multiple disciplinary traditions. Against this backdrop, bibliometric approaches offer a systematic and objective means of mapping the intellectual structures, thematic clusters, and conceptual transformations that define digital education research (Aria & Cuccurullo, 2017). This study addresses this gap by conducting a bibliometric and science-mapping analysis of highly cited publications indexed in Scopus between 2001 and 2025. Using keyword co-occurrence, thematic evolution, and strategic mapping, the review identifies dominant, supporting, and declining themes within the digital education literature, with particular attention to the role of the digital divide. Specifically, the research seeks to answer the following questions:

1. What are the publication trends in digital education research from 2001 to 2025, particularly in relation to the digital divide?
2. Which articles, journals, and authors have most influenced the field?
3. How do countries and institutions vary in productivity and citation impact?
4. What intellectual structures and thematic clusters frame the connection between digital education and the digital divide?
5. How have themes evolved over time, and what areas are emerging, persisting, or declining?
6. What gaps and future research directions can be identified to strengthen equity and inclusiveness in digital education?

The findings of this review hold relevance for multiple audiences. For academics, it consolidates fragmented scholarship into a coherent map of conceptual development, offering an evidence-based foundation for new inquiries. For practitioners, it highlights practical insights into how technological and pedagogical innovations intersect with equity challenges. For policymakers, it underscores the need for coordinated governance and inclusive digital strategies to ensure that digital education contributes to social justice rather than exacerbating inequality. The remainder of this paper is structured as follows: Section 2 presents the methodological framework and data collection strategy; Section 3 outlines the bibliometric results, including performance and science mapping analyses; and Section 4 discusses the implications for research, practice, and policy, before concluding with directions for future scholarship.

2. Theoretical Background

The digital transformation of education has introduced new paradigms of teaching, learning, and access, reshaping how knowledge is created, delivered, and consumed. However, the success of this transformation is profoundly shaped by the persistence of the digital divide, which continues to act as a structural barrier to inclusivity in digital education. Existing scholarship highlights that digital inequality is not limited to the absence of devices or connectivity, but extends to disparities in skills, usage, and socio-technical capacity that determine who meaningfully participates in digital learning environments (Chapman, Masters, & Pedulla, 2010; Mpungose, 2020; Nautwima et al., 2025). Understanding these disparities is therefore critical for assessing the extent to which digital education can deliver on its promises of equity and democratization. The digital divide has been theorized in multiple ways, offering a layered understanding of both structural and agentic constraints (Nautwima et al., 2022). Van Dijk's four-access model, for example, situates digital inequality across motivational, material, skills, and usage dimensions, showing how barriers accumulate to shape exclusionary patterns in digital participation (Van Dijk, 2005). This framework has been validated in contemporary contexts. Mpungose (2020) observed how South African students faced compounded barriers during the COVID-19 pandemic, as inadequate devices, unaffordable internet, and limited digital skills restricted access to online learning. Similarly, Frei-Landau and Avidov-Ungar (2022) reported that digital skill gaps among trainee teachers perpetuated inequalities in participation, even in contexts where digital infrastructure was present. These findings suggest that digital exclusion must be understood as a multi-level process, not simply a question of access to technology.

Complementing this perspective, Bourdieu's theory of cultural capital provides critical insights into how socioeconomic background shapes digital learning outcomes. Studies such as Ren, Zhu, and Yang (2022) demonstrate that adolescents' digital experiences are strongly mediated by parental support, linguistic competence, and prior familiarity with digital tools. Such forms of cultural capital determine not only access but also the depth of engagement with online learning environments. This reinforces the idea that digital divides are deeply embedded within broader social structures, reproducing existing inequalities in education rather than dismantling them. Together, Van Dijk's structural framework and Bourdieu's cultural lens provide a comprehensive basis for examining how access, skills, motivation, and

socioeconomic resources interact to shape educational transformation in the digital age. Empirical research further illustrates that digital inequalities persist across contexts and scales. Chapman et al. (2010) showed that disparities endure even in well-funded environments, pointing to the role of socioeconomic conditions in mediating digital access. Hill and Lawton (2018) warned that unless institutions address these inequities, the rise of the global knowledge economy risks deepening North–South divides, entrenching global educational inequalities. Spector (2016) added an ethical dimension, arguing that digital education must prioritize justice, inclusion, and equity if it is to avoid reproducing existing hierarchies under the guise of innovation. These insights emphasize that digital education cannot be viewed purely as a technological shift but as a social transformation requiring alignment between policy, pedagogy, and infrastructure.

From this literature emerges a conceptual model linking the digital divide to the pathways through which education systems are being transformed. Three core dimensions stand out: access to infrastructure, including devices, connectivity, and power supply (Ren et al., 2022); digital literacy, encompassing the competencies of both learners and educators (Frei-Landau & Avidov-Ungar, 2022); and socioeconomic challenges, such as poverty, language barriers, and cultural capital (Hill & Lawton, 2018). These dimensions interact with foundational enablers such as coherent policy alignment (Chohan & Hu, 2022), strong stakeholder collaboration (Akour & Alenezi, 2022), and capacity-building efforts through training programs and curricula (Spector, 2016). Collectively, they capture the dynamic interplay of structure and agency that defines digital education transformation. By integrating these theoretical and empirical insights, this study situates the digital divide not as a peripheral challenge but as a central determinant of how digital education evolves. The digital revolution in education is therefore best understood as a contested process, shaped by access, skills, cultural capital, and institutional readiness, and moderated by the policies and practices that govern educational systems. This framing provides the foundation for the bibliometric analysis that follows, which maps how the digital divide has been conceptualized in scholarly discourse and how it has influenced the trajectory of digital education research.

3. Research Methodology

3.1. Search criteria and document selection

This review followed a systematic protocol to ensure methodological rigor in document retrieval and screening. The Scopus database was searched on 9 April 2025 using a Boolean strategy that combined terms related to the digital divide, digital transformation, education, and Africa. The initial search yielded 948 records, as seen in Table 1. Filtering by subject area, restricted to Social Sciences, Computer Science, Engineering, Decision Sciences, and Business, Management and Accounting, narrowed the dataset to 867 documents. Subsequent screening applied criteria for document type, language, and record validity. Only peer-reviewed articles, reviews, and conference papers were retained, while non-English publications, duplicates, and records without valid author information were excluded. This reduced the dataset further to 733 documents. The final corpus of 733 publications represents a robust and high-quality dataset suitable for bibliometric analysis. It provides comprehensive coverage of scholarship on the digital divide and digital education transformation in Africa while excluding irrelevant, incomplete, or non-peer-reviewed material.

Table 1: Search criteria and document selection

Filtering criteria	Exclude	Include
Search engine: Scopus Search date: 09-04-2025 Search term: (("digital divide" OR "ICT inequality" OR "technology gap") AND ("digital transformation" OR "digitalization" OR "ICT integration") AND ("education" OR "schooling" OR "learning") AND ("Africa" OR "Sub-Saharan Africa"))		948
Subject area: Social Sciences, Computer Science, Engineering, Decision Sciences, Business, Management and Accounting,	81	867
Document type: Articles, Conference papers, and Reviews	102	765
Language screening: English only	26	739
Erroneous records screening: Include documents with valid author information only, and delete duplicates	7	732
Total Selected Documents		733

Source: Authors’ compilation (2025)

3.2. Techniques for analysis

To systematically address the research questions, this study employed a bibliometric approach that combined performance analysis with science mapping. The analysis was conducted using VOSviewer (Van Eck & Waltman, 2010) and the Bibliometrix R package accessed through its Biblioshiny interface (Aria & Cuccurullo, 2017). These tools offered

an objective, replicable, and comprehensive framework for mapping the intellectual structures, thematic clusters, and conceptual evolution of scholarship on the digital divide and digital education transformation. Performance analysis was used to capture descriptive indicators such as year-wise publication trends, top authors, influential articles, prolific journals, leading institutions, and contributing countries. This established the productivity and scholarly impact of the field, helping to identify where research activity has been concentrated and which contributions have exerted the most influence.

In parallel, science mapping techniques explored the intellectual foundations and thematic progressions of the literature. Keyword co-occurrence analysis was applied to trace the conceptual development of core themes and to identify linkages between equity, technology, pedagogy, and institutional contexts. Bibliographic coupling and co-citation networks were further employed to reveal shared theoretical underpinnings and cross-disciplinary connections across studies. Cluster maps and strategic thematic networks generated in VOSviewer, based on normalized algorithms and total link strength (TLS), facilitated the classification of themes into motor, basic, niche, and emerging or declining categories. To capture changes over time, temporal overlays in Biblioshiny were applied to segment the literature into distinct periods (2001–2010, 2011–2017, and 2018–2025). This temporal framing made it possible to identify shifts from broad constructs such as ICT and e-learning toward more focused concerns with digital literacy, digital inequality, and educational resilience in the wake of the COVID-19 pandemic. Additional outputs, including thematic maps, collaboration networks, word clouds, and thematic evolution maps, were generated to provide both quantitative precision and visual clarity. This methodological strategy ensured a descriptive account of productivity, a well as a structural and conceptual interpretation of the field’s evolution by integrating performance analysis with science mapping. This dual approach offers a systematic and transparent account of how digital education scholarship has developed around the digital divide, highlighting persistent gaps and laying a strong foundation for identifying emerging research frontiers.

4. Results

4.1. Year-wise publication trend

Figure 1 illustrates the trajectory of publications on the digital divide and digital education transformation from 2001 to 2025. The early phase (2001–2018) was characterized by relatively low scholarly attention, with annual publications averaging fewer than 20. During this period, debates primarily centred on the integration of ICT in education and the challenges of extending infrastructure to low-income contexts. A modest peak was recorded in 2008, with 25 publications, coinciding with global initiatives such as the Millennium Development Goals (MDGs), which placed strong emphasis on expanding ICT access in education systems. A significant turning point occurred in 2019, when output increased from 23 publications in 2018 to 52, followed by a sharp escalation to 86 in 2020 and a peak of 109 in 2022. This surge is closely associated with the COVID-19 pandemic, which forced a global pivot to emergency remote learning and foregrounded issues of access, digital literacy, and educational resilience. The crisis underscored the urgency of addressing the digital divide, prompting both empirical research and policy-oriented critiques (Mpungose, 2020; Frei-Landau & Avidov-Ungar, 2022). Although publication numbers remained strong in 2023 (97) and 2024 (100), a sharp drop to 25 is observed in 2025. This decline is best interpreted as an artefact of database indexing delays and the natural time lag between research production and publication visibility, rather than a waning of scholarly interest. It may also reflect an emerging shift of focus toward adjacent themes such as artificial intelligence, adaptive learning, and the ethics of digital technologies in education. Overall, the publication trend reveals a structural shift in the research field: the digital divide has evolved from a peripheral concern associated with infrastructure gaps to a central theme in debates on digital education. The sharp rise in publications post-2020 signifies its recognition as a critical determinant of educational equity and resilience, firmly embedding digital inequality within broader discussions of pedagogical transformation and global education reform.

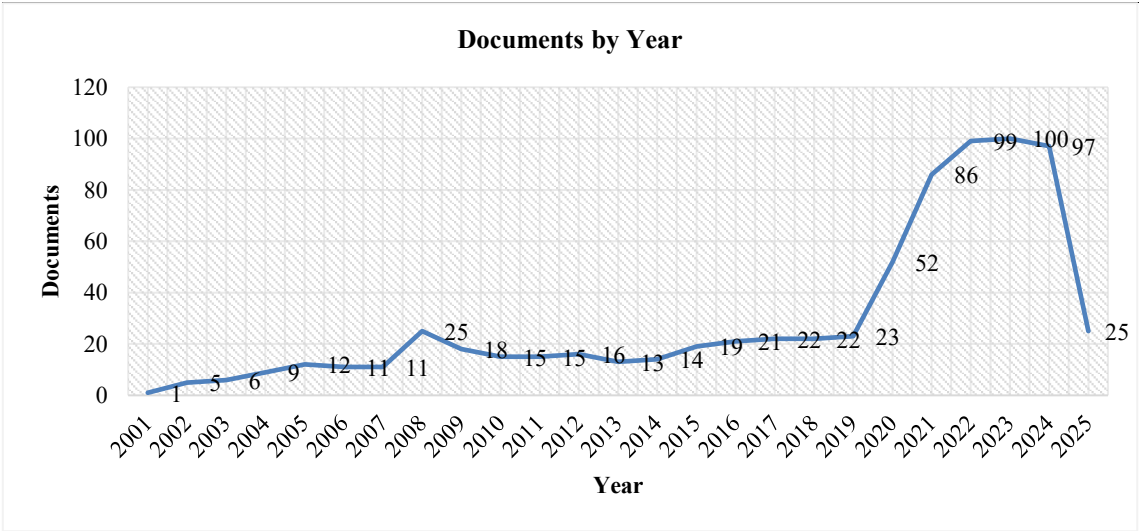


Figure 1: Year-wise publication trend
Source: Authors' compilation (2025)

4.2. Top prominent author bibliometric citation analysis

Figure 2 presents the top authors by total publications (TP). The figure highlights that while Bennett, Sue leads in productivity with three publications, most other leading authors contributed one or two studies. This distribution underscores that the field remains relatively dispersed, with no single dominant author but rather a cluster of scholars contributing incrementally to its development. The figure also reinforces the observation from Table 2 that productivity does not always translate into citation impact: highly cited authors such as Sharma and Ventä-Olkkonen appear at the lower end of the productivity spectrum, while more prolific contributors such as Bennett or Waycott recorded lower citation totals relative to single-publication leaders. In a nutshell, Figure 2 and Table 2 suggest that intellectual leadership in digital divide and digital education research is shaped both by highly cited, seminal contributions and by sustained, collaborative engagement across multiple studies. This dual dynamic reflects a field where theoretical breakthroughs often emerge from single landmark works, while thematic continuity and conceptual refinement are sustained by networks of collaborative authors.

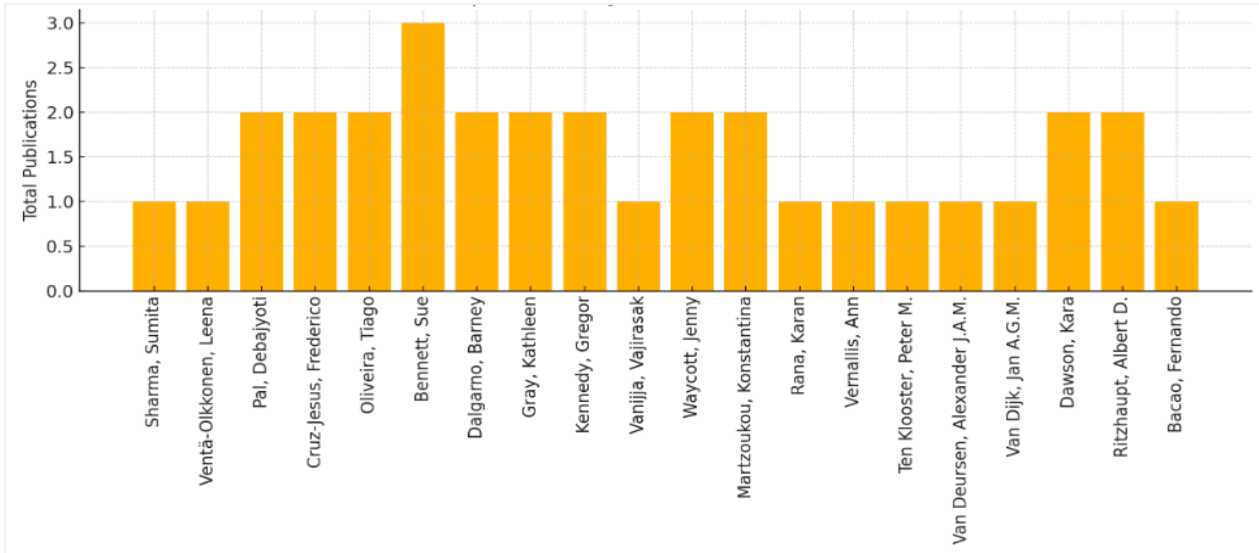


Figure 2: Top authors by total publications
Source: Authors' compilation (2025)

Table 2 complements these results by visualizing the top 20 authors by total citations (TC). The results reveal that influence in this domain is not always tied to productivity. For instance, Sharma, Sumita and Ventä-Olkkonen, Leena each recorded only a single publication, yet both achieved the highest citation counts (TC = 615). This indicates that their individual works have served as landmark contributions, heavily shaping subsequent debates on digital inequality. Similarly, Pal, Debajyoti demonstrates considerable impact with two publications accruing 413 citations, showing how concentrated, high-quality research can elevate scholarly visibility. In terms of productivity, Bennett, Sue emerges as the most prolific author, contributing three publications with a total of 291 citations and moderate collaborative ties (TLS = 6). By contrast, Cruz-Jesus, Frederico and Oliveira, Tiago each published two papers, but with strong citation counts (TC = 292 each) and the highest collaboration scores (TLS = 43). Their profiles suggest that visibility in this field is strongly enhanced by participation in co-authorship networks and cross-institutional collaborations. Other steady contributors such as Dalgarno, Gray, Kennedy, and Waycott maintain balanced positions, with two publications apiece and citation counts in the range of 229–280, reflecting consistent engagement with pedagogical and technological themes in digital learning research.

Table 2: Most prominent authors in the field by TC

Rank	Authors	TP	TC	TLS
1	Sharma, Sumita	1	615	0
2	Ventä-Olkkonen, Leena	1	615	0
3	Pal, Debajyoti	2	413	0
4	Cruz-Jesus, Frederico	2	292	43
5	Oliveira, Tiago	2	292	43
6	Bennett, Sue	3	291	6
7	Dalgarno, Barney	2	280	6
8	Gray, Kathleen	2	280	6
9	Kennedy, Gregor	2	280	6
10	Vanijja, Vajirasak	1	271	0
11	Waycott, Jenny	2	229	6
12	Martzoukou, Konstantina	2	200	2
13	Rana, Karan	1	194	0
14	Vernallis, Ann	1	194	0
15	Ten Klooster, Peter M.	1	170	1
16	Van Deursen, Alexander J.A.M.	1	170	1
17	Van Dijk, Jan A.G.M.	1	170	1
18	Dawson, Kara	2	169	4
19	Ritzhaupt, Albert D.	2	169	4
20	Bacao, Fernando	1	149	39

Note(s): TP: Total publications; TC: Total Citations; TLS: Total Link Strength

Source: Authors' compilation (2025)

4.3. Bibliometric analysis of top influential countries/territories

The bibliometric evaluation of countries in Table 3 offers insights into both productivity (total publications, TP) and scholarly influence (total citations, TC), thereby mapping the geographical distribution of research leadership in the study of the digital divide and digital education transformation. When examined by total publications (TP), the United States stands out as the most prolific contributor with 152 publications, far surpassing other countries. This reflects the country's strong academic capacity, extensive digital education infrastructure, and longstanding investment in educational technology research. South Africa follows with 68 publications, positioning itself as the leading contributor within the African continent. India and the United Kingdom also emerge as highly productive, with 60 publications each, while China (44), Spain (39), and Australia (29) demonstrate consistent scholarly engagement. A number of emerging economies, including Malaysia, the Philippines, Indonesia, and Saudi Arabia, also feature in the top 20, showing a widening geographical base of scholarship on digital inequality and education. This distribution suggests that while research leadership remains concentrated in advanced economies, developing and middle-income countries are increasingly contributing to the global debate, particularly where digital divides are most visible.

By contrast, an examination based on total citations (TC) highlights a different pattern of influence. The United States again ranks first with 2,248 citations, consolidating its role as both the most productive and most influential actor in this domain. The United Kingdom, however, rises to second place with 1,298 citations despite being fourth in productivity, indicating the strong impact of its fewer but highly cited publications. India holds third position in both rankings, reflecting its balance of productivity and scholarly influence. Finland (TC = 637) and Spain (TC = 630) are particularly noteworthy: although Finland contributed only seven publications, their exceptionally high citation count underscores the global relevance of its scholarship. Similarly, Thailand and New Zealand demonstrate disproportionately high impact relative to their modest output, pointing to influential single or small sets of studies shaping international debates. Overall, the dual analysis of TP and TC suggests that leadership in digital divide research is shaped not only by volume of contributions but also by the strategic influence of key studies. The United States combines scale with impact, while countries such as the United Kingdom, Finland, Spain, and Thailand demonstrate how fewer but seminal works can achieve global recognition. South Africa's strong productivity but lower citation ranking indicates its growing regional role, though with opportunities to strengthen global visibility and impact. Overall, the results reveal a geographically diverse but uneven field, where advanced economies dominate citations, yet emerging and middle-income countries are expanding their research presence in ways that could reshape the landscape of digital education scholarship in the future.

Table 3: Top influential countries/territories by TP and TC

Top 20 based on Documents				Top 20 based on Citations			
Rank	Country	TP	TC	Rank	Country	TP	TC
1	United States	152	2248	1	United States	152	2248
2	South Africa	68	594	2	United Kingdom	60	1298
3	India	60	856	3	India	60	856
4	United Kingdom	60	1298	4	Finland	7	637
5	China	44	417	5	Spain	39	630
6	Spain	39	630	6	Australia	29	629
7	Australia	29	629	7	South Africa	68	594
8	Malaysia	24	157	8	Thailand	9	457
9	Canada	23	231	9	China	44	417
10	Taiwan	22	171	10	New Zealand	14	385
11	Germany	19	274	11	Portugal	10	308
12	Italy	16	42	12	Germany	19	274
13	Philippines	15	142	13	Netherlands	4	273
14	New Zealand	14	385	14	Canada	23	231
15	Indonesia	11	148	15	Ireland	9	212
16	Saudi Arabia	11	165	16	Pakistan	8	196
17	South Korea	11	77	17	Greece	6	185
18	Bangladesh	10	94	18	France	8	177
19	Portugal	10	308	19	United Arab Emirates	7	174
20	Brazil	9	48	20	Taiwan	22	171

Note(s): TP: Total Publications; TC: Total Citations

Source: Authors' compilation (2025)

4.4. Bibliometric analysis of top impactful institutions

The institutional-level analysis of top contributors (Table 4) shows that while each organization has produced only one indexed publication (TP = 1), their citation impact (TC) demonstrates considerable scholarly influence. This finding suggests that in the field of digital divide and digital education research, institutional prominence is often driven by highly cited single studies rather than large volumes of output. Leading the ranking, the Interact Research Unit at the University of Oulu, Finland achieved 615 citations with a single publication, marking it as the most influential institution in the dataset. This result underscores Finland’s reputation for pioneering digital education frameworks and illustrates how one seminal work can shape global debates on digital inequality. Similarly, the School of IT at King Mongkut's University of Technology Thonburi, Thailand ranks second with 271 citations. Despite limited productivity, its single contribution has been globally recognized, showing how impactful scholarship can emerge from middle-income country contexts where digital inequities are most visible. A cluster of Australian institutions, including the Faculty of Education at Charles Sturt University, the Faculty of Education at the University of Wollongong, and the Faculty of Medicine, Dentistry and Health Sciences at the University of Melbourne, each recorded 211 citations. This consistency highlights Australia’s strong role in shaping pedagogical and digital inclusion debates, with influential research addressing both practice and policy dimensions of digital education. The Innovation and Enterprise Unit at Birmingham City University (UK) also shows notable impact with 194 citations, reflecting the United Kingdom’s high global citation influence. Dutch institutions such as the University of Twente’s Departments of Psychology, Health and Technology and Communication Science recorded 170 citations each, illustrating the Netherlands’ active role in bridging technology and social science perspectives. North American universities, including the University of South Florida (169 citations) and the University of Memphis (148 citations), also feature prominently, though their contributions are less heavily cited compared to their European and Australasian counterparts.

Other impactful entries include the University of Otago (New Zealand, 153 citations) and institutions in Portugal (Banco de Portugal and Nova Information Management School, both around 143–149 citations). The presence of government-affiliated bodies such as the UK Home Office (122 citations) demonstrates that high-impact work in this area extends beyond academia, with policy-driven studies also influencing scholarly debates. Overall, the citation-based ranking reveals a dispersed yet globally influential landscape, where institutions across Europe, Asia-Pacific, and North America

have produced singular but highly impactful studies. These findings emphasize that institutional impact in digital divide research is less about sustained output and more about producing seminal contributions that resonate globally, advancing debates on digital equity, inclusion, and educational transformation.

Table 4: Top impactful institutions

Rank	organization	TP	TC
1	Interact Research Unit, University of Oulu, Finland	1	615
2	School of It, King Mongkut's University of Technology Thonburi, Bangkok, Thailand	1	271
3	Faculty of Education, Charles Sturt University, Wagga Wagga, Nsw 2678, Australia	1	211
4	Faculty of Education, University of Wollongong, Wollongong, Nsw 2522, Australia	1	211
5	Faculty of Medicine, Dentistry and Health Sciences, The University of Melbourne, Vic. 3010, Australia	1	211
6	Innovation and Enterprise, Birmingham City University, Birmingham, United Kingdom	1	194
7	University of Twente, Dep. of Psychology, Health and Technology, Drienerlolaan 5, Enschede, 7500, Ae, Netherlands	1	170
8	University of Twente, Department of Communication Science, Drienerlolaan 5, Enschede, 7500, Ae, Netherlands	1	170
9	University of South Florida, United States	1	169
10	University of Otago, New Zealand	1	153
11	Applied Economics, University of Oviedo, Oviedo, 33006, Spain	1	149
12	Nova, Information Management School, Campus De Campolide, Lisboa, 1070-312, Portugal	1	149
13	University of Memphis, 365 Innovation Drive, Memphis, 38152, Tn, United States	1	148
14	Banco De Portugal, Lisbon, Portugal	1	143
15	Department of Teaching and Learning, Montclair State University, Montclair, Nj, United States	1	143
16	Nova Information Management School (Nova Ims), Universidade Nova De Lisboa, Campus De Campolide, Lisbon, 1070-312, Portugal	1	143
17	School of It, King Mongkut's University of Technology Thonburi, Bangkok, Thailand	1	142
18	School of Education and Human Development, University of Colorado, Denver, United States	1	123
19	Home Office, Direct Communications Unit, London Sw1p 4df, 2 Marsham Street, United Kingdom	1	122
20	Oxford Internet Institute, Oxford, United Kingdom	1	122

Note(s): TP: Total Publications; TC: Total Citations

Source: Authors' compilation (2025)

4.5. Bibliometric analysis of top prolific journals

The analysis of journals publishing research on the digital divide and educational transformation offers insights into the preferred outlets for dissemination as well as the relative influence of different sources. When ranked by total publications (TP), Table 5 shows that research is concentrated in conference proceedings and technology-focused outlets. The Lecture Notes in Computer Science series leads with 24 publications, followed closely by the ACM International Conference Proceeding Series (21) and Communications in Computer and Information Science (17). This dominance reflects the strong role of computer science and applied ICT venues in advancing early discussions on digital education. Among peer-reviewed journals, Sustainability (Switzerland) emerges as the most prolific with 14 papers, while Educational Technology and Society (11), Computers and Education (8), British Journal of Educational Technology (8), and Education and Information Technologies (6) represent highly active educational technology outlets. Other journals such as Telematics and Informatics (6), Frontiers in Education (5), and Education Sciences (5) also demonstrate consistent engagement with the topic, highlighting that scholarship on the digital divide spans both technology-oriented and pedagogical platforms. However, when assessed by total citations (TC), the picture shifts considerably. The International Journal of Information Management leads the field with 615 citations from a single article, illustrating how one seminal publication can outweigh multiple outputs in terms of scholarly impact. High-impact education and technology journals also feature prominently: Computers and Education (583 citations from 8 papers) and Telematics and Informatics (301 citations from 6 papers) show how consistent productivity combined with strong citation performance translates into field leadership. Similarly, the British Journal of Educational Technology (258 citations), Frontiers in Education (229 citations), and Education Sciences (204 citations) indicate enduring influence within education-focused debates.

The contrast between TP and TC rankings highlights a dual dynamic in the field. On the one hand, high-output conference proceedings and technical series (e.g., Lecture Notes in Computer Science and ACM Proceedings) provide the main platforms for volume-driven dissemination but with relatively low citation impact. On the other hand, peer-reviewed journals such as *Computers and Education*, *British Journal of Educational Technology*, and *Telematics and Informatics* are the true centers of scholarly influence, generating far higher citation counts despite fewer total publications. Taken together, these findings suggest that while conference proceedings have been important in building early momentum around digital divide and ICT-in-education discussions, long-term intellectual impact is concentrated in specialized educational technology and information management journals. This indicates that researchers seeking to maximize visibility and influence should strategically balance between contributing to conference-driven technical debates and publishing in high-impact peer-reviewed journals where the scholarship has more enduring citation value.

Table 5: Top prolific journals by TP and TC

Rank	Journal by TP	TP	TC	Rank	Jornal by TC	TP	TC
1	Lecture Notes in Computer Science	24	64	1	International Journal of Information Management	1	615
2	ACM International Conference Proceeding Series	21	81	2	Computers and Education	8	583
3	Communications in Computer and Information Science	17	26	3	Telematics and Informatics	6	301
4	Sustainability (Switzerland)	14	162	4	Children and Youth Services Review	2	273
5	Educational Technology and Society	11	174	5	British Journal of Educational Technology	8	258
6	Computers and Education	8	583	6	Frontiers In Education	5	229
7	British Journal of Educational Technology	8	258	7	Computers in Human Behavior	3	228
8	Proceedings of The International Conference On E-Learning, Icel	7	35	8	Humanities and Social Sciences Communications	1	210
9	Telematics and Informatics	6	301	9	Education Sciences	5	204
10	Education and Information Technologies	6	99	10	Information Communication and Society	4	184
11	Turkish Online Journal of Educational Technology	6	48	11	Educational Technology and Society	11	174
12	Perspectives in Education	6	39	12	Information (Switzerland)	4	170
13	Lecture Notes in Networks and Systems	6	3	13	Information Systems Frontiers	2	170
14	Frontiers in Education	5	229	14	Sustainability (Switzerland)	14	162
15	Education Sciences	5	204	15	Distance Education	2	157
16	Computers in the Schools	5	57	16	International Journal of Artificial Intelligence In Education	2	149
17	Telecommunications Policy	5	48	17	Journal of Research on Technology In Education	2	144
18	Procedia Computer Science	5	28	18	Journal of Further and Higher Education	2	143
19	Proceedings of the Annual Hawaii International Conference On System Sciences	5	26	19	International Journal of Human-Computer Interaction	1	142
20	Asee Annual Conference and Exposition, Conference Proceedings	5	22	20	Journal of Information Technology Education: Research	4	133

Note(s): *TP*: Total Publications; *TC*: Total Citations

Source: Authors' compilation (2025)

4.6. Bibliometric analysis of impactful articles

The top 10 most cited articles (Table 6) provide a concentrated picture of the foundational works shaping debates on digital inequality and digital education. These studies highlight the centrality of access, crisis-induced adaptation, and socio-technical disparities in defining the trajectory of educational transformation. At the forefront, Iivari et al. (2020) is the most influential contribution, with 616 citations. Its analysis of how the COVID-19 pandemic transformed basic education among young learners reframed digital transformation as not merely a technical shift but a societal and pedagogical disruption. This article set the agenda for subsequent studies linking digital inequality to educational resilience. Similarly, Pal and Vanijja (2020) (271 citations) examined Microsoft Teams adoption in India, offering critical insights into system usability, technology acceptance, and how crisis-driven online learning illuminated pre-existing inequities in digital literacy and infrastructure. Waycott et al. (2010) (211 citations) and Mpungose (2020) (210 citations) further strengthened early and pandemic-era perspectives. Waycott and colleagues highlighted differences in how staff and students perceived ICT adoption, emphasizing cultural and institutional barriers to inclusivity, while Mpungose’s South African study illustrated how emergency remote teaching deepened exclusion in resource-constrained contexts. Together, they show that digital divides manifest across both developed and developing educational systems. Other top-cited articles expand the thematic reach. Bashir et al. (2021) (194 citations) analyzed bioscience higher education during COVID-19, underscoring sector-specific challenges of hybrid and online delivery. Van Deursen et al. (2015) (170 citations) highlighted demographic inequalities in internet use across gender, age, education, and income, framing digital inequality as a persistent societal problem. Daniel (2019) (153 citations) provided a critical review of big data in education, drawing attention to both opportunities and ethical challenges in digital learning environments. Cruz-Jesus et al. (2016) (149 citations) examined digital divides across the EU-28, offering a comparative regional perspective, while Nye (2015) (148 citations) assessed intelligent tutoring systems in developing countries, connecting technological innovation with global equity concerns. Overall, these top 10 studies demonstrate three key patterns. First, the pandemic catalyzed a surge of influential scholarship that positioned the digital divide as a defining lens for understanding educational transformation. Second, longstanding structural inequalities, captured by pre-pandemic works—continue to frame contemporary debates, showing that COVID-19 intensified rather than replaced existing challenges. Third, the field is marked by both global North (EU, US, Australia) and global South (India, South Africa) perspectives, underscoring the universal yet uneven nature of digital inequality in education.

Table 6: Top impactful articles

Rank	Author	Title	TC
1	Iivari et al. (2020)	Digital transformation of everyday life – How COVID-19 pandemic transformed the basic education of the young generation and why information management research should care?	616
2	Pal & Vanijja (2020)	Perceived usability evaluation of Microsoft Teams as an online learning platform during COVID-19 using system usability scale and technology acceptance model in India	271
3	Waycott et al. (2010)	Digital divides? Student and staff perceptions of information and communication technologies	211
4	Mpungose (2020)	Emergent transition from face-to-face to online learning in a South African University in the context of the Coronavirus pandemic	210
5	Bashir et al. (2021)	Post-COVID-19 Adaptations; the Shifts Towards Online Learning, Hybrid Course Delivery and the Implications for Biosciences Courses in the Higher Education Setting	194
6	Van Deursen et al. (2015)	Increasing inequalities in what we do online: A longitudinal cross sectional analysis of Internet activities among the Dutch population (2010 to 2013) over gender, age, education, and income	170
7	Daniel (2019)	Big Data and data science: A critical review of issues for educational research	153
8	Cruz-Jesus et al. (2016)	The education-related digital divide: An analysis for the EU-28	149
9	Nye, (2015)	Intelligent tutoring systems by and for the developing world: A review of trends and approaches for educational technology in a global context	148
10	Elena-Bucea et al. (2021)	Assessing the Role of Age, Education, Gender and Income on the Digital Divide: Evidence for the European Union	143

Source: Authors’ compilation (2025)

4.7. Bibliometric analysis of global research country collaboration networks

The bibliometric analysis of country-level contributions (Table 7) shows that global research on the digital divide and educational transformation is highly uneven but characterized by strong cross-national collaborations. Productivity, measured by total publications (TP), reveals that the United States leads with 62 publications, confirming its position as the dominant global hub in this domain. The country also records the highest citation count (TC = 5,392) and strong link strength (TLS = 25), underlining its dual role as both the most productive and the most influential actor. Close behind, India ranks second with 61 publications, reflecting its growing research engagement with issues of digital inequality, particularly in the context of large-scale digital education initiatives and pandemic-induced challenges. India’s relatively high TLS (19) also highlights its integration into international collaboration networks. China ranks third with 25 publications, though its citation count (TC = 448) and collaboration ties (TLS = 9) suggest that while research activity is increasing, its global influence remains more modest compared to the US and India. European countries also feature prominently, with the United Kingdom (20 TP; 784 TC; TLS = 19), Spain (12 TP; 277 TC), France (10 TP; 709 TC; TLS = 18), and Finland (9 TP; 398 TC) contributing consistent outputs. Their relatively strong citation counts demonstrate how European scholarship continues to influence debates on digital equity and educational policy. Smaller European states such as Norway (8 TP; 628 TC) and Cyprus (4 TP; 310 TC) also appear, showing that impactful work can emerge even from lower-output contexts. From the Asia-Pacific region, Malaysia (16 TP; 270 TC; TLS = 8), Australia (11 TP; 313 TC; TLS = 7), and South Korea (7 TP; 509 TC) contribute actively, with Australia and South Korea benefiting from relatively high citation averages. Meanwhile, countries such as New Zealand (7 TP; 251 TC) and Turkey (6 TP; 145 TC) highlight regional engagement. North American contributions beyond the US are led by Canada (6 TP; 133 TC), while European heavyweights such as the Netherlands (5 TP; 257 TC), Germany (3 TP; 11 TC), and Switzerland (2 TP; 1,471 TC) reflect differing balances between volume and impact. Switzerland is particularly notable for its extraordinary citation impact (TC = 1,471) despite very low publication numbers, suggesting the global significance of a few landmark studies.

Table 7: Top countries in global research collaborations:

Rank	Country	TP	TC	TLS
1	United States	62	5392	25
2	India	61	1157	19
3	China	25	448	9
4	United Kingdom	20	784	19
5	Malaysia	16	270	8
6	Spain	12	277	5
7	Australia	11	313	7
8	France	10	709	18
9	Finland	9	398	7
10	Greece	8	422	0
11	Norway	8	628	7
12	New Zealand	7	251	4
13	South Korea	7	509	4
14	Canada	6	133	1
15	Turkey	6	145	2
16	Netherlands	5	257	2
17	Cyprus	4	310	4
18	Japan	3	21	79
19	Germany	3	11	62
20	Switzerland	2	18	1471

Note(s): TP: Total publications; TC: Total Citations; TLS: Total Link Strength

Source: Authors’ compilation (2025)

The collaboration network visualization (Figure 3) complements these findings by showing how countries are interconnected through co-authorship clusters. The United States appears at the center of the largest cluster, linking closely with India, China, and several Asia-Pacific partners such as Malaysia and the Philippines. The United Kingdom forms another dense cluster, connecting strongly with European partners such as Germany, Greece, Spain, and Ireland, while also bridging collaborations with Australia. South Africa emerges as a key hub for African research, connected to

Botswana, Nigeria, and Sudan, highlighting regional leadership in contexts where digital inequality is acutely experienced. Briefly, Table 7 and Figure 3 reveal two important dynamics. First, the United States and India dominate global output, with European countries contributing high-impact studies that balance quality with productivity. Second, collaboration networks are increasingly cross-continental, linking global North and South researchers and reflecting the universal nature of digital divide challenges. However, the relative absence of some regions (e.g., Latin America and large parts of Africa outside South Africa) suggests persistent geographical imbalances in global knowledge production

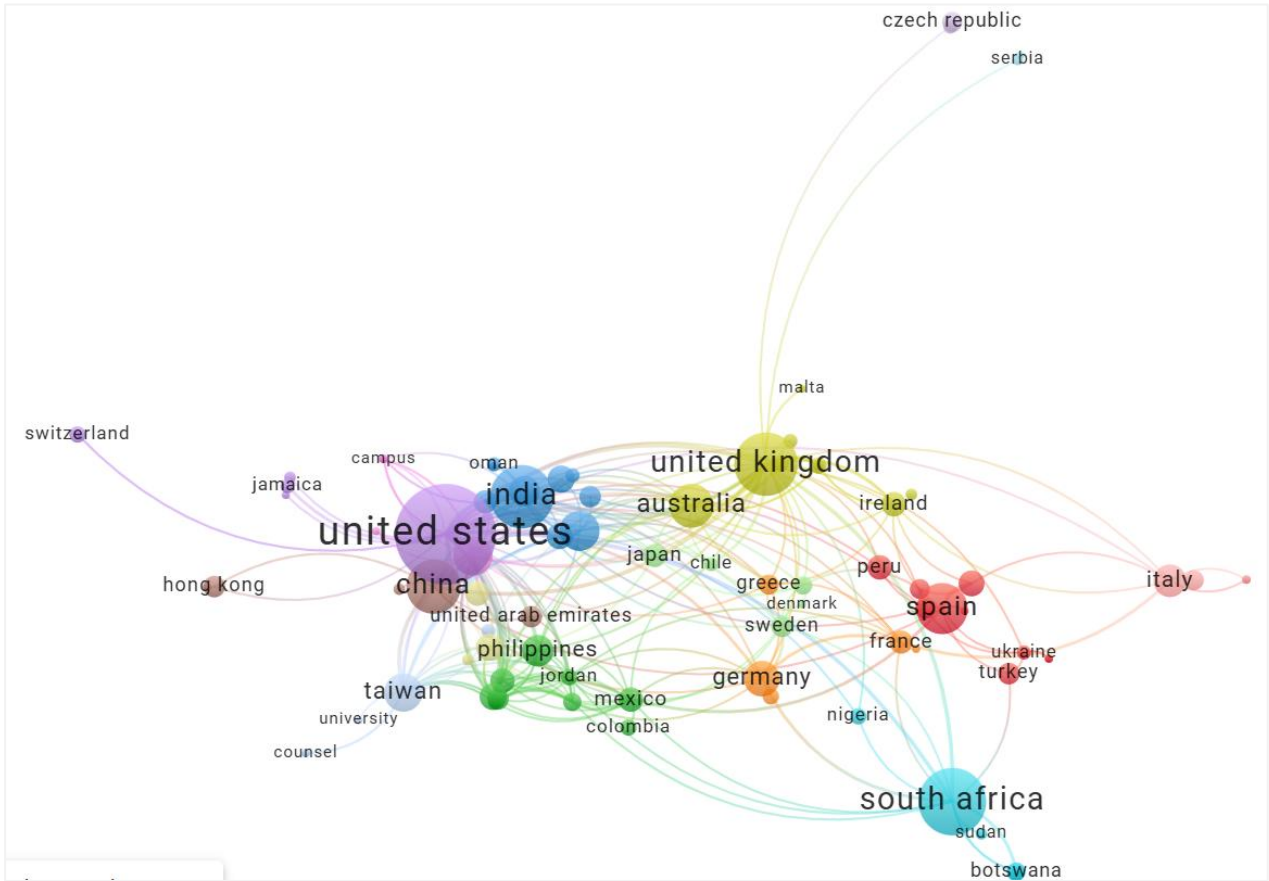


Figure 3: Top countries in global research collaborations network
Source: Authors’ compilation (2025)

4.8. Bibliometric analysis of keyword occurrences

The keyword co-occurrence analysis (Table 8) reveals the central intellectual architecture of research on the digital divide and the transformation of digital education. Unsurprisingly, “digital divide” dominates with 292 occurrences and a total link strength (TLS) of 1,090, affirming its role as the unifying core of the field. Around this central theme, the strongest conceptual clusters emerge across pedagogical models, technological enablers, crisis contexts, and equity-focused dimensions. Among related concepts, “e-learning” (103 occurrences, TLS = 421) and “online learning” (86 occurrences, TLS = 323) are particularly prominent. Their frequent co-occurrence with the digital divide suggests that scholarship has increasingly examined how digital inequalities directly shape access to, and outcomes of, digitally mediated education. Similarly, “Covid-19” (96 occurrences, TLS = 367) represents a pivotal turning point. Its strong ties to keywords such as remote learning, digital inequality, and online education confirm that the pandemic catalyzed an unprecedented surge in research on crisis-driven educational adaptation (Mpungose, 2020; Frei-Landau & Avidov-Ungar, 2022). Other recurring terms highlight the structural and pedagogical layers of this debate. “Educational technology” (53 occurrences, TLS = 212) and “higher education” (53 occurrences, TLS = 248) reflect the sustained focus on institutional adoption, teacher preparedness, and student experiences. “Education” (49 occurrences) remains a broader framing category but with lower relational depth (TLS = 191). Meanwhile, “digital literacy” (29 occurrences, TLS = 123) and “digital skills” (14 occurrences, TLS = 54) point to the agentic side of the divide, emphasizing competencies that enable equitable participation. Emerging but significant topics include “distance learning” (24 occurrences), “distance education” (20 occurrences), and “blended learning” (15 occurrences), which together reflect the diversification of instructional modalities. Keywords such as “artificial intelligence” (15 occurrences, TLS = 76) and “mobile learning” (13 occurrences, TLS = 46) indicate future-oriented directions, showing that attention is gradually expanding from access inequities toward the transformative potential of advanced technologies.

Table 8: Summary of top 20 keyword occurrences

Rank	Author Keywords	Occurrences	TLS
1	Digital Divide	292	1090
2	E-Learning	103	421
3	Covid-19	96	367
4	Online Learning	86	323
5	Educational Technology	53	212
6	Higher Education	53	248
7	Education	49	191
8	Digital Literacy	29	123
9	Distance Learning	24	110
10	Digital Inequality	23	70
11	Distance Education	20	115
12	ICT	19	75
13	Covid-19 Pandemic	18	70
14	Online Education	17	83
15	Artificial Intelligence	15	76
16	Blended Learning	15	71
17	Technology	15	83
18	Digital Skills	14	54
19	Internet	13	75
20	Mobile Learning	13	46

Source: Authors’ compilation (2025)

The co-occurrence network (Figure 4) visually supports these insights by clustering related keywords into thematic blocs. The red cluster emphasizes pandemic-induced adaptations (Covid-19, online learning, distance learning, digital equity), while the green cluster highlights institutional and pedagogical contexts (higher education, distance education, educational technology). The yellow cluster centers on structural enablers (ICT, digital skills, technology, accessibility), while the blue and purple clusters capture emerging domains such as mobile learning, artificial intelligence, and social media. Across these clusters, the central positioning of digital divide underscores its anchoring function in connecting disparate research strands. Overall, the keyword analysis confirms that the digital divide is not treated in isolation but rather as a cross-cutting concern embedded in debates about educational resilience, technological equity, and future pedagogical innovation. This evolution indicates that scholarship is progressively shifting from describing inequalities to exploring strategies for bridging gaps and transforming education systems in both crisis and long-term contexts:

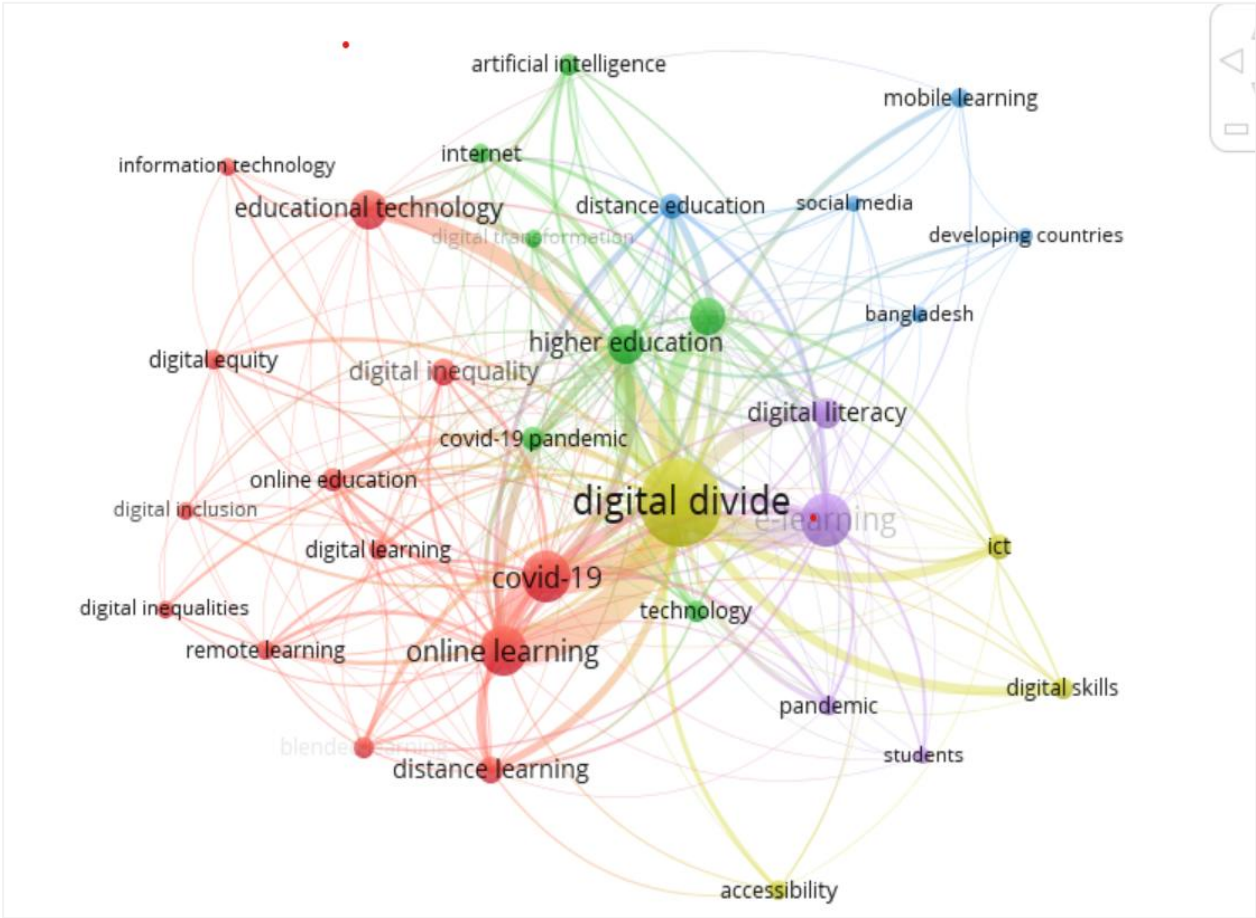


Figure 4: Keyword co-occurrence network
Source: Authors' compilation (2025)

4.9. Bibliometric analysis of thematic evolution and thematic evolution map

The thematic evolution map in Figure 5 illustrates how the discourse on the digital divide has progressed over time, reflecting shifting societal concerns, technological advancements, and policy priorities. In the early phase from 2001 to 2013, the digital divide was framed primarily through the lens of social inclusion and education and inequality. Scholarship during this period focused on structural barriers to access, with emphasis on affordability, connectivity, and how unequal infrastructure reproduced broader patterns of social and educational disadvantage. This early framing positioned access to ICTs as a fundamental social justice issue. From 2014 to 2020, the focus of research shifted toward institutional contexts, particularly higher education and educational technology. Rather than centering only on questions of who had access, scholarship began to investigate how ICTs were being integrated into teaching and learning practices within universities and colleges. This represented a maturation of the field, as attention moved beyond access gaps to include pedagogical adaptation, institutional readiness, and the role of technology in shaping educational outcomes.

The period between 2021 and 2023, shaped significantly by the COVID-19 pandemic, marked a turning point in the literature. The digital divide became central to discussions of educational resilience and equity, intersecting strongly with themes such as higher education, educational technology, and social inequality. The pandemic magnified existing disparities, highlighting challenges of affordability, digital literacy, and preparedness for emergency remote teaching. This period revealed the multidimensional nature of the digital divide, which encompassed not only access to devices and connectivity but also issues of usage, skills, and institutional adaptation. Looking ahead to 2024–2025, the thematic evolution suggests a consolidation of key themes around educational technology and social inequality. While the digital divide remains central, research is increasingly oriented toward future challenges, focusing on how technological solutions can be leveraged to promote inclusion while acknowledging their potential to perpetuate inequality. The persistence of higher education within this trajectory indicates that universities continue to serve as critical arenas for addressing digital inequities. At the same time, the emergence of new thematic directions underscores the continued importance of balancing innovation in digital education with equity-driven approaches.

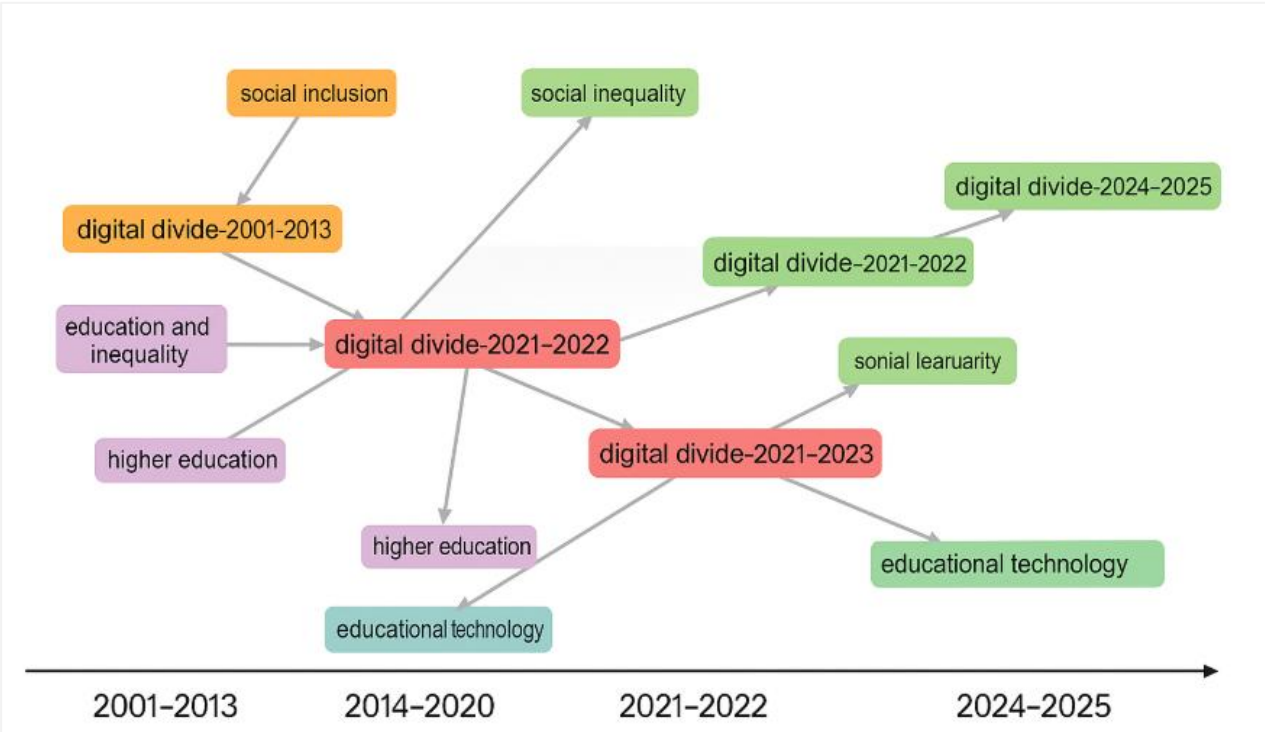


Figure 5: Thematic evolution network
Source: Authors' compilation (2025)

Additionally, the thematic map in Figure 6 provides a structured view of how research on the digital divide and digital education is positioned conceptually, while the complementary network visualization reinforces the interconnectedness of these themes. At the center of both maps are the motor themes (digital divide and e-learning) highlighted as the most influential drivers of the field. Their large size and central positioning indicate both high relevance and strong internal development. The network visualization confirms this, as these terms form dense clusters with strong co-occurrence links to educational technology, higher education, and digital literacy. This dual positioning demonstrates that digital divide and e-learning act as the intellectual “core” of the field, steering ongoing debates and anchoring new research trajectories. Surrounding this core are the basic themes, including educational technology, higher education, information technology, internet, and education. These themes are central but less conceptually developed, suggesting that while they provide foundational scaffolding, they are often used in support of other discussions rather than as independent research frontiers. The network visualization further emphasizes their bridging function, as these terms frequently appear as connectors across clusters. This underlines their importance in ensuring coherence across the field but also signals the need for more theoretical refinement.

In contrast, the niche themes, such as online learning, parents, instructional design, and technology integration, appear in more peripheral positions. They are well-developed conceptually but have limited centrality, meaning they speak to specialized communities rather than shaping the broader discourse. Their presence at the margins of the network visualization supports this interpretation, as they cluster in small, tightly connected groups linked to the central digital divide themes but not deeply embedded in the wider structure. Finally, the emerging or declining themes, such as professional development and WiMAX, occupy the bottom-left quadrant of the thematic map. Their weak positioning in both centrality and development suggests limited influence on the current trajectory of research. WiMAX, for instance, reflects an earlier preoccupation with connectivity infrastructure, while professional development, despite its practical importance, has not yet matured as a major research stream. In the network visualization, these themes are sparsely connected, further confirming their marginal or transitional role in literature. In a nutshell, the thematic map and network visualization provide a complementary understanding of the field’s intellectual architecture. They show a strong, centralized core around digital divide and e-learning, surrounded by foundational yet underdeveloped themes, specialized niche areas, and peripheral or declining topics. This layered structure underscores how the field has matured around core concerns of equity and digital transformation while leaving space for emerging areas that could gain centrality with further research.

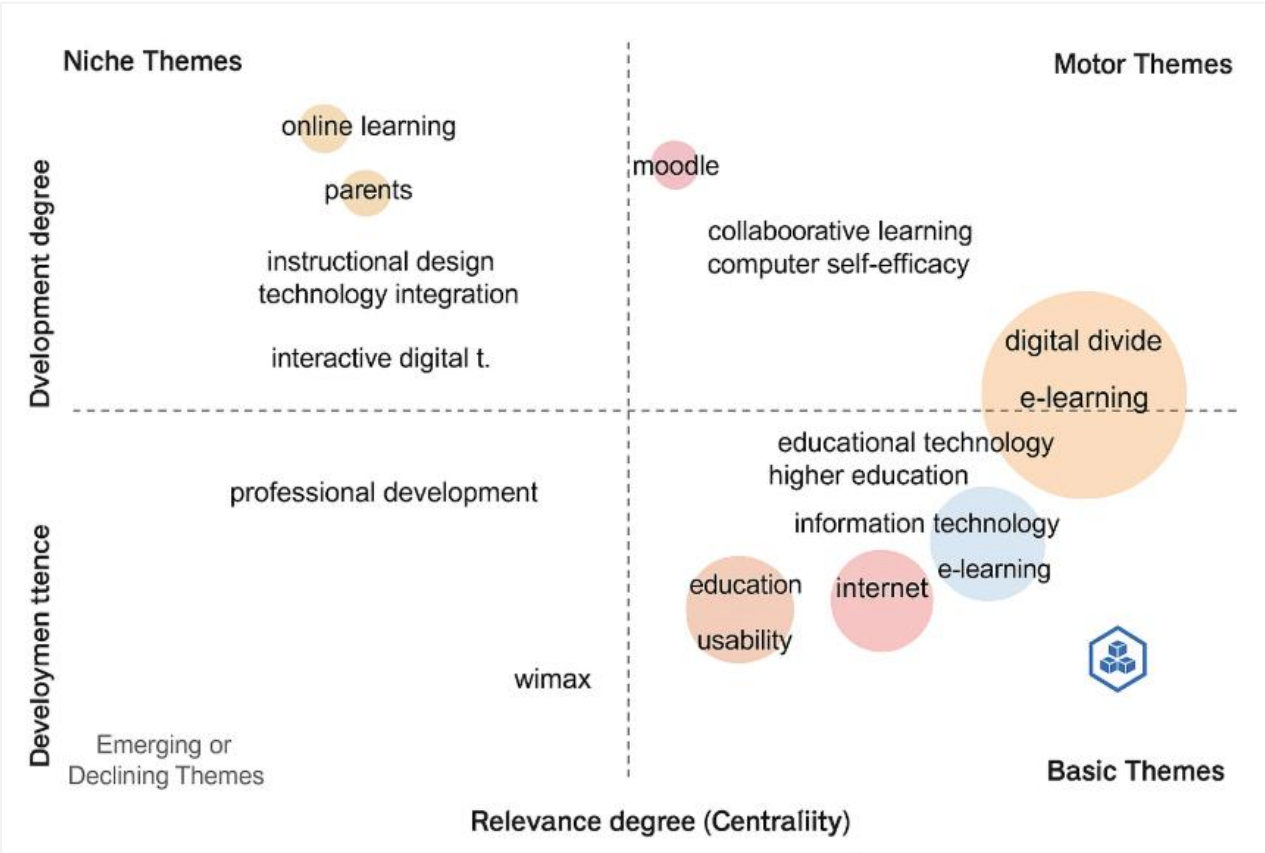


Figure 6: Four-quadrant strategic thematic evolution map
Source: Authors' compilation (2025)

5. Discussion and Conclusion

This review shows that the digital divide is no longer a background condition for digital education—it is the organizing lens through which the field now explains access, learning opportunities, and system resilience (Van Dijk, 2005; Chapman, Masters, & Pedulla, 2010; Mpungose, 2020). Across two decades, scholarship has moved from early access-focused debates to institutionally grounded analyses of integration, capacity, and pedagogy, with COVID-19 catalyzing a sharp turn toward questions of equity-by-design and educational resilience (Iivari et al., 2020; Pal & Vanijja, 2020; Mpungose, 2020; Frei-Landau & Avidov-Ungar, 2022). Thematic mapping positions digital divide and e-learning as the field's motor themes, while educational technology and higher education function as basic, high-centrality but under-developed anchors (Aria & Cuccurullo, 2017; Van Eck & Waltman, 2010). Niche areas (e.g., online learning, parental engagement, instructional design) demonstrate depth without breadth (Waycott et al., 2010; Pal & Vanijja, 2020), and declining foci (e.g., WiMAX) mark the literature's technological turnover. Together, these patterns indicate a maturing field that now treats inequity as multi-layered, spanning infrastructure, affordability, skills, usage, and institutional readiness, and increasingly situates solutions at the intersection of pedagogy, governance, and technology design (Van Dijk, 2005; Spector, 2016; Chohan & Hu, 2022).

Several implications follow. First, for research, the dominance of single, highly cited contributions alongside dispersed productivity suggests the need for programmatic, comparative work that accumulates evidence across contexts and time (Iivari et al., 2020; Cruz-Jesus et al., 2016). Future studies should (i) operationalize multi-level models that connect Van Dijk's access layers to outcomes; (ii) integrate Bourdieu-informed measures of cultural capital—parental support, language, prior familiarity—into learning analytics (Ren, Zhu, & Yang, 2022); and (iii) move beyond cross-sectional designs toward longitudinal and quasi-experimental evaluations of equity interventions (e.g., device and data subsidies, teacher upskilling) that have surfaced in pandemic research (Mpungose, 2020; Bashir et al., 2021). Methodologically, the field would benefit from open, replicable pipelines using established bibliometric toolchains (Aria & Cuccurullo, 2017; Van Eck & Waltman, 2010) and from triangulating bibliometrics with systematic reviews and meta-analyses to connect thematic salience with effect sizes (Donthu et al., 2021; Cobo et al., 2011). Second, for policy and system governance, the results argue for equity-by-design strategies that address all four access layers simultaneously: motivation, material access, skills, and meaningful use (Van Dijk, 2005). Evidence from South Africa, India, and the EU shows that affordability, device provision, and skill gaps jointly shape participation and outcomes (Mpungose, 2020; Pal & Vanijja, 2020; Cruz-Jesus et al., 2016; Elena-Bucea et al., 2021). Governance frameworks should therefore align infrastructure investment with inclusive design and accountability mechanisms (Chohan & Hu, 2022), while avoiding

policy fragmentation that blunts system-level impact (Hill & Lawton, 2018). Publication and collaboration patterns highlight leadership from the United States, India, and key European systems but also reveal regional gaps; donors and ministries can use these maps to prioritize north–south and south–south consortia and support cross-country replications of high-impact interventions (Iivari et al., 2020; Cruz-Jesus et al., 2016).

Third, for institutions and practitioners, the persistence of higher education and educational technology as basic themes signals unfinished work inside universities: moving from emergency adoption to sustainable, inclusive models (Waycott et al., 2010; Mpungose, 2020). Practical priorities include universal design for learning in digital courseware; targeted supports for first-generation and low-income learners (device loans, data stipends, offline-first resources); routine measurement of digital readiness at onboarding; and faculty development that couples pedagogy with platform fluency and data ethics (Spector, 2016). Notably, professional development appears under-developed in the maps; institutions should elevate it via micro-credentials and coaching tied to demonstrable equity gains (Spector, 2016; Frei-Landau & Avidov-Ungar, 2022). Fourth, for technology developers and EdTech markets, the shift from broad ICT to digital literacy, skills, and fairness implies that product success will be judged not only by functionality but by equity impact (Van Deursen et al., 2015; Daniel, 2019). Design implications include low-bandwidth/offline modes, multilingual interfaces, accessibility-first standards, learning analytics that surface equity gaps, and privacy-preserving architectures suitable for resource-constrained settings (Spector, 2016). As AI becomes more prominent in adjacent discourse, responsible roadmaps should include bias audits on under-represented learner groups and teacher-in-the-loop workflows that augment pedagogy rather than replace it (Daniel, 2019). Fifth, for journals and research infrastructure, outlet analysis shows that long-term influence concentrates in education- and information-focused journals, while volume is driven by conference series. Editors and societies can accelerate progress by standardizing equity reporting, context, connectivity, device access, baseline digital skills, encouraging cross-regional special issues, and requiring data/code availability where feasible (Donthu et al., 2021; Aria & Cuccurullo, 2017). Funders can incentivize networked studies spanning Global North and South institutions to address authorship and citation imbalances revealed in this mapping (Cruz-Jesus et al., 2016; Iivari et al., 2020).

5. Conclusion and Future Directions

This study has demonstrated that the digital divide remains a central concern in the transformation of digital education. The evolution of themes over the past two decades shows a shift from early debates on access and social inequality toward more complex considerations of institutional readiness, digital literacy, and technological integration. The COVID-19 pandemic further intensified this discourse, positioning the digital divide and e-learning as the most influential drivers of research and policy attention. Supporting themes such as educational technology and higher education continue to provide the foundation for scholarly inquiry, while niche and declining topics highlight the uneven development of the field.

Looking ahead, future research should move beyond questions of access to examine how digital divides manifest across different educational levels and socio-economic contexts. There is a need for more longitudinal and comparative studies that capture how inequalities in access, skills, and meaningful use shape long-term educational outcomes. Greater attention should also be given to the role of families, communities, and cultural capital in mitigating or reinforcing digital divides, as well as to the potential of emerging technologies like artificial intelligence to either narrow or widen existing gaps. Furthermore, expanding the scope of research beyond higher education to include schools, vocational training, and informal learning environments will provide a more holistic understanding of the issue. As scholars pursue these directions, they can contribute to developing inclusive digital education systems that balance technological advancement with equity and social justice.

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