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Menelusuri Tren Riset Terkait Teknologi Pendidikan dalam Pendidikan Inklusif: Sebuah Tinjauan Bibliometrik

Exploring Research Trends Related to Educational Technology in Inclusive Education: A Bibliometric Review

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ABSTRACT

Meskipun literatur mengenai teknologi pendidikan inklusif berkembang pesat, pemetaan sistematis mengenai evolusi struktural bidang ini, terutama yang berkaitan dengan respons terhadap disrupsi pandemi dalam konteks sekolah, masih terfragmentasi dan kurang terintegrasi secara konseptual. Penelitian ini bertujuan untuk mengisi kesenjangan tersebut dengan membedah tren produktivitas, struktur tematik, dan *novelty* penelitian masa depan. Menggunakan protokol PRISMA, studi bibliometrik ini menganalisis 40 dokumen terpilih dari database Scopus (2007–2024) yang secara spesifik menyoroti implementasi teknologi di tingkat sekolah. Analisis dilakukan menggunakan RStudio untuk performa bibliografi dan VOSviewer untuk visualisasi jejaring intelektual. Hasil penelitian mengungkap pergeseran paradigma fundamental: pandemi COVID-19 bertindak sebagai katalisator utama yang mengubah fokus riset dari sekadar "aksesibilitas fisik" menjadi "konektivitas pedagogis". Analisis klaster menyingkap adanya kesenjangan kritikal antara ketersediaan inovasi teknologi (Klaster Hijau) dan kesiapan pedagogis guru (Klaster Biru), yang mengindikasikan bahwa perangkat keras belum diimbangi dengan kompetensi UDL. Analisis kebaruan kata kunci mengidentifikasi kemunculan terminologi *Deep Learning* dan *Universal Design* pada spektrum 2023–2024, yang menandakan transisi bidang ini menuju era "Inklusi Cerdas".

Although the literature on inclusive education technology is growing rapidly, systematic mapping of the field's structural evolution, particularly in response to pandemic disruptions in the school context, remains fragmented and conceptually disjointed. This study addresses this gap by examining productivity trends, thematic structures, and the potential for future research. Using the PRISMA protocol, this bibliometric study analyzes 40 selected documents from the Scopus database (2007–2024) that specifically highlight the implementation of technology at the school level. The analysis was conducted using RStudio for bibliographic performance and VOSviewer for visualization of the intellectual network. The results reveal a fundamental paradigm shift: the COVID-19 pandemic served as a significant catalyst, redirecting research from mere "physical accessibility" to "pedagogical connectivity." Cluster analysis revealed a critical gap between the availability of technological innovations (Green Cluster) and teachers' pedagogical readiness (Blue Cluster), indicating that hardware has not been matched with UDL competencies. Keyword novelty analysis identified the emergence of Deep Learning and Universal Design terminology during 2023–2024, signaling the field's transition toward an era of "Smart Inclusion".

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PENDAHULUAN

Although the principle of inclusive education in Indonesia has a strong legal basis through the 1945 Constitution and Permendikbud No. 70/2009, the reality on the ground shows a significant gap in implementation. Teachers face technical obstacles in curriculum adaptation and diversity management (Asfaruddin et al., 2021), which are exacerbated by limited resources and school management that is not yet adaptive (Komarudin & Kaeni, 2023; Ratheeswari & Nallathambi, 2023). In this context, educational technology is generally positioned as a potential solution to improve accessibility and personalization (Ali et al., 2024; Metatla et al., 2018; Salas-Pilco et al., 2022). However, the integration of technology in an inclusive environment often proceeds without a clear strategic direction, creating new risks, including a digital divide, if not correctly mapped out (Ali et al., 2024). Therefore, understanding the global research landscape is important for ensuring the adoption of appropriate technologies rather than simply following the trend of digitalization.

Efforts to map the relationship between educational technology and inclusivity have been undertaken through various reviews. However, existing reviews have not captured the post-pandemic paradigm shift in technology. For example, the bibliometric study by Vidal Esteve et al. (2019) provides crucial insights into digital tools, but its analysis stops at 2019. This results in findings that overlook the substantial surge in technological innovation that occurred during and after the COVID-19 pandemic, including the use of AR and Deep Learning in inclusive settings. Similarly, Cretu & Morandau (2020) those who focus on pre-service education have not explored in depth how emerging technologies (such as AI or Assistive Tech) affect teacher pedagogy in real classrooms. This lack of comprehensive mapping has led to the fragmentation of knowledge, making it difficult for researchers and practitioners to identify the most effective and sustainable strategies for technology integration.

This study aims to bridge this gap by applying bibliometric analysis to the Scopus database to holistically deconstruct the field's intellectual structure. Unlike previous partial studies, this study makes a new contribution by mapping publication trends and identifying the evolution of conceptual themes and neglected research clusters. The main theoretical contribution of this study is to provide a roadmap for developing evidence-based teacher education curricula and inclusive policies, and to offer a new direction for a more focused and impactful future research agenda.

METODE

This study uses the Scopus database, which was selected due to its high-quality indexing and comprehensive coverage of educational technology literature (Oluwadele et al., 2023). To ensure the acquisition of accurate and contextually relevant data, a targeted search strategy was applied using the search string: TITLE-ABS-KEY ("educational technology") AND TITLE-ABS-KEY ("inclusive") AND TITLE-ABS-KEY ("education") AND ("school"). The inclusion of the term "school" is a deliberate methodological decision to restrict the scope to formal education. This aims to minimize bias from inclusive education literature that focuses on higher education, corporate training, or informal learning environments. Data collection was conducted on October 26, 2024. The data collection process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (M. J. Page et al., 2021). To ensure transparency and reproducibility. The selection process is shown in full in Figure 1.

Bibliometric data analysis was conducted using three complementary software programs: (1) RStudio (Bibliometrix package) for performance analysis, including annual productivity and country affiliation; (2) VOSviewer for mapping co-occurrence networks and keyword clusters; and (3) Publish or Perish for calculating impact metrics (h-index/g-index). This multi-tool approach ensures a comprehensive evaluation of both the structural and dynamic aspects of this research field.

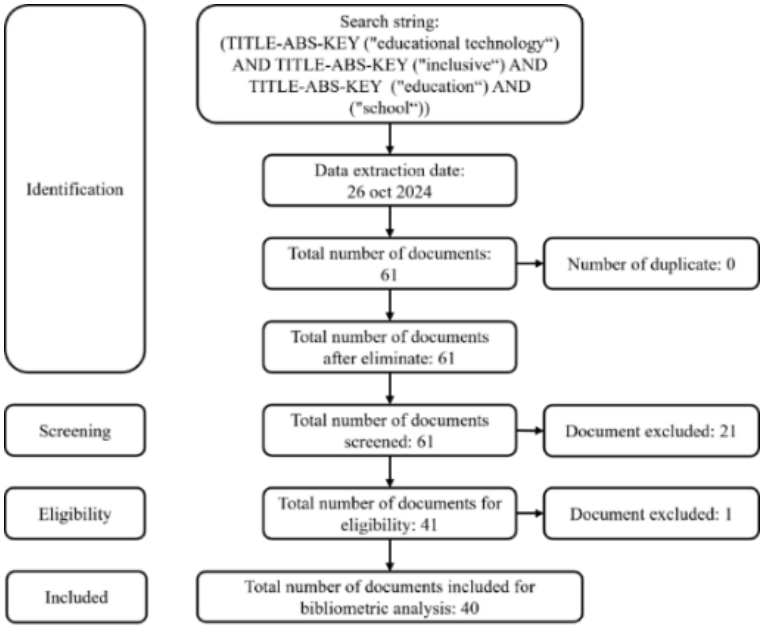

Figure 1. Bibliometric Analysis Flowchart Using PRISMA

HASIL PENELITIAN

An analysis of 40 selected documents (2007 to 2024) reveals that, despite the relatively small number of publications, this field has a substantial scientific impact, with an average of 8.17 citations per document. The annual growth rate of 4.16% indicates stable evolution. However, the surge in citations and international collaboration (15% of documents are cross-border) indicates that this topic has become an urgent global issue, especially in the post-pandemic era. Further details are shown in Figure 2.

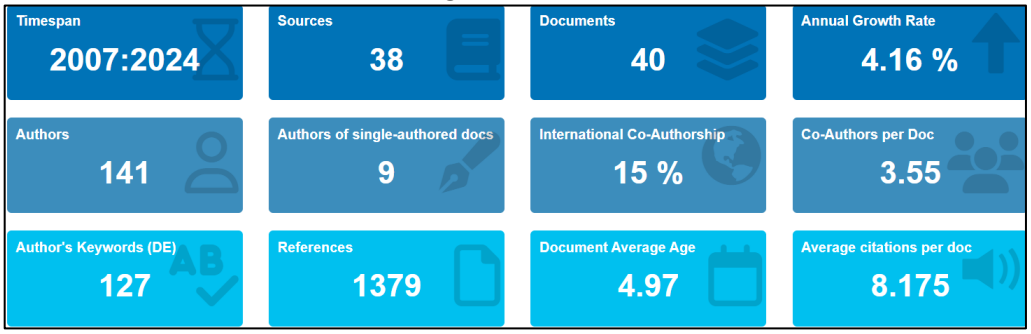

Figure 2. Main Information

Productivity Dynamics and Scientific Impact

The annual trend (Table 1) shows a clear pattern of evolution. The period from 2007 to 2014 was an incubation phase with sporadic productivity. A turning point occurred during 2018-2020, when publications increased significantly, peaking in 2021 with six articles, which accounted for 138 citations (42.46% of total citations). The sharp spike in citations in 2021 was not a statistical coincidence, but rather a direct response by the academic community to the COVID-19 crisis. The pandemic accelerated the adoption of technology in inclusive education, transforming it from a secondary option to a primary necessity, as evidenced by the high impact of articles published during this period.

Table 1. Citations Statistics per Year

Years	Total of Documents	Total of Citations	MeanTCperYear	h-index
2007	1 (2,5%)	6	0,32	1
2008	1 (2,5%)	7	0,39	1
2009	0 (0%)	0	0	0
2010	1 (2,5%)	28	1,75	1

Years	Total of Documents	Total of Citations	MeanTCperYear	h-index
2011	0 (0%)	0	0	0
2012	0 (0%)	0	0	0
2013	1 (2,5%)	3	0,23	1
2014	0 (0%)	0	0	0
2015	2 (5%)	2	0,09	1
2016	0 (0%)	0	0	0
2017	3 (7,5%)	3	0,11	1
2018	5 (12,5%)	51	1,27	4
2019	5 (12,5%)	28	0,80	3
2020	4 (10%)	4	0,17	1
2021	6 (15%)	138	4,60	4
2022	4 (10%)	41	2,56	2
2023	5 (12,5%)	3	0,20	1
2024	2 (5%)	13	3,25	1

Map of Geographic Contributions and Research Gaps

The geographical dominance in this literature reveals a sharp disparity between productivity and scientific impact, as summarized in Table 2. Based on these data, Spain leads in quantity, with 16 documents (13.01%), but its academic impact is relatively low, with only nine total citations. In contrast, Australia exhibits the highest impact efficiency: contributing to only seven documents, it recorded 85 citations, far exceeding those of other countries. This gap indicates that publications from Australia tend to present empirical findings or practical policies that are more relevant and widely cited globally than Spanish publications, which are often more local or descriptive.

Table 2. Top Five Countries With the Most Publications

Rank	Country	Continent	Total of Publications	Total of Citations
1st	Spain	Europe	16 (13,01%)	9 (3,61%)
2nd	USA	North America	14 (11,38%)	39 (15,66%)
3rd	Italy	Europe	13 (10,57%)	-
4th	Nigeria	Africa	12 (9,76%)	2 (0,80%)
5th	UK	Europe	10 (8,13%)	3 (1,20%)

The fragmentation of the scientific community is clearly illustrated by a map of the country's collaboration network, which is polarized into three isolated clusters. The first cluster (red) represents the Continental European network, in which Spain serves as the central hub, facilitating regional collaboration with Portugal, Belgium, Ireland, and Greece. The second cluster (blue) reflects the transcontinental Anglophone network, with the United Kingdom (UK) as the central point connecting researchers from the United States, Australia, and Nigeria. Meanwhile, the third cluster (green) comprises North Macedonia and South Africa, which collaborate incidentally and to a limited extent.

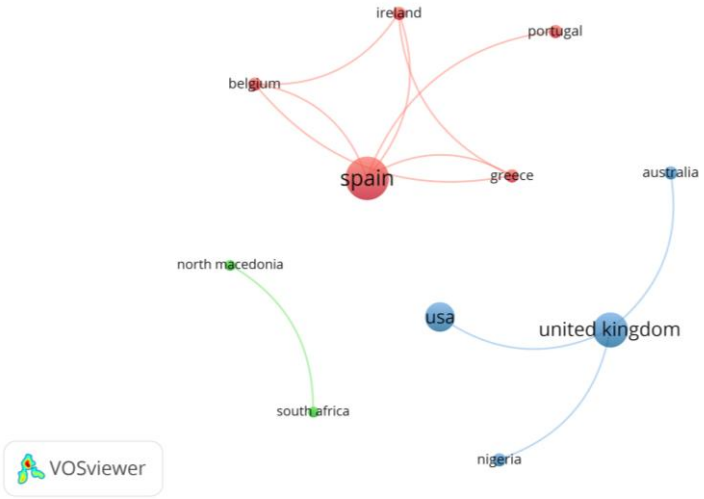

Figure 4. Collaboration Between Countries

The most critical visual finding from this map is the absence of connectivity between the main clusters. The European, Anglophone, and Peripheral groups appear to be working in their own "silos," with no significant bridges of collaboration (brokerage). This indicates that knowledge exchange on this research topic remains geographically and linguistically fragmented rather than globally integrated.

Pola Diseminasi dan Dampak Ilmiah

Table 3. Top Sources by Scientific Impact

Rank	Journal	Publishing	NP[a]	TC[b]	Main Focus
1st	Sage Open	Sage Publications	1	32	Interdisipliner
2nd	International Journal of Inclusive Education	Taylor & Francis	2	28	Pedagogi & Kebijakan Inklusif
3rd	Turkish Online Journal of Educational Technology	Sakarya University	1	28	Implementasi EdTech
4th	British Journal of Educational Technology	Wiley-Blackwell	1	25	Desain Instruksional
5th	Multicultural Education & Technology Journal	Emerald	1	21	Keragaman Budaya dan Teknologi

a: Number of Publications
b: Total of Citations

Although the articles are spread across various outlets, scientific impact analysis (see Table 3) confirms that the most influential discourse in this dataset centers on educational challenges at the school level. Journals with the highest citation impact, such as the International Journal of Inclusive Education and the Journal of Special Education Technology, consistently serve as key references because of their focus on classroom pedagogy and accessibility for school-age students, rather than on higher education or corporate training.

For example, the articles with the highest impact in this dataset (Harris et al., 2022; Liu, 2021) were published in these journals and explicitly discussed school closures and strategies for primary and secondary school teachers during the crisis. This supports the selection of source titles in this study. Although some journals are interdisciplinary (e.g., SAGE Open), the articles that passed the selection process and had a substantial impact were those that focused exclusively on the dynamics of inclusion in formal school environments. The apparent fragmentation of sources indicates that the issue of school inclusion is now discussed not only in specialized education journals but also in general educational technology journals that emphasize practical classroom application.

Geographical Distribution and Institutional Context

Table 4. Top Countries of Origin and Scientific Production

Rank	Country	Documents	Dominant Focus in Dataset
1st	Spain	6	Teacher Training & Digital Competence
2nd	United Kingdom	5	Policy & Inclusive Pedagogy

3rd	Russian	5	Specialized Education & Distance Learning
4th	United States	5	Assistive Technology & UDL
5th	Italy	4	ICT in Compulsory Schooling

In terms of institutional contributions, the research landscape is globally distributed but institutionally fragmented. No single university dominates this dataset; instead, research output is distributed across multiple research centers. Therefore, to understand macro trends, Table 4 categorizes contributions by country of origin.

The data confirm a strong European dominance, with Spain (6 documents), the United Kingdom (5), Russia (5), and Italy (4) collectively accounting for a significant share of the research output. This concentration is in line with the European Union's strict policy framework on digital inclusion and teacher competence (such as the DigCompEdu framework). Specifically, studies originating from Spain and Russia often focus on pre-service teacher training, which directly bridges the gap between preparation in higher education and practical implementation in primary and secondary school classrooms.

Outside Europe, the United States (5 documents) remains a major contributor, particularly to the development of the Universal Design for Learning (UDL) framework and to the implementation of assistive technology hardware in schools. Meanwhile, representation from the Global South, although present (e.g., Brazil, Nigeria, Argentina), appears more sporadic. One significant example is a study from the Universidad Nacional de Quilmes (Argentina) that offers a critical perspective on bioinformatics in secondary schools, showing that innovative, inclusive practices also emerge in developing countries, albeit with fewer publications than in the Global North.

Most Influential Documents

The citation analysis in Table 5 reveals a fundamental paradigm shift in the literature on inclusive technology: from "ideal design" to "crisis mitigation." The absolute dominance of articles published during the pandemic (Harris et al., 2022; Liu, 2021; A. Page et al., 2021) at the top of the rankings confirms that COVID-19 was not merely a backdrop but the primary catalyst that changed the direction of research in this field.

The high number of citations for A. Page et al. (2021) (52 citations) and Liu (2021) (32 citations) indicates that academic discourse has shifted from theoretical discussions of assistive technology to pragmatic strategies for maintaining school connectedness and addressing the digital divide. In contrast to pre-pandemic literature, such as Starcic (2010), which focused on developing technology for ideal inclusive classrooms, the latest literature better reflects efforts to "survive exclusion" in an emergency digital environment.

In the context of academic policy, Pérez (2021) fourth-place ranking (31 citations) has important implications: the surge in demand for technology in schools necessitates radical reform in teacher education. The high number of references to this Augmented Reality training study indicates that the primary obstacle to inclusion in schools today is no longer the availability of hardware but rather the pedagogical readiness of pre-service teachers to operate such complex technology.

Table 5. Top 5 Most Cited Documents

Rank	Authors (Year)	Title	TC
1st	A. Page et al (2021)	Fostering school connectedness online for students with diverse learning needs: inclusive education in Australia during the COVID-19 pandemic	52
2nd	Harris et al (2022)	Catering for 'very different kids': distance education teachers' understandings of and strategies for student engagement	33
3rd	Liu (2021)	Bridging the Digital Divide Amidst Educational Change for Socially Inclusive Learning During the COVID-19 Pandemic	32
4th	Pérez (2021)	La realidad aumentada como recurso para la formación en la educación superior	31
5th	Starcic (2010)	Educational technology for the inclusive classroom	28

Trend Topics

The evolution of keywords (Figure 6) illustrates the research field's maturity. In the early phase (2018–2019), the discourse centered on generic actors ("students", "e-learning"). By 2020–2022, the focus narrowed to specific interventions driven by the pandemic ("COVID-19", "accessibility"). Currently (2023–2024), the trend has shifted

towards systemic solutions, evidenced by the emergence of "Universal Design" as a dominant keyword. This trajectory suggests that the field is moving away from reactive measures toward proactive, sustainable, and inclusive frameworks.

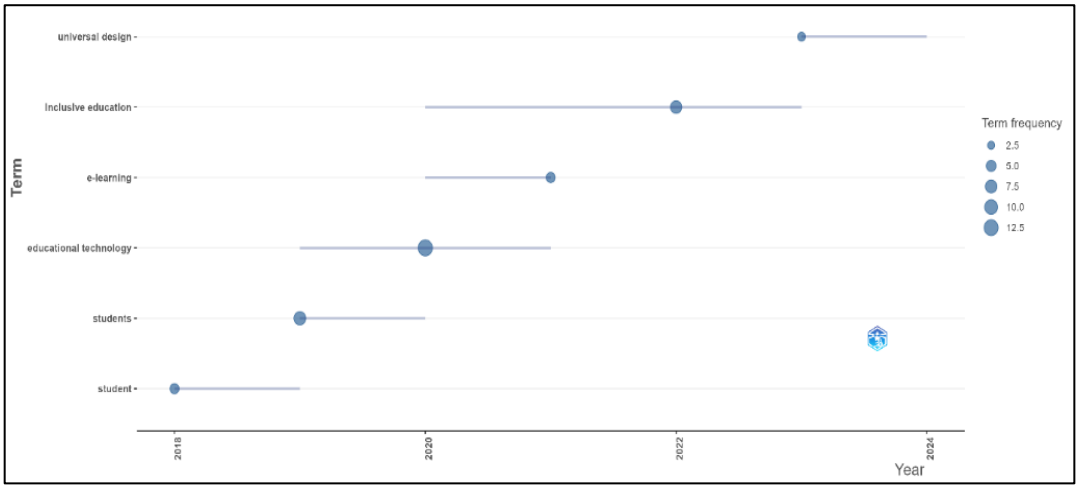

Figure 5. Trend Topics

Research Focus and Keyword Novelty

Table 6. Thematic Clustering of Keywords

Rank	Group Colour	Group Name	Keyword
1st	Red (12 items/32,43%)	Information technology and learning in the school environment	Adolescent, article, child, controlled study, education, educational process, information and communication, information technology, learning, school, students, video recording
2nd	Green (8 items/21,62%)	Educational technology and distance learning	Accessibility, augmented reality, COVID-19, distance education, distance learning technology, e-learning, educational technology, online learning
3rd	Blue (8 items/21,62%)	Inclusive design and teacher education	Design, engineering education, inclusion, information use, learning systems, teacher education, universal design, universal design for learning
4th	Yellow (6 items/16,22%)	Technology supports inclusive education	Assistive technology, inclusive education, intellectual disability, learning disabilities, special education, technology
5th	Purple (3 items/8,11%)	Integrated learning and innovative technology approach	Blended learning, computer-aided instruction, and deep learning

The keyword network visualization indicates that the research landscape is not monolithic but rather comprises five distinct thematic streams (Table 6). The largest cluster (Red) represents the locus of research, confirming that "school" and "students" are central objects of study, consistent with the methodological scope of this review. Interestingly, the network shows a clear separation between "technological triggers" (Green Cluster: COVID-19, Distance Learning) and "pedagogical solutions" (Blue Cluster: Teacher Education, UDL). This separation implies a crucial finding: the sudden shift to online learning during the pandemic (Green) has compelled the academic community to reevaluate teacher readiness and instructional design frameworks (Blue), rather than focusing solely on providing hardware infrastructure.

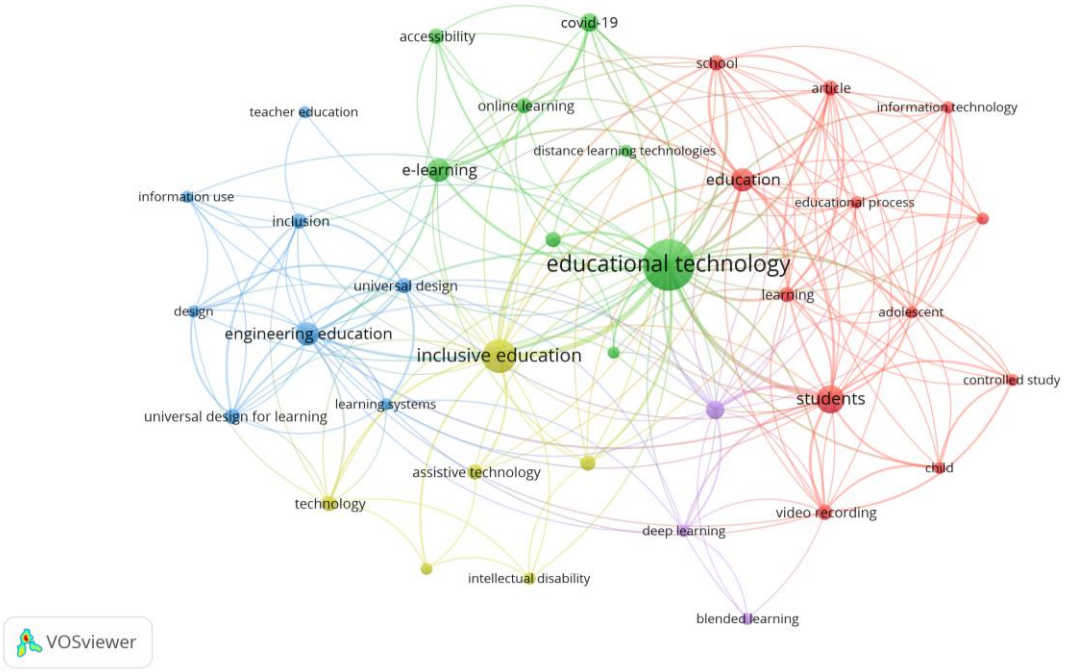

Figure 6. Keyword Network Visualization

Furthermore, the overlay visualization (Figure 6) illustrates the novelty and maturity level of this field. Temporal evolution analysis reveals a sharp shift from general concepts in the early phase (2018–2019: e-learning, students) to specific crisis-response terminology during the peak of the pandemic (2020–2021: COVID-19, accessibility). The most significant finding is the emergence of new keywords in the 2023–2024 spectrum, such as Deep Learning and Universal Design. This trajectory indicates that future research is moving toward "smart inclusion," a transition from basic digital accessibility to AI-based adaptive learning systems and sustainable inclusive frameworks following the post-pandemic emergency.

PEMBAHASAN

Bibliometric data shows a surge in productivity in 2020-2021 that correlates with the pandemic, indicating that technology in inclusive education has evolved from a complementary tool to a fundamental necessity. These findings confirm that the focus of research is no longer merely on providing physical access (accessibility), but on how technology can improve the quality of student interaction and engagement.

Recent literature supports this trend by documenting a shift in technology's function. Whereas previously technology served only as an access aid, such as screen readers and text-to-speech applications that support blind students' independence (Diniz, 2024), it is now used to visualize abstract concepts. A study by Nurjanah et al. (2024) shows how AR can make complex material more concrete for students with visual learning disabilities. Furthermore, Gulboy & Denizli-Gulboy (2024) found that this type of technological intervention not only aids cognitive understanding but also significantly increases students' intrinsic motivation. This implies that modern inclusive technology works on two levels simultaneously: overcoming sensory barriers and increasing students' psychological participation.

One of the most critical findings from the cluster mapping (Figure 6) is the separation of the "technology" (Green) and "teacher education" (Blue) clusters. This separation indicates a gap between the availability of advanced tools and teachers' ability to use them. Although the Green cluster offers various adaptive innovations, such as 3D-printed models for CAD courses (Giles et al., 2024) or assistive technologies for individuals with intellectual disabilities (Mpu, 2024)—these technologies will be ineffective without an appropriate pedagogical framework. Therefore, the Blue cluster, which emphasizes UDL, becomes a vital bridge. Evans (2020) emphasizes that teachers must be trained to design materials in various formats from the outset, rather than making reactive adaptations when problems arise. Without UDL competencies, technology becomes nothing more than a static artifact. This integration is also highlighted by Hartati et al. (2023), who argue that an integrated learning approach enables more effective personalization of materials within the context of inclusion. This means that the success of

inclusive technology in schools depends heavily on a shift in teachers' roles: from mere conveyors of material to instructional designers capable of operating adaptive technology.

Keyword novelty analysis predicts that the future of this field will be dominated by the convergence of assistive technology and artificial intelligence (Deep Learning). While previous research has focused on partial assistive tools to bridge the achievement gap for students with intellectual disabilities Ribeiro et al. (2023), future trends point toward more autonomous and responsive systems. Li et al. (2023; Veytia Bucheli et al., 2024) provide the basis for the concept of "Smart Inclusion," in which Deep Learning-based learning systems can adapt in real time to student needs, making the learning experience more personalized than conventional methods. Going forward, the main challenge is to formulate a UDL framework that specifically integrates this artificial intelligence (Veytia Bucheli et al., 2024) and to ensure that this innovation can be implemented in developing countries. Thus, inclusion technology is no longer just a passive tool, but an intelligent partner that actively breaks down learning barriers for every student.

SIMPULAN

This bibliometric study reveals two significant theoretical contributions in the literature on inclusive educational technology. First, there has been a fundamental paradigm shift triggered by the COVID-19 pandemic: research focus has shifted from the discourse of "physical accessibility" (the provision of assistive devices) to "pedagogical connectivity" (strategies for maintaining student engagement during crises). This finding refutes the assumption that inclusion technology is purely technical; instead, the data show that technology has become a key survival tool for guaranteeing the right to education in formal schools.

Second, cluster analysis reveals a structural gap between technological innovation (Green Cluster) and teachers' pedagogical capacity (Blue Cluster). The urgent policy implication of this finding is the need for teacher education reform that places UDL as a core competency, not merely a supplement. Without a strong pedagogical framework, advanced technologies such as AR or adaptive systems will remain static artifacts with no impact on learning outcomes. Furthermore, the emergence of the keyword "Deep Learning" indicates that the future of this field will move toward "Smart Inclusion," in which AI systems play an active role in autonomously personalizing learning.

Methodologically, this study is limited by its reliance on a single database (Scopus) and its exclusive focus on the context of "schools." Although these limitations were intentional to minimize bias from higher education and corporate training literature, they may overlook inclusive innovations occurring in informal learning spaces or in local (non-English) literature. Therefore, future research is recommended to expand the scope to the ubiquitous learning ecosystem and validate the effectiveness of the emerging "Smart Inclusion" framework in real classroom practice in developing countries.

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