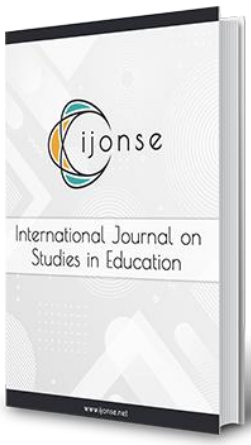

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Mapping the Integration of Digital Technology in Mathematics Learning for Children with Disabilities in Inclusive Early Childhood Education: A Bibliometric Study

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Abstract

This bibliometric study analyzes research trends on the integration of digital technology in mathematics learning for children with disabilities within inclusive early childhood education settings. Using bibliometric methods, the study examines publication output, authorship patterns, productive institutions, and key thematic areas over the past two decades. The findings reveal a gradual increase in research activity, with a notable surge during the COVID-19 pandemic, highlighting the growing importance of digital tools in inclusive education. However, the overall volume of publications remains low, with contributions concentrated in high-income countries such as the United States and Russia. Leading authors, including Augestad, Liv Berit and Drigas, Athanasios, have made significant contributions, though the field lacks widespread scholarly engagement. Notably, journals such as Integration of Education and Education Sciences have published the most influential studies, while institutions like the Norwegian University of Science and Technology and STATPED have been among the most productive. The study also identifies gaps in curriculum integration, pedagogical strategies, and accessibility in low-resource settings. By addressing these gaps, the study aims to inform future innovations in digital technology and foster equitable access to quality mathematics education for children with disabilities. The findings emphasize the urgency of integrating research, policy, and practice to create inclusive learning environments that empower all learners.

Introduction

The global commitment to inclusive education is underlined by international frameworks such as the Sustainable Development Goals (SDG's) and the Convention on the Rights of Persons with Disabilities (CRPD). Goal 4 of the SDGs emphasizes the need to ensure inclusive and equitable quality education for all, specifically targeting the removal of barriers faced by children with disabilities (Bexell & Jönsson, 2017). However, despite these ambitious global goals, the reality for many children with disabilities remains unattractive, with barriers to education still entrenched in many regions. Similarly, Article 24 of the CRPD highlights the importance of accessible education systems, assistive technology, and individualized support as critical enablers of effective

learning (Alper & Goggin, 2017). While these frameworks collectively call for transformative approaches to education, particularly during the foundational years of early childhood, significant gaps persist in the systematic implementation of these principles, especially in low-resource settings. Therefore, addressing these gaps is critical to achieving the intended goals of inclusive education.

In light of these challenges, an estimated 50% of children with disabilities are excluded from formal education globally, with exclusion rates exceeding 40% in regions such as South Asia and Latin America (Mizunoya et al., 2018). While global frameworks like the SDGs emphasize inclusive education, these statistics highlight the harsh reality many children with disabilities face in accessing education. These staggering statistics highlight the urgent need to dismantle systemic barriers such as inaccessible infrastructure, inadequately trained teachers, and discriminatory attitudes, which deny millions of children their fundamental right to education. In low-resource settings, these challenges are often worsened. For example, in Sub-Saharan Africa, over 90% of children with disabilities are excluded from formal education. Those who do access schools are frequently placed in segregated settings, limiting their opportunities for social integration and academic achievement (Walton et al., 2020). Amid these challenges, integrating digital technology into mathematics learning offers a transformative opportunity to bridge these gaps, particularly in inclusive early childhood education.

Inclusive education, as described by Florian & Black-Hawkins, (2011), seeks to address the diverse needs of learners through flexible and adaptive teaching approaches, creating environments where every child can thrive. Nelis et al. (2023) further defines inclusive education as a system that embraces diversity, promotes the participation of all learners, and removes barriers to learning. By fostering such environments, inclusive education offers a pathway to reducing stigma, promoting social inclusion, and building cohesive societies (Deroncele-Acosta & Ellis, 2024). However, the realization of inclusive education varies significantly across different regions, with developing countries often facing unique challenges. In Sub-Saharan Africa, countries are gradually adopting inclusive education policies, yet significant challenges persist, particularly in rural and underfunded areas. For instance, in Tanzania, Miles et al. (2018) found that despite governmental efforts to integrate children with disabilities into mainstream schools, many classrooms still lack essential resources and adequately trained teachers. Bridging the gap between policy and practice is imperative to ensure that inclusive education not only exists as a theoretical ideal but becomes a lived reality for every child, regardless of their abilities.

Furthermore, one critical stage where inclusive education can be effectively implemented is in early childhood education. ECE, defined as the provision of structured educational experiences for children from birth to the age of eight, focuses on their holistic development, including cognitive, emotional, social, and physical growth (Rao et al., 2021). This stage is crucial for laying the groundwork for lifelong learning, equipping children with essential skills and attitudes that shape their future success in education and beyond (Heckman, 2011). For children with disabilities, ECE plays a vital role in ensuring their inclusion and equitable participation in learning opportunities, addressing disparities early, and fostering both academic and social development. Beyond the individual child, ECE also benefits families by reducing caregiving burdens and enabling parents, particularly mothers, to engage more fully in the workforce or pursue further education. At a national level, investing in ECE yields significant economic advantages by reducing future costs associated with remedial education, unemployment, and social

welfare, while fostering a skilled and equitable workforce (Rao et al., 2021).

On the other hand, Mathematics education is a core element of early childhood education and plays a significant role in developing cognitive and problem-solving skills essential for children's academic and social development (Clements & Sarama, 2016). In inclusive ECE settings, ensuring that children with disabilities have equal access to mathematics learning is crucial. The integration of digital technologies presents a promising solution to overcoming barriers to participation in mathematics education. Tools such as interactive applications, screen readers, and other assistive technologies can modify learning experiences to meet the unique needs of diverse learners. For instance, digital applications designed for mathematics instruction can provide interactive features that cater to various learning styles and abilities, helping children with disabilities engage with mathematical concepts in a personalized and meaningful way (Borba et al., 2016; Mahmoud, 2023). These technologies can not only enhance accessibility but also foster engagement, allowing children with disabilities to build confidence in their mathematical abilities and actively participate in learning activities (Kramarenko et al., 2021; Pitchford et al., 2018). Thus, the interaction between inclusive education and digital technologies in ECE settings plays a vital role in enhancing educational accessibility for all learners. In particular, it equips children with disabilities with the skills they need for academic success and social integration.

Nevertheless, despite these advances, there is a significant gap in the systematic integration of digital technology into inclusive early childhood education. Existing research often focuses on the broad application of digital tools in education or inclusive education as a general concept, without probing into the intersection of digital technology, mathematics, and disability in inclusive ECE settings. Moreover, limited attention has been given to how these technologies can specifically enhance mathematics education for children with disabilities in inclusive early childhood settings. Furthermore, conflicting findings in the literature, ranging from the potential benefits of digital tools to challenges such as infrastructure limitations and teacher readiness (Clark-Wilson et al., 2020; Crompton et al., 2021; Haleem et al., 2022), highlight the need for a more detailed understanding of this topic.

To bridge these gaps and address the complexities of integrating digital technology into mathematics learning for children with disabilities in inclusive ECE settings, this bibliometric study explores global research trends. It specifically maps how digital technology is being incorporated into mathematics education for children with disabilities. By analyzing key themes, influential authors, and publication patterns, the study aims to provide insights that inform educational practice, policy, and future research. Ultimately, its findings will contribute to advancing inclusive education by identifying evidence-based strategies for making use of digital technology to enhance early mathematics education for children with disabilities. In doing so, this study aligns with global efforts to achieve inclusive and equitable education, ensuring that no child is left behind in their journey of learning.

Methods

This bibliometric study applied a systematic approach to investigate the integration of digital technology in mathematics education for children with disabilities within inclusive early childhood settings. Using bibliometric

analysis, a quantitative method, the study examined citation patterns, publication characteristics, and frequently used keywords to identify key research trends, influential scholars, and emerging areas of interest (Donthu et al., 2021; Mukherjee et al., 2022). To ensure a comprehensive and unbiased analysis, well-defined search criteria and reliable data sources were employed, enhancing the accuracy and replicability of the findings (Passas, 2024; Zupic & Čater, 2015). The systematic nature of this analysis provides critical insights into the evolving body of research, contributing to a deeper understanding of how digital technology supports mathematics learning for children with disabilities in inclusive education contexts.

Data Source and Extraction

The data for this study were extracted from the Dimensions database, which was selected due to its comprehensive and multidisciplinary coverage, particularly in education and social sciences (Herzog et al., 2020). Dimensions is widely recognized within the academic community and has been extensively used for bibliometric analyses (Pranckutė, 2021). Compared to other databases, such as Scopus and Web of Science, Dimensions offers broader access to publications, including non-traditional and open-access journals, which are crucial for capturing emerging research trends in inclusive mathematics education (Hook et al., 2018). Additionally, it provides a robust collection of linked research data within a single platform, enabling researchers to conduct in-depth bibliometric investigations (García-Sánchez et al., 2019; Guerrero-Bote et al., 2020).

Moreover, Dimensions includes various document types, such as journal articles, conference papers, and book chapters, allowing for a more holistic analysis of global research trends. It is also recognized for its up-to-date citation indexing and comprehensive bibliometric metrics, making it a reliable source for high-quality literature reviews (Ellegaard & Wallin, 2015). Further, unlike other database such as Google Scholar, which lacks reliable bibliometric tools for network visualization and citation analysis, Dimensions provides advanced analytical features that enhance the accuracy and depth of bibliometric studies (Martín-Martín et al., 2021). Given these advantages, Dimensions was deemed the most suitable database for this bibliometric study.

Search Strategy

This study employed a systematic search strategy to identify relevant literature on integrating digital technology in mathematics learning for children with disabilities within inclusive early childhood education settings. The search process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines Moher et al. (2016), ensuring a rigorous and transparent approach to literature identification, screening, and selection. Boolean operators (AND, OR) were applied to refine the search, combining key terms such as “digital technology,” “mathematics learning,” “children with disabilities,” “inclusive education,” and “early childhood education.” These carefully selected terms ensured that the search captured studies addressing the intersection of digital technology, disability, and inclusive mathematics education. As of October 21, 2024, a total of 5102 studies were identified in the Dimensions database based on the established search criteria. Figure 1 presents the PRISMA flow diagram, which outlines the sequential process from identifying records to selecting the final articles. This structured approach strengthens the study transparency and ensures its replicability (Page

et al., 2021).

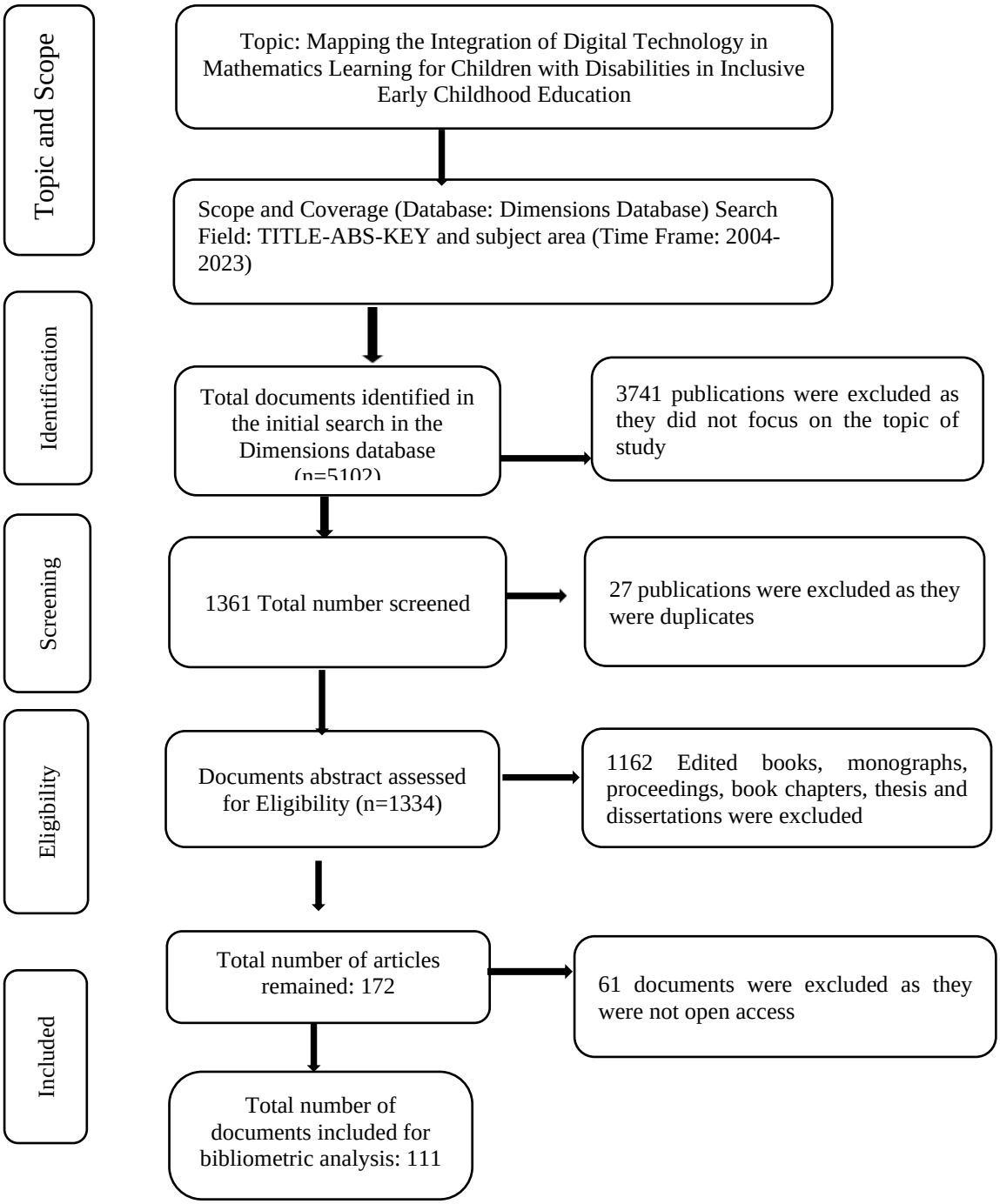

Figure 1. Data Collection Process

Inclusion and Exclusion Criteria

The selection of studies adhered to well-defined inclusion and exclusion criteria to ensure relevance and methodological rigor. Only peer-reviewed journal articles were considered, as they undergo rigorous evaluation, ensuring scholarly integrity and credibility (Gough et al., 2012). The review focused on research examining the use of digital technology in mathematics education for children with disabilities in inclusive early childhood

settings. Digital tools play a crucial role in enhancing engagement, accessibility, and individualized learning Iskakova, (2023), aligning with global commitments to equity in education, as emphasized in the Sustainable Development Goals.

To capture the evolution of inclusive education and technological advancements, the review covered a 20-year period (2004-2023). Only English-language publications were included to maintain consistency in interpretation, given English's prominence in global academic discourse (O'Neil, 2018). Additionally, priority was given to open-access articles to enhance transparency, reproducibility, and accessibility for researchers and practitioners (Piwowar et al., 2018). These criteria ensured a comprehensive and methodologically sound bibliometric analysis of digital technology integration in inclusive mathematics education. A summary of the inclusion and exclusion criteria is presented in Table 1.

Table 1. Publication Inclusion and Exclusion Criteria

Criteria	Inclusion criteria	Exclusion criteria
Database	Dimensions database	Other databases
Accessibility	Open access	Closed access
Publication years	From 2004-2023	Documents published before 2004 and in 2023
Publication type	Article from peer-reviewed journals	Edited books, book chapter, conference proceedings, Monographs, thesis and dissertations
Subject area	Articles that focus on digital technology in mathematics education for children with disabilities in inclusive early childhood	Articles that do not focus on digital technology in mathematics education for children with disabilities in inclusive early childhood
Language	English	Other languages

Data Analysis

The bibliometric analysis employed quantitative methods to examine publication trends, citation patterns, and keyword co-occurrences in the field. Key indicators included total publications (TP), total citations (TC), and the most prolific authors, institutions, and countries, providing insights into research impact and contributions to digital technology integration in mathematics learning for children with disabilities (Mukherjee et al., 2022). Additionally, collaborative networks and keyword co-occurrence patterns were mapped to visualize relationships among influential contributors and emerging research themes (van Eck & Waltman, 2010).

Further, data analysis was conducted using VOSviewer, a specialized tool for constructing and visualizing bibliometric networks. Chosen for its ability to generate detailed graphical representations, VOSviewer facilitated the identification of patterns in large datasets by illustrating relationships among authors, publications, and key terms. Through network visualization, the tool highlighted central research areas, influential scholars, and

evolving themes, revealing the structure and progression of scholarly discourse. Beyond identifying prominent researchers and significant works, the analysis also uncovered gaps in the literature and potential areas for future collaboration (van Eck & Waltman, 2010). Ultimately, this study provides a comprehensive mapping of academic contributions, serving as a valuable resource for researchers, teachers, and policymakers seeking to advance inclusive education practices and policies.

Results and Discussion

This section presents the key findings from the bibliometric analysis. It highlights the evolving research focus on integrating digital technology in mathematics learning for children with disabilities within inclusive early childhood education. The examination of publication trends, citation metrics, and collaborative networks reveals significant contributors and prominent themes in the literature. Additionally, the results identify potential gaps that warrant further exploration in future research.

Annual Publication Trend

In order to understand the publication area in this field of study, it is essential to examine the annual publication trends over the past two decades. Figure 2 illustrates the publication trends on the integration of digital technology in mathematics learning for children with disabilities in inclusive early childhood education over the past two decades. The data reveals notable fluctuations and key milestones, with the lowest output recorded in 2005 (nine publications), reflecting the early stages of both digital technology and inclusive education research. This limited output aligns with the lack of global awareness regarding the potential of digital tools for accessibility and learning (Harris et al., 2018). Additionally, it coincides with the early phase of international policy frameworks such as the United Nations Convention on the Rights of Persons with Disabilities, which had not yet gained widespread influence on educational practices (Sharma & Salend, 2016).

In contrast, research output peaked in 2012 with 1,176 publications, coinciding with increasing advocacy for inclusive education and the rapid integration of digital technologies in classrooms. This surge reflects the growing recognition of digital tools as essential for equitable learning, particularly in mathematics education, where children with disabilities face significant challenges (Bouck et al., 2018). Notably, 2020 and 2023 marked the third and second highest outputs, with 626 and 907 publications, respectively. The sharp increase in 2020 can be attributed to the COVID-19 pandemic, which emphasized the urgent need for accessible digital learning solutions (Zhang et al., 2020). The sustained high output in 2023 suggests a lasting shift in research priorities toward improving digital accessibility and inclusion in mathematics education.

Despite these encouraging trends, overall research output in this field remains relatively low, indicating that the integration of digital technology in mathematics learning for children with disabilities within inclusive early childhood education is still in its developmental stage (Al-Attiyah et al., 2022). However, the steady increase in annual publications suggests a growing scholarly interest and commitment to this area, driven by advancements in assistive technologies and a broader push for inclusive education (Setiawan, 2024). These emerging studies

provide a foundation for future research, fostering evidence-based practices that enhance learning outcomes for children with disabilities and promote equitable access to mathematics education.

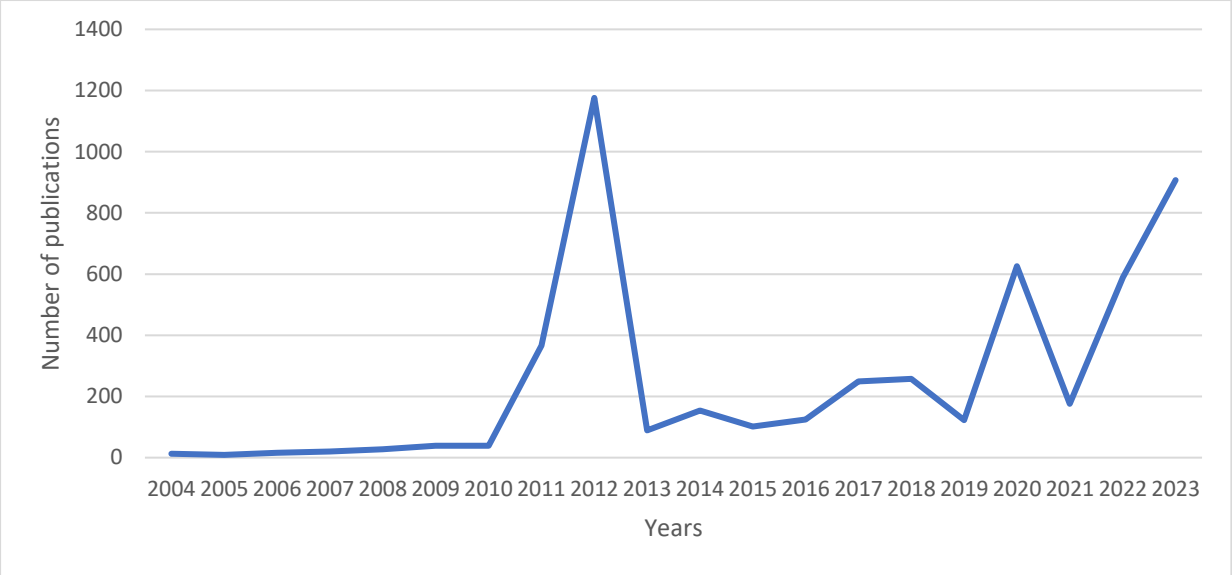

Figure 2. Annual Publication Trend in the Field of Integrating Digital Technology in Mathematics Learning for Children with Disabilities in Inclusive Early Childhood Education Settings

The Most Influential Authors

Table 2 highlights the most productive authors in the field of digital technology for mathematics learning among children with disabilities, offering several critical insights. Notably, all eight leading authors have published only two works each, suggesting that while their contributions are meaningful, the field remains in its early stages. This limited output indicates a lack of dedicated researchers focusing exclusively on this niche, which may hinder the development of a sustained and cohesive body of knowledge. Compared to more established research areas such as general educational technology or inclusive education where leading scholars often have extensive publication records; the current context appears fragmented. This observation aligns with previous findings that research on digital tools for children with disabilities is still emerging, with notable gaps in both theoretical frameworks and empirical evidence (Bouck et al., 2018).

Despite the modest number of publications, the citation counts of these authors underline their academic influence. Augestad, Liv Berit, leads with 56 citations, followed closely by Drigas, Athanasios, with 54 citations. These citation figures reflect the relevance and impact of their work, suggesting that their research is shaping ongoing scholarly discussions. For instance, Drigas's studies on assistive technologies and Augestad's focus on inclusive pedagogical practices likely address pressing challenges in the field, resonating with both researchers and educators. However, the relatively lower citation counts of other scholars (e.g., Borgonovi, Francesca, with 27 citations) highlight the need for greater visibility and dissemination of research in this area. This is particularly crucial given the increasing global emphasis on inclusive education and the transformative potential of digital tools in addressing barriers faced by children with disabilities (Deroncele-Acosta & Ellis, 2024).

Table 2. Most Productive Authors based on Number of Citations and Publications

Rank	Authors	Documents	Citations	Link strength
1	Augestad, Liv Berit	2	56	5
2	Drigas, Athanasios	2	54	11
3	Bøg, Martin	2	45	11
4	Dietrichson, Jens	2	45	11
5	Filges, Trine	2	45	11
6	Klokker Rasmus H.	2	45	11
7	Viinholt, Bjorn C. A.	2	45	11
8	Borgonovi, Francesca	2	27	1

*(N ≥ 10) N = Number of the citations

A notable collaborative effort among five authors Bøg, Martin; Dietrichson, Jens; Filges, Trine; Klokker, Rasmus H.; and Viinholt, Bjorn C. A. further enriches the discourse. All affiliated with The Danish Center for Social Science Research, these scholars demonstrate strong connectivity, as illustrated in Figure 3. Such interdisciplinary and cross-institutional partnerships are essential for advancing research in complex fields like inclusive mathematics education, where multiple perspectives are required to develop effective solutions(Zhang et al., 2020). Their shared emphasis on evidence-based interventions and policy-relevant research positions them as key contributors to future advancements. However, the geographic concentration of these scholars in Denmark raises concerns about the global representation of research in this domain. Expanding collaborations to include researchers from diverse contexts, particularly from low- and middle-income countries, could foster more inclusive and contextually relevant insights (Gilmore, 2019). Encouraging such global research networks will be crucial for developing comprehensive strategies that address the unique educational challenges faced by children with disabilities worldwide.

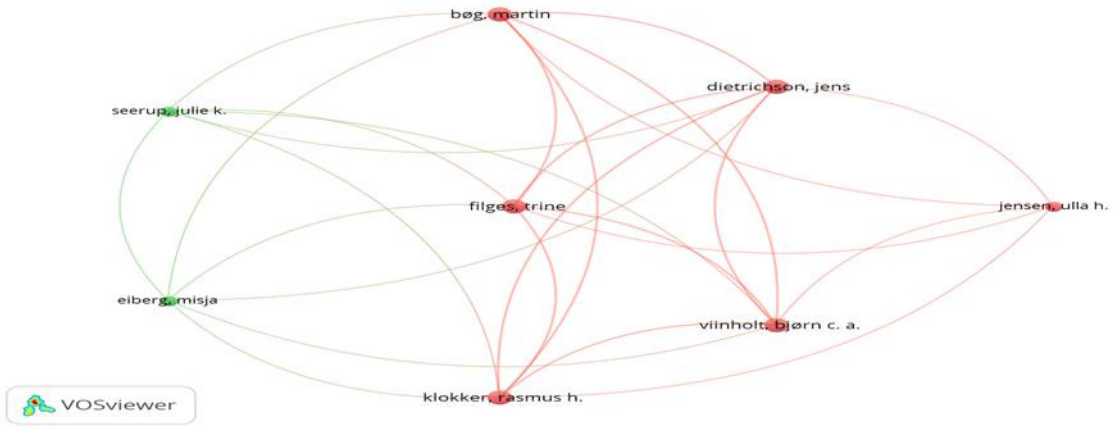

Figure 3. Authors' Co-authorship Network

The Most Productive Journals

The analysis of the most productive journals in the field of integrating digital technology into mathematics learning for children with disabilities reveals a fragmented yet evolving research context. As shown in Table 3,

Integration of Education leads with 49 publications, significantly outpacing other journals such as Education Sciences (6 publications) and Cogent Education (3 publications). This dominance suggests that journal of Integration of Education serves as a key platform for research on educational integration, particularly within the context of digital technology (Mishra & Koehler, 2006). However, the relatively low publication counts across other journals indicate that the field lacks a critical mass of dedicated publication outlets, which may limit the dissemination and visibility of research findings. This aligns with broader observations that specialized areas in educational technology often struggle to establish themselves in high-impact journals (Selwyn, 2016). Furthermore, the fact that the journal of Integration of Education is ranked in Q4 underlines the need for greater engagement with higher-tier journals to enhance the scholarly impact of research in this domain.

Table 3. Most Productive Journals in terms of Publications

Rank	Journal	Documents	Citations	TLS	Quartile 2023
1	Integration of Education	49	291	0	Q4
2	Education sciences	6	56	8	Q2
3	Cogent education	3	28	14	Q2
4	Campbell systematic reviews	2	45	8	Q1
5	Sustainability	2	36	2	Q2
6	Journal of policy and practices in intellectual disabilities	2	10	0	Q2

*(N ≥ 5) N = Number of the citations *TLS Total Link Strength

In terms of citations, Table 4 highlights the interdisciplinary nature of research in this field, with the Journal of Physics: Conference Series leading with 73 citations. While its prominence may seem unexpected for an education-focused topic, it reflects the cross-disciplinary nature of digital technology research, where innovations in educational tools frequently intersect with advancements in scientific and engineering domains (Koretsky & Magana, 2019). Similarly, the visibility of high-ranking journals such as Exceptional Children, Computers & Education, and PLOS ONE suggests that inclusive mathematics education benefits from a multidimensional approach, integrating insights from special education, psychology, and digital learning technologies (Bouck et al., 2018). The strong citation performance of the Journal of Educational Psychology further indicates that research in this area contributes to broader discussions on cognitive and learning processes, reinforcing the field's relevance across multiple disciplines.

Despite these encouraging trends, the field remains in its formative stages, as evidenced by the limited number of publications and the uneven distribution of citations across journals. The concentration of publications in the journal of Integration of Education, coupled with the high citation impact of interdisciplinary journals, suggests that the field is still establishing its identity within the broader academic context. This fragmentation may pose challenges in developing a cohesive research agenda and limit the field's capacity to influence educational policy and practice (Kim et al., 2017). Moving forward, fostering stronger collaborations between researchers, journals, and disciplines will be crucial in consolidating knowledge, addressing research gaps, and enhancing the overall impact of the field. By integrating perspectives from educational technology, special education, inclusive

education and related disciplines, future research can contribute to more effective and inclusive approaches to mathematics learning for children with disabilities (Gülbay et al., 2024).

Table 4. Most Productive Journals in terms of Citations

Rank	Journal	Citations	Total Link strength	Quartile 2023
1	Journal of Physics: Conference Series	73	72	N/A
2	Journal of Educational Psychology	54	2425	Q4
3	Exceptional Children	41	1580	Q1
4	Computers & Education	41	926	Q1
5	Plos One	40	297	Q1
6	Remedial and Special Education	37	1092	Q1
7	Teaching and Teacher Education	37	776	Q1
8	Child & Youth Care Forum	37	198	Q1
9	Journal of Learning disabilities	34	1700	Q1
10	International Journal of Inclusive Education	34	309	Q1

*(N ≥ 10) N = Number of the citations

Figure 4 presents a co-citation network visualization map, illustrating the interconnectedness of primary publication sources in this field. The map provides a comprehensive overview of the scholarly context, highlighting key journals and their relationships, which collectively shape discourse on integrating digital technology into mathematics learning for children with disabilities.

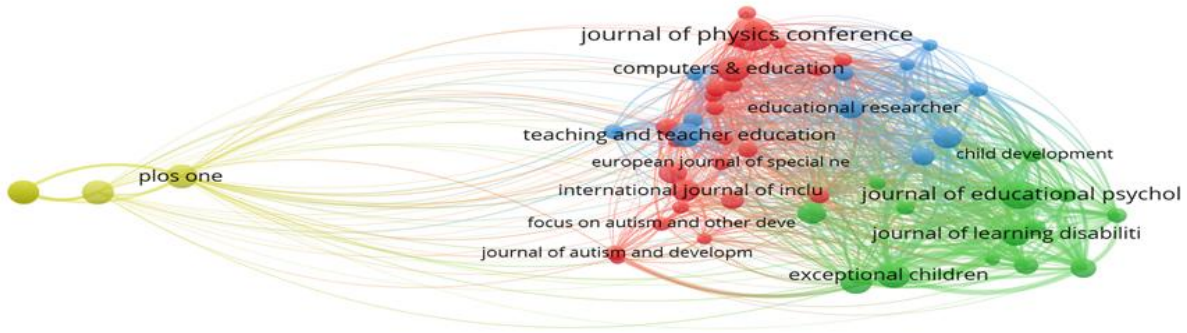

Figure 4. Co-citation Network Visualization Map for Main Sources of Publications

Most Productive Countries

The analysis of the most productive countries in integrating digital technology into mathematics learning for children with disabilities reveals a geographically diverse but unevenly distributed research environment. As shown in Table 4, the United States leads with 12 publications and 122 citations, followed by Russia (7 publications) and Indonesia (5 publications). Collectively, the top countries account for 41 publications and 469

citations, indicating growing scholarly interest. However, the relatively low overall output suggests that the field is still emerging, aligning with broader observations that research on digital tools for inclusive education struggles to gain momentum outside a few leading nations (Bouck et al., 2018; Selwyn, 2016).

Moreover, the United States' dominance, contributing nearly 30% of publications and over a quarter of citations, highlights its pivotal role in shaping discourse. This leadership likely stems from its well-established infrastructure for educational research, substantial funding opportunities, and strong policies supporting inclusive education (Bornmann et al., 2018). However, the comparatively lower contributions from Russia and Indonesia highlight disparities in research engagement and impact. Notably, while China and Norway have fewer publications, their high citation counts (78 and 67, respectively) suggest that their research is particularly influential. This imbalance may reflect variations in research quality, accessibility, or integration into global academic networks, underscoring the need for greater equity in scholarly visibility and collaboration.

These findings highlight the importance of fostering international collaboration to advance this emerging field. The concentration of research activity in a few countries risks limiting perspectives and may not fully address the diverse needs of children with disabilities worldwide (Ramos-Rincón et al., 2019). Notably, low- and middle-income countries where challenges in implementing inclusive education are most pronounced are significantly underrepresented. Expanding research efforts to include these contexts could provide valuable insights into how digital tools can be adapted to different cultural, economic, and educational settings (Dalle et al., 2025; Shonfeld et al., 2021). Strengthening cross-border partnerships and promoting knowledge exchange will be essential in developing a more inclusive and globally relevant research agenda, ensuring that technological advancements in mathematics learning benefit all children, regardless of their geographical location.

Table 5: Most Productive Countries

Rank	Journal	Documents	Citations	Average citations
1	United States	12	122	10.16
2	Russia	7	36	5.15
3	Indonesia	5	30	6
4	United Kingdom	4	50	12.5
5	Spain	4	42	10.5
6	China	3	78	26
7	Norway	3	67	22.33
8	Australia	3	44	14.66

*(N ≥ 5) N = Number of the citations

Most Productive Institutions

Institutions play a crucial role in advancing research and shaping the trajectory of emerging fields, particularly in specialized areas such as integrating digital technology in mathematics learning for children with disabilities. The distribution of research activity across institutions, however, reveals a context characterized by both engagement

and fragmentation. As shown in Table 6, no institution has produced more than two publications, underlining the field's nascent stage and the absence of dominant research hubs. Despite this, 36 out of 115 identified institutions have met the citation threshold of 10, suggesting that while publication output is relatively low, the field benefits from a broad base of institutional engagement. This dispersed scholarly impact aligns with prior findings that emerging research areas often exhibit widespread but uncoordinated contributions before achieving consolidation around leading institutions (Ellegaard & Wallin, 2015).

The Norwegian University of Science and Technology and STATPED (National Support System for Special Needs Education in Norway) jointly lead in terms of citations, each accumulating 56 citations, followed closely by the Danish Center for Social Science Research and Lundbeck, both with 45 citations. The prominence of these institutions reflects their capacity to generate influential studies, reinforcing the role of well-established research centers in shaping global academic discourse (Florian & Beaton, 2018). Norway's leadership aligns with its strong emphasis on inclusive education policies and its commitment to integrating digital tools into pedagogical frameworks (Haug, 2017). Similarly, the Danish Center for Social Science Research benefits from interdisciplinary collaborations, a factor widely recognized as essential in advancing complex educational fields (Zhang et al., 2020). However, the limited number of publications from these institutions suggests that despite their impact, sustained research efforts remain insufficient. This pattern is consistent with previous observations that high-citation studies in niche areas often stem from isolated efforts rather than continuous institutional commitment (Bornmann et al., 2018).

A closer examination of research productivity reveals disparities in institutional visibility and influence. Collectively, the top 10 institutions have contributed 20 publications and 317 citations, averaging 31.7 citations per institution. While this indicates a concentrated level of scholarly impact, the relatively low publication counts highlight gaps in long-term engagement with the topic. For instance, institutions such as the Indonesia University of Education and the University of Djuanda, despite meeting the citation threshold, have significantly lower citation counts (8 each), reflecting challenges in research visibility and integration into global scholarly networks (Hamdan & Alsuqaih, 2024). These disparities align with broader findings that institutions in low- and middle-income countries often face systemic barriers to research funding, international collaboration, and journal accessibility, thereby limiting their impact (Chikwari et al., 2024; Kalbarczyk et al., 2021).

The uneven distribution of institutional contributions highlights the need for greater investment in research capacity and international collaboration. Without strategic efforts to strengthen research networks, the field risks being shaped predominantly by a small number of high-impact institutions, potentially overlooking diverse educational contexts and needs. Expanding institutional partnerships and fostering knowledge exchange between leading research centers and emerging institutions could address these disparities, ensuring a more inclusive and comprehensive development of the field. Prior studies have emphasized the importance of such collaborations in bridging research gaps and fostering innovation, particularly in fields where localized challenges require context-specific solutions (Isaac et al., 2024). By promoting sustained institutional engagement and cross-border research partnerships, scholars can contribute to a more globally representative and impactful knowledge base on digital technology in mathematics learning for children with disabilities.

Table 6. Most Productive Institutions

Rank	Institution	Country	Documents	Citations
1	Norwegian University of Science and Technology	Norway	2	56
2	STATPED	Norway	2	56
3	Danish Center for Social Science Research	Denmark	2	45
4	Lundbeck	Denmark	2	45
5	UNSW Sydney	Australia	2	44
6	University of Cambridge	United Kingdom	2	43
7	Indonesia University of Education	Indonesia	2	8
8	University of Djuanda	Indonesia	2	8
9	National Research Mordovia State University	Russia	2	7
10	The University of Texas at Austin	United states	2	5

*(N ≥ 10) N = Number of the citations

Mostly Used Keywords

Keywords serve as critical markers of research focus and emerging trends, offering valuable insights into the thematic structure of a field. In this study, an analysis of 2,428 author-provided keywords, refined to 63 meeting the inclusion threshold, reveals the central themes and conceptual priorities in integrating digital technology into mathematics learning for children with disabilities. As shown in Table 7, the most frequently occurring keywords such as “Teacher” (133 occurrences), “Need” (48), “Practice” (46), and “Instruction” (45) highlight the field’s emphasis on pedagogical practices, instructional strategies, and the role of educators in leveraging digital tools for inclusive education. These findings align with existing literature, which underlines the importance of teacher training and evidence-based practices in effectively integrating technology into special education settings (Bouck et al., 2018; Florian & Beaton, 2018). The prominence of keywords like “Child” (43) and “Intervention” (39) further reflects the field’s focus on children-centered approaches and targeted support for learners with disabilities, a perspective strongly advocated in contemporary inclusive education research (Zeng et al., 2018).

The co-occurrence network map in Figure 5 provides a visual representation of the relationships between these keywords, revealing clusters of interconnected themes. Larger nodes, such as “Teacher” and “Instruction,” indicate dominant areas of research interest, while the connections between nodes illustrate how these themes intersect. For instance, the linkage between “Teacher,” “Training,” and “Practice” suggests a strong emphasis on professional development and the application of digital tools in classroom settings. This finding is consistent with previous studies emphasizing the need for robust teacher preparation programs to enhance the effective use of assistive technology in mathematics education (Jones et al., 2021). Similarly, the connection between “Intervention,” “Outcome,” and “Effects” highlights the field’s focus on evaluating the impact of digital interventions on children learning, aligning with broader trends in educational technology research, which prioritize evidence-based approaches and learning outcome measurements (Mishra & Koehler, 2006; Selwyn,

2016).

Table 7. Most Frequently Occurring Keywords

Rank	Keywords	Occurrences	Relevance
1	Teacher	133	0.49
2	Need	48	0.42
3	Practice	46	0.33
4	Instruction	45	0.56
5	Child	43	1.01
6	Intervention	39	1.05
7	Paper	39	0.43
8	Article	35	0.74
9	Outcome	31	0.71
10	Activity	31	1.09
11	Evidence	30	0.41
12	Mathematics	30	0.56
13	Challenge	30	0.42
14	Effects	29	1.90
15	Curriculum	26	1.22
16	Review	25	0.52
17	Training	24	0.76
18	Integration	23	1.08
19	University	23	0.76
20	Context	23	0.56

However, the relatively low frequency of keywords such as “Mathematics” (30) and “Curriculum” (26) suggests that the field has not yet fully addressed the specific challenges of mathematics education for children with disabilities. This gap is particularly concerning, given that mathematics learning often requires tailored instructional strategies that accommodate diverse cognitive needs (Bouck et al., 2018). Research has shown that children with disabilities frequently encounter difficulties in mathematics due to abstract concepts and symbolic representations, necessitating the development of adaptive digital tools to enhance accessibility (Heyd-Metzuyanim, 2013). Additionally, the limited occurrence of keywords such as “Integration” (23) and “Context” (23) points to a need for greater exploration of how digital tools can be seamlessly incorporated into diverse educational settings, particularly in low-resource environments where infrastructure constraints may hinder implementation (Ugwu et al., 2024). Addressing these gaps could help the field move beyond general discussions of technology and pedagogy to develop more nuanced, evidence-based, and context-specific solutions.

The findings also reveal opportunities for future research. The prominence of “Challenge” (30) and “Evidence” (30) suggests that researchers are grappling with the practical and methodological difficulties of implementing and evaluating digital interventions. This aligns with calls for more rigorous and longitudinal studies to assess the

sustainability and scalability of digital tools in inclusive education (Zhang et al., 2020). Moreover, the growing emphasis on "Activity" (31) and "Curriculum" (26) indicates an increasing interest in designing interactive and curriculum-aligned digital resources, which could enhance engagement and learning outcomes for children with disabilities (Leary et al., 2016). Future research should explore the development of culturally responsive and universally designed digital tools to ensure equitable learning experiences for all children (Rabinowitz & Tondreau, 2022). By addressing these research gaps and fostering interdisciplinary collaboration, scholars can contribute to a more comprehensive understanding of how digital technology can be leveraged to support mathematics learning for children with disabilities in diverse educational contexts.

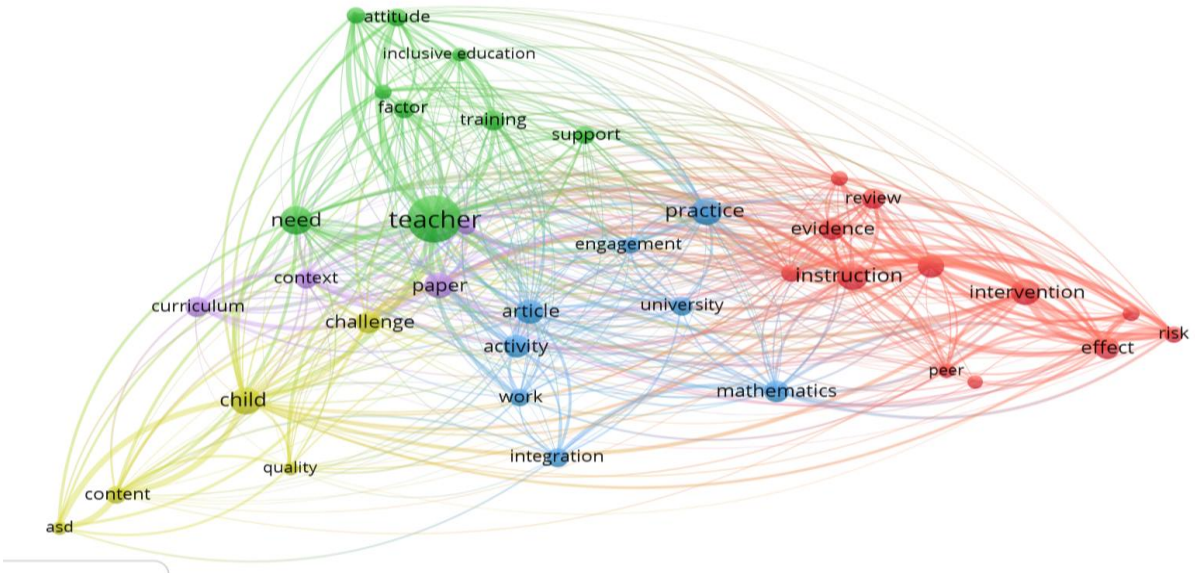

Figure 6. The Author Keywords Co-occurrence Networks

Conclusion

The findings of this bibliometric analysis highlight a growing but still underdeveloped research context on the integration of digital technology in mathematics learning for children with disabilities within inclusive early childhood education settings. Over the past two decades, research output in this field has shown a gradual increase, with a notable surge during the COVID-19 pandemic as digital learning approaches gained prominence. However, despite this progress, the overall volume of publications remains relatively low, suggesting that this area of inquiry is still in its formative stages. This limited research output highlights the need for sustained scholarly attention to fully harness the potential of digital technology in enhancing mathematics learning for children with disabilities. Furthermore, the study reveals that the number of contributing authors and publishing journals in this domain is relatively small, signaling the necessity for broader academic engagement and interdisciplinary collaboration. The analysis of productive institutions further reinforces this concern, as most institutions contributed a maximum of only two publications. This suggests that despite the critical role of digital tools in fostering inclusive mathematics education, research efforts remain fragmented and insufficiently institutionalized. Strengthening international research collaborations and fostering knowledge exchange among scholars, policymakers, and practitioners could help bridge this gap and promote more comprehensive investigations into the effective integration of digital

technology in inclusive education.

Given these findings, this study calls for greater investment in research initiatives that explore innovative, evidence-based digital interventions tailored to the diverse learning needs of children with disabilities. Future research should prioritize the development of scalable and contextually relevant digital tools, particularly in low-resource settings where accessibility remains a challenge. By addressing these gaps, scholars can contribute to a more robust and well-informed discourse on inclusive digital education, ensuring that technological advancements translate into meaningful learning opportunities for all children.

Recommendations

Advancing research on the integration of digital technology in mathematics learning for children with disabilities requires strong international and interdisciplinary collaboration. Researchers, institutions, and funding bodies should prioritize partnerships that bring together experts in educational technology, special education, and mathematics education to address the complexities of inclusive learning. Special attention should be given to underrepresented regions, particularly low- and middle-income countries, to ensure that research findings are globally relevant and equitable. Establishing dedicated research networks and consortia would facilitate knowledge exchange, resource sharing, and the development of innovative, context-specific solutions. Strengthening these collaborations would not only enhance the quality and impact of research but also promote equal access to digital learning tools for children with disabilities worldwide.

Furthermore, policymakers and educators must play a proactive role in transforming research insights into tangible strategies. Governments and educational institutions should invest in teacher training programs that equip educators with the necessary skills to effectively integrate digital tools into inclusive mathematics instruction. Policies should also support the development and widespread dissemination of accessible, curriculum-aligned digital resources tailored to the diverse learning needs of children with disabilities. By aligning research, policy, and practice, stakeholders can create a sustainable framework that ensures the effective implementation of digital technologies in inclusive education. These efforts will maximize the potential of digital tools, empowering all children to thrive in mathematics learning and beyond.

Limitations

Despite its comprehensive approach, this study has several limitations. First, the reliance on a single database (Dimensions) may have excluded relevant publications indexed in other databases, potentially limiting the scope of the literature reviewed (Zhu & Liu, 2020). Second, the restriction to English-language publications might have overlooked valuable studies published in other languages, which could affect the generalizability of the findings (Mongeon & Paul-Hus, 2016). Nevertheless, these limitations are partially mitigated by the extensive coverage of the Dimensions database, which spans a wide range of disciplines and journals, and by the consistency achieved through the language restriction, which ensures uniformity in the bibliometric analysis. Future studies could address these limitations by incorporating multiple databases and including non-English publications to provide

a more inclusive and representative analysis of the field.

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