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A Bibliometric Study of Global Research Trends on Dyscalculia

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ABSTRACT

Dyscalculia is a mathematics learning disability that is receiving increasing attention in international research. However, systematic mapping of the development and direction of global research in this field remains limited. Therefore, this study aims to analyze global research trends on dyscalculia from 2020 to 2025 by examining publication dynamics, thematic structure, and collaboration patterns among researchers and countries. This study employed a bibliometric approach with data obtained from the Scopus database. The analysis was conducted using VOSviewer software to visualize the network of keyword co-occurrences, authorship, and geographic distribution of publications. The analysis results show a significant increase in publications, particularly after 2021, reflecting growing scientific attention to dyscalculia in the context of mathematics learning difficulties and neurodevelopmental research. The thematic analysis identified five main clusters: cognitive, pedagogical, psychological, demographic, and theoretical, which are interconnected and demonstrate that dyscalculia is understood as a multifactorial disorder involving both cognitive and instructional aspects. Furthermore, research contributions are still dominated by developed countries such as the United States and the United Kingdom, although contributions from Indonesia and other developing countries are increasing. These findings underscore the importance of interdisciplinary collaborations integrating neuroscience, pedagogy, and technology as a foundation for developing inclusive, evidence-based learning interventions for students with dyscalculia.

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1. INTRODUCTION

Mathematics is an essential discipline that contributes significantly to students' intellectual, cognitive, and logical thinking development at various levels of education. Understanding mathematical concepts is the primary foundation for successful learning, not only in mathematics but also in other disciplines that require quantitative reasoning skills.

However, in practical learning, not all students can master and apply mathematical concepts optimally, especially those with learning difficulties. Learning difficulties refer to conditions in which students encounter obstacles in the learning process due to various internal and external factors [1].

Previous research indicates that mathematics learning difficulties are influenced by internal factors, such as health conditions, sensory function, cognitive capacity, interest, and motivation to learn, and external factors, including limited parental support, a less conducive learning environment, social influences, and high levels of digital media use [2]. The combination of these factors can hinder understanding of mathematical concepts and contribute to students' low academic achievement. Furthermore, mathematics learning difficulties are often associated with specific learning difficulties that impact academic ability, communication skills, and students' readiness to face increasingly complex educational demands [3].

Conceptually, a specific learning disability is defined as a disorder in one or more academic skills that is not caused by sensory impairments, low intelligence, emotional states, environmental factors, or cultural background. Common forms of specific learning disabilities include dyslexia, dyscalculia, and dysgraphia. Dyscalculia is a specific learning disability characterized by significant difficulties in understanding numerical concepts, performing arithmetic operations, and effectively processing mathematical information [3]. This disorder is not related to intellectual disability or lack of learning opportunities, but rather to impairments in cognitive function and specific neuropsychological mechanisms [4].

Empirical findings indicate that approximately 5% of elementary school-aged children are estimated to have dyscalculia, and without adequate treatment, this condition has the potential to persist into adolescence and adulthood. The impact of dyscalculia extends beyond academic domains and affects an individual's personal, social, and professional dimensions. Difficulties in mathematics can lower self-confidence, increase anxiety, and create obstacles in daily activities that require numerical reasoning, such as financial management and quantitative decision-making [5].

From a neurocognitive perspective, dyscalculia is associated with deficits in working memory, visuospatial processing abilities, and symbolic and non-symbolic numerical representation [6]. However, teachers' limited understanding of dyscalculia's characteristics remains a major obstacle to early identification and intervention efforts in educational settings [7], despite evidence-based interventions showing promising effectiveness.

While the study of dyscalculia continues to grow, most previous research has focused on diagnostic aspects, cognitive characteristics, and the effectiveness of interventions at the individual level. Studies that systematically map the development of dyscalculia research, including publication trends, dominant research themes, and patterns of global scientific collaboration using a bibliometric approach, are still relatively limited. This situation results in a lack of a comprehensive picture of the direction of dyscalculia research and in underexplored research opportunities, particularly in the context of mathematics education.

Based on this, this study aims to analyze trends in dyscalculia research for the period 2020–2025 using a bibliometric approach. This analysis is expected to provide a comprehensive overview of publication dynamics, thematic structure, and geographic

contributions to dyscalculia research. Furthermore, the results are expected to serve as a foundation for researchers, educators, and policymakers in designing further research, strengthening interdisciplinary collaborations, and developing inclusive, evidence-based mathematics learning strategies for students with dyscalculia.

2. METHOD

This research employs a bibliometric analysis method to examine scientific publications, enabling a quantitative assessment of publication volume, research developments, and collaboration patterns among authors, institutions, and countries involved in this domain. The purpose of the bibliometric analysis is to map publication distribution, determine prevailing research themes, and analyse the interconnections among elements in the literature on dyscalculia. This approach was selected because it provides a comprehensive quantitative overview of research trends, scholarly collaborations, and the geographical and institutional distribution of publications [8]. In this study, the Scopus database was used as the primary data source due to its standing as a reputable international scientific database with broad access to peer-reviewed scholarly articles. Scopus was chosen because all indexed publications undergo rigorous peer review, ensuring the reliability and credibility of the data. Data collection was conducted through a series of systematic procedures. Initially, data were retrieved using a focused title–abstract–keyword search with the term “dyscalculia”.

This search yielded several relevant articles on digital transformation and education. Subsequently, a filtering process was applied to ensure that only articles meeting the relevance criteria were included in the analysis. The screening process consisted of several stages. First, only journal articles were selected. Second, only articles that had been officially published were included. Third, the publication period was limited to the years 2020–2025. These screening steps ensured that only high-quality articles with clear relevance to the research topic were included in the analysed, thereby enhancing the integrity and validity of the dataset.

For data visualisation, this study employed VOSviewer, which facilitates visual mapping of keyword co-occurrence, author collaboration networks, and thematic relationships within the literature [9]. Strict inclusion criteria were applied to ensure only relevant, high-quality publications were included in the bibliometric analysis. Eligible articles had to be final, complete, written in English, and explicitly address dyscalculia, with particular emphasis on the role and impact of digital transformation in education.

Conversely, the exclusion criteria excluded articles published in non-academic journals without a peer-review process, as their quality could not be assured. Articles published as early access versions, irrelevant studies, incomplete documents, and duplicate publications were also excluded. This selection strategy was implemented to maintain the rigour and validity of the research, ensuring that only the most relevant and verified studies were incorporated into the analysis.

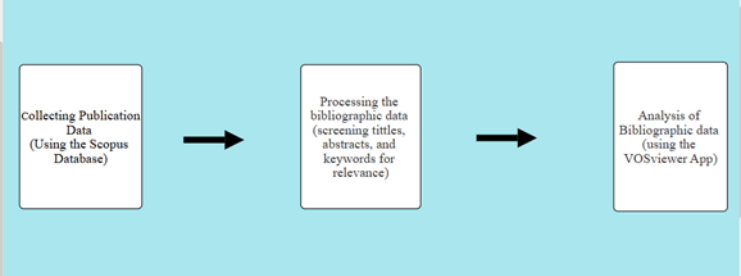

Figure 1. Three-Step Bibliometric Analysis Method

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Visualization VOSviewer

Based on the VOSviewer network map in Figure 2, the keyword co-occurrence pattern delineates a multidisciplinary landscape of learning-disorder research. The prominence of the central node *"disorder"* underscores that the study of learning difficulties, including dyscalculia, is not limited to a single perspective but integrates clinical, cognitive, pedagogical, and demographic dimensions. Within the domain of dyscalculia (mathematics learning difficulties), the green cluster highlights a close relationship among keywords such as *"mathematical learning difficulty (MLD),"* *"mathematical skill,"* and *"word problem"* connected to *"instruction,"* *"screening,"* *"risk,"* *"task,"* *"grade,"* *"age,"* *"pupil,"* and *"group."* This pattern indicates that dyscalculia is not merely a deficit in numerical competence but a multifaceted condition that requires early screening, task-based assessment, and tailored instructional interventions. This interpretation aligns with findings that revealed that Indonesian students with dyscalculia experience persistent conceptual and procedural difficulties in mathematical reasoning, especially in algebraic problem-solving [10].

The red cluster represents the pedagogical and instructional dimension, emphasizing the linkage between learning difficulties and classroom contexts, as reflected in keywords such as *"educator,"* *"classroom,"* *"strategy,"* and *"technology."* In line with this, [11] conducted a systematic review showing that the use of digital, visual, and gamified learning technologies effectively supports dyscalculic children in developing arithmetic and numerical understanding, highlighting the importance of adaptive and technology-supported learning environments. Meanwhile, the blue cluster underscores population heterogeneity and comorbidity, as reflected in terms such as *"symptom,"* *"difference,"* *"sample,"* and *"population."* This is consistent with the meta-analytic findings of Azhari et al. [12], who identified significant comorbidity between dyscalculia and other learning disorders, notably dyslexia and attention-deficit disorders, suggesting that intervention approaches should consider overlapping cognitive characteristics.

The purple cluster captures the psychological–cognitive aspect by highlighting *"anxiety,"* *"attention,"* and *"control,"* indicating that emotional and cognitive regulation—such as math anxiety and attentional control—are integral to understanding dyscalculia. Lastly, the yellow cluster encompasses theoretical and developmental aspects (*"model,"*

"term," "treatment," "children/adult"), reflecting the ongoing refinement of conceptual frameworks and intervention strategies across age groups. Taken together, the integration of these clusters positions dyscalculia as a complex, multidimensional learning disorder in the Indonesian academic landscape, one that is addressed through pedagogical innovation, technological adaptation, psychological insight, and early diagnostic approaches. This holistic understanding supports the call for interdisciplinary collaboration in educational research and instructional practices for learners with mathematical learning difficulties.

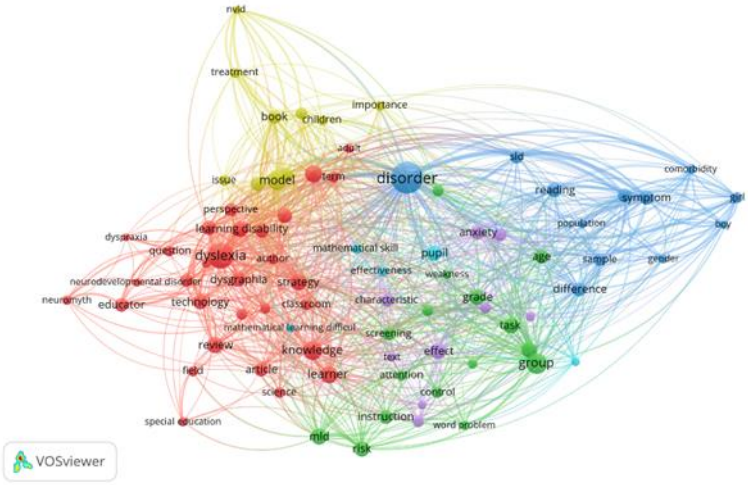

Figure 2. Visualization VOSviewer

3.1.2 Publications by Year

Based on Figure 3 (reduced results) for the 2020–2025 period, a total of 190 documents on dyscalculia were identified, revealing an uneven annual distribution. In 2020, there were 22 publications, followed by a decrease to 18 in 2021. A significant rise was observed in 2022, reaching 41 documents, indicating an acceleration in scholarly output on dyscalculia research. The number of publications then decreased to 28 in 2023, but the trend rose again in 2024 to 39 documents, peaking in 2025 at 42. This trajectory reflects a fluctuating yet overall upward trend in publications after 2021, with 2022 marking a notable surge and continued growth through 2024–2025.

From an interpretive perspective, the rising number of publications likely reflects increasing academic interest in the complexity of dyscalculia as a specific learning disability. This is consistent with recent literature emphasizing the multifaceted nature of dyscalculia, which impacts numerical cognition, conceptual understanding, and educational outcomes [13]. Additionally, empirical studies show that students with dyscalculia struggle with fundamental mathematical concepts and problem-solving, reinforcing the need for targeted instructional approaches and early identification [10]. Collectively, these findings suggest that the observed publication growth may be driven by a broader effort to understand dyscalculia's cognitive, diagnostic, and pedagogical dimensions, while acknowledging that 2025 data should be interpreted cautiously due to potential incomplete indexing for the current year.

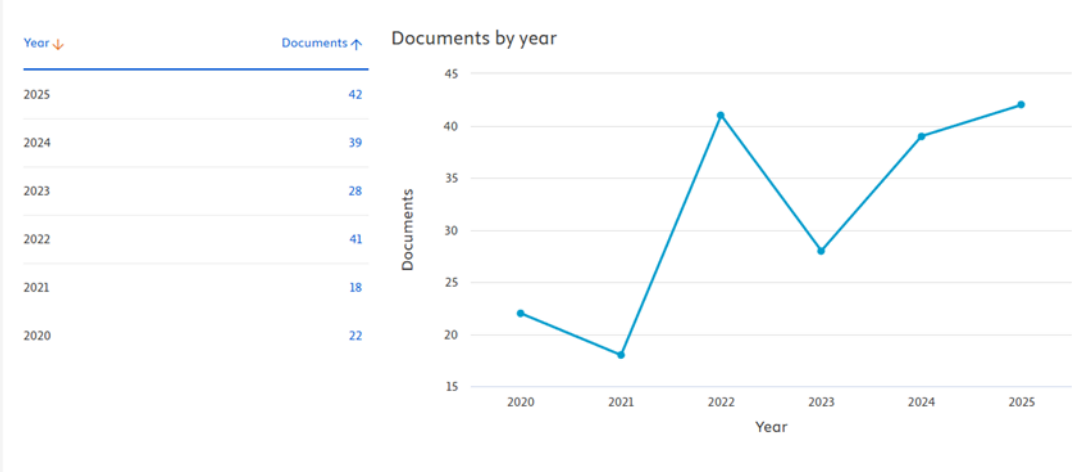

Figure 3. Publications by Year

3.1.3 Publications by Year *by source* data

Based on the *Documents per year by source* data shown in Figure 4 for the period 2021–2025, the distribution of publications on dyscalculia across leading journals reveals distinct patterns, highlighting both disciplinary focus and publishing trends. Among the indexed sources, the Journal of Learning Disabilities consistently dominates with the highest output (14 documents), particularly with an upward contribution in 2025, indicating sustained interest from specialized outlets in learning disability research. Other journals, such as the *European Journal of Special Needs Education*, *British Journal of Special Education*, *Frontiers in Education*, and the *International Electronic Journal of Elementary Education*, contribute smaller, yet meaningful counts, reflecting a diversification of platforms addressing dyscalculia from both special education and general pedagogical perspectives.

This distribution aligns with broader scholarly emphases on dyscalculia as a multifaceted learning difficulty that intersects cognitive development, instructional design, and educational psychology. For instance, research in *Frontiers in Education* underscores that dyscalculia involves disruptions in numerical cognition and conceptual understanding, necessitating domain-specific interventions and assessment practices [13]. Similarly, studies published in *the Journal of Learning Disabilities* emphasize diagnostic profiles and the efficacy of interventions to support learners with mathematics learning difficulties [14], further justifying why this journal appears most frequently as a source.

Moreover, the presence of journal output focusing on special needs education suggests that dyscalculia is increasingly framed not only as a cognitive deficit but also as an educational challenge embedded within inclusive pedagogical frameworks (*British Journal of Special Education* and *European Journal of Special Needs Education*). This is consistent with findings that dyscalculia research frequently intersects with instructional strategies, teacher preparation, and curriculum adaptations to support diverse learners [15]. Taken together, the source distribution illustrates that dyscalculia research during 2021–2025 is disseminated through both highly specialized and broader educational forums, reflecting its interdisciplinary nature and the need to address it from cognitive, pedagogical, and inclusive education angles.

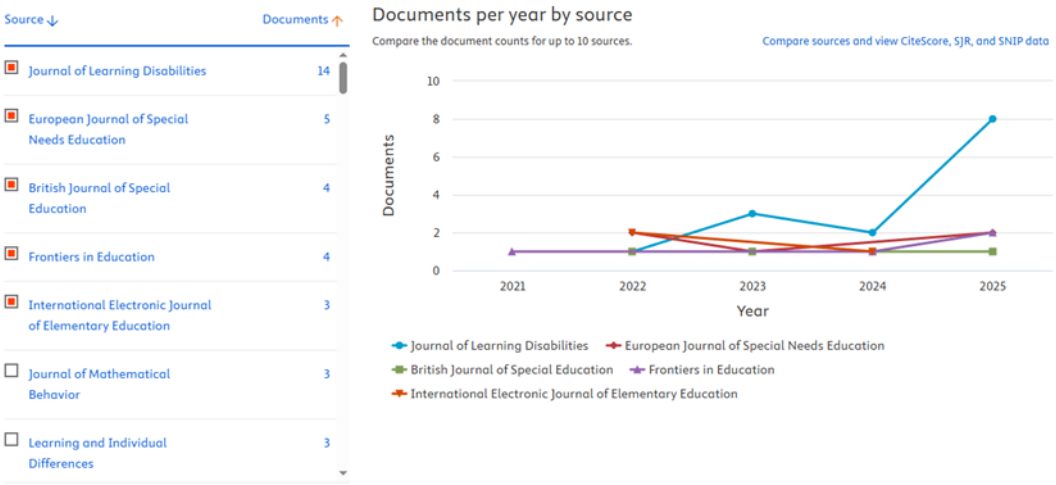

Figure 4. By source data

3.1.4 Publications by Authors

Based on the Documents by Author visualization in Figure 5, the bibliometric mapping identifies the leading contributors in the global research landscape on learning disorders, particularly dyscalculia, and reveals varied productivity and collaborative patterns among authors. The chart indicates that several key researchers, including *Skeide, M.A., Jamaludin, A., Koponen, T., and Kroesbergen, E.H.*, demonstrate consistent publication output, highlighting the interdisciplinary nature of dyscalculia research that bridges neurocognitive, pedagogical, and psychological domains. Authors such as *Aunola, K., and Baccaglini-Frank, A.* are also noted for integrating instructional innovations and mathematical cognition. At the same time, *Arsenault, T.L., and Zhou, X.* contribute to cross-cultural perspectives on learning difficulties, reinforcing the notion that dyscalculia research spans both global and contextual educational frameworks.

This distribution pattern corresponds to the increasing emphasis on collaborative and data-driven inquiry aimed at identifying the cognitive, pedagogical, and affective determinants of mathematics learning difficulties. Such trends are echoed in the Indonesian academic context, where studies published in SINTA 3 journals have begun to contextualize dyscalculia through empirical classroom research, diagnostic interventions, and teacher-mediated instructional frameworks, and examined instructional approaches and diagnostic assessments aimed at supporting mathematics learning difficulties in early childhood education.

Their findings affirm the theoretical view that dyscalculia requires not only cognitive remediation but also adaptive classroom methodologies and early-stage screening mirroring global patterns seen in Scopus-indexed author collaborations emphasizing structured assessment frameworks [16]. Explored teacher perceptions and adaptive learning strategies, concluding that pedagogical flexibility and differentiated instruction significantly mitigate mathematical anxiety and performance gaps among students with dyscalculic tendencies. Their research parallels the work of international authors such as Kroesbergen and Koponen, who emphasize the teacher's central role in addressing mathematical learning diversity within inclusive educational settings [17]. Svraka et al. [18] investigated cognitive-affective

predictors of mathematics achievement, revealing that mathematical anxiety, attention control, and self-efficacy exert substantial effects on students with learning difficulties. This aligns with the psychological dimension of dyscalculia represented in the author network through keywords such as anxiety, control, and attention, frequently explored by leading figures like Skeide and Aunola.

Thus, both international and Indonesian research converge in emphasizing that dyscalculia must be understood as a multifactorial disorder—encompassing cognitive impairments, emotional regulation, pedagogical adaptation, and instructional design. The convergence of high-productivity authors in Scopus and the emerging empirical studies within SINTA-indexed Indonesian journals underscores an evolving research paradigm: one that moves from isolated neurocognitive inquiry toward interdisciplinary, classroom-embedded, and technology-supported educational practice. Collectively, the global–local synthesis evident in these bibliometric trends underscores the need to develop evidence-based interventions and teacher training programs to diagnose and support dyscalculic learners effectively, positioning Indonesia's recent research contributions within a broader international trajectory in learning-disorder scholarship.

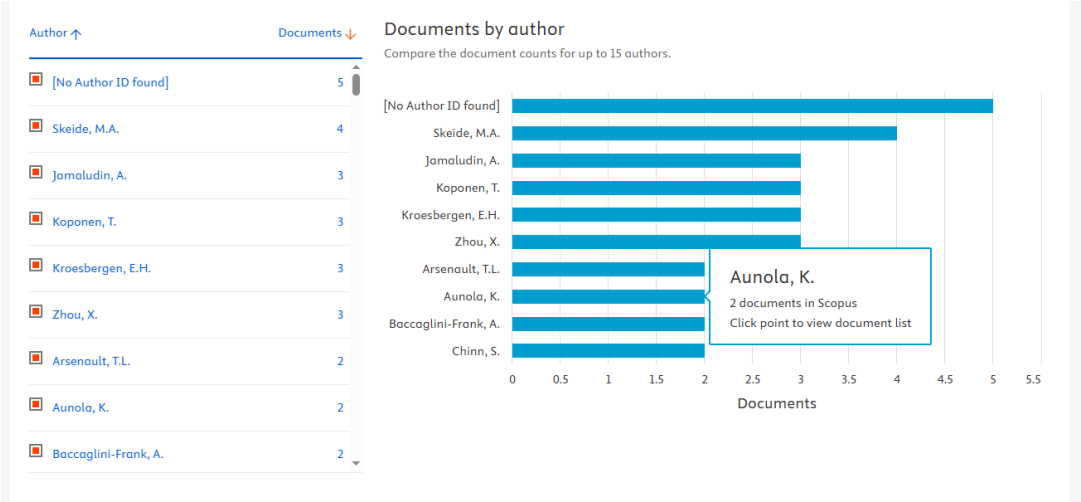

Figure 5. Publications by Authors

3.1.5 Publications by Country

Based on the *Documents by country or territory* panel (Figure 6) for dyscalculia-related publications, the geographic distribution of research output is clearly uneven. The United States contributes the largest share (n = 25), followed by the United Kingdom (n = 22) and Germany (n = 16). This concentration suggests that dyscalculia research is strongly anchored in countries with well-established research infrastructures, mature special education systems, and sustained funding for studies in cognitive development and learning disabilities. A second tier of contributors includes India (n = 13) and Italy (n = 11), indicating that interest in dyscalculia is also expanding beyond Western Europe and North America, although at a comparatively lower publication intensity. Meanwhile, Spain (n = 8) and China (n = 7) show moderate output, reflecting emerging but still developing research activity within the field.

Importantly, Indonesia appears among the contributing countries with n = 6 documents (comparable to Malaysia, n = 6). Although this indicates that dyscalculia has attracted scholarly attention in Southeast Asia, the relatively small volume suggests that research production remains limited, potentially due to constraints in large-scale data collection, fewer specialized research groups, or lower visibility of publications in internationally indexed outlets. In addition, the presence of an "Undefined" category (n = 13) implies that a substantial proportion of indexed records do not provide clearly attributed country/affiliation metadata. This issue may arise from incomplete author affiliation information, inconsistencies in database indexing, or multi-affiliated authorship that is not fully standardized; therefore, national productivity comparisons should be interpreted with caution because the "Undefined" group could partially redistribute counts across countries if metadata were complete.

Overall, the pattern indicates that dyscalculia research is concentrated in high-output research systems, particularly the US and UK, while contributions from emerging contexts, including Indonesia, remain comparatively modest. This gap highlights both the need and the opportunity to strengthen research capacity through improved institutional support, greater international publication engagement, and cross-country collaboration, especially to generate evidence that is culturally and educationally contextualized for diverse learning environments.

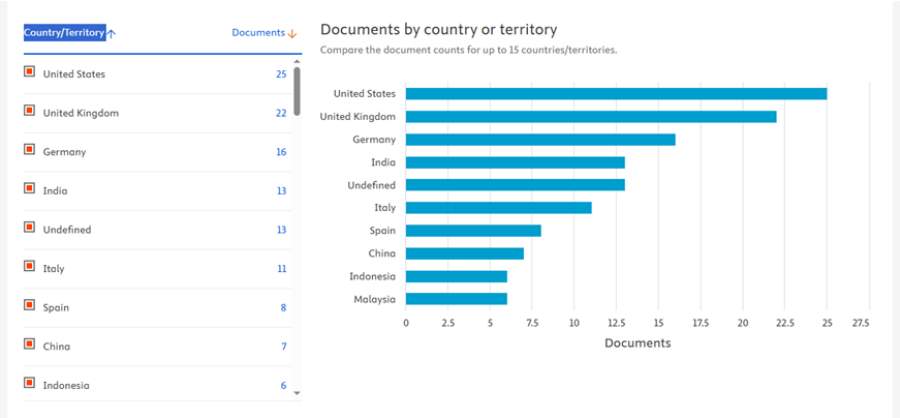

Figure 6. Publications by Country

3.2 Discussion

This study reveals a progressive and multidimensional trend in research on dyscalculia between 2020 and 2025, reflecting an increasing global awareness of mathematical learning difficulties as part of the broader spectrum of neurodevelopmental disorders. The bibliometric analysis indicates a clear shift from early descriptive and diagnostic research toward interdisciplinary, evidence-based approaches that integrate cognitive psychology, educational neuroscience, and instructional technology to address learning challenges holistically. This evolution mirrors broader shifts in educational research, in which cognitive, affective, and pedagogical dimensions are recognized as critical for designing effective interventions for learners with dyscalculia.

Analysis of publication trends shows that research activity remains concentrated in established research hubs such as the United States, the United Kingdom, and Germany, while emerging research contexts, such as India, Indonesia, and Brazil, have shown increasing scholarly output. For instance, Scott [19] reported that learner-centered instructional strategies significantly improved students' mathematical reasoning among those with dyscalculia in Indonesian primary schools, underscoring the role of localized pedagogical innovation. This finding aligns with the global trend of prioritizing contextually relevant educational practices that enhance numerical cognition.

Thematic mapping further reveals that dyscalculia research can be categorized into five major clusters—cognitive, pedagogical, psychological, demographic, and theoretical—reinforcing the notion that dyscalculia is a multifactorial learning disorder. The green cluster, linking *"mathematical learning difficulty (MLD)"* with *"instruction," "screening,"* and *"risk,"* underscores the importance of early identification and assessment. Supporting this, Bowie [20] demonstrated that early screening tools effectively differentiate between typical development and dyscalculia, enabling targeted remediation.

The red cluster, dominated by terms such as *"educator," "technology,"* and *"strategy,"* reflects a pedagogical shift toward adaptive, technology-mediated instruction. In this context, Wijaya and Pereira [21] found that interactive mathematical games and digital manipulatives significantly improved number sense among students at risk of dyscalculia, highlighting the potential of educational technology to support differentiated learning.

The blue cluster, including *"gender," "population,"* and *"comorbidity,"* emphasizes the complex intersectionality of dyscalculia with other conditions. Documented how co-occurring attention deficits and reading difficulties can compound mathematical learning delays, recommending multimodal intervention programs that address both cognitive and attentional domains. The purple cluster captures psychological correlates like *"anxiety," "attention,"* and *"control,"* indicating that emotional factors significantly influence mathematical performance. Showed that mathematics anxiety mediates performance deficits in students diagnosed with dyscalculia, suggesting that interventions must integrate emotional regulation strategies alongside cognitive training [22].

Finally, the yellow cluster pertains to conceptual and theoretical development, including frameworks for early detection and computational modeling. Explored the integration of machine learning techniques for predicting dyscalculia risk based on early numerical task performance, highlighting how computational tools can enhance diagnostic precision [23].

Taken together, these new findings confirm that dyscalculia research has transitioned from isolated cognitive descriptions to interdisciplinary, technology-enhanced, and learner-focused paradigms, reflecting a broader transformation in educational science. Sustainable progress in this field will depend on multidisciplinary collaboration that integrates cognitive, pedagogical, affective, and technological perspectives to support equitable and effective learning outcomes across diverse educational contexts.

4. CONCLUSION

This study provides a conceptual overview of the development of dyscalculia studies between 2020 and 2025 using a bibliometric approach. Overall, the study results indicate that dyscalculia research is evolving in an increasingly interdisciplinary and comprehensive manner, viewing dyscalculia as a complex learning disorder that involves interactions among cognitive, pedagogical, psychological, and contextual factors. These findings confirm a shift in the research paradigm from a single, deficit-based approach to a more holistic understanding of dyscalculia.

The implications of this study suggest that dyscalculia treatment efforts in the context of mathematics education should be collaboratively designed and evidence-based, integrating adaptive pedagogical approaches, the use of learning technology, and an understanding of students' neurocognitive development. For educators and policymakers, the results of this study can serve as a basis for formulating inclusive learning strategies and education policies that are more responsive to the needs of students with dyscalculia, particularly in developing countries.

While this study provides a systematic mapping, it has several limitations. First, the data analyzed were limited to publications indexed in the Scopus database, thus potentially missing relevant research. Second, the bibliometric analysis was quantitative-descriptive in nature and did not thoroughly evaluate the methodological quality or effectiveness of the interventions reported in each study. Furthermore, the limited research timeframe of 2020–2025 does not fully represent the long-term historical development of dyscalculia research.

Based on these limitations, future research is recommended to combine a bibliometric approach with a systematic review or meta-analysis to gain a deeper understanding of the effectiveness of dyscalculia interventions. Furthermore, more contextual studies in developing countries, including Indonesia, are needed to explore learning practices, technology utilization, and education policies that are appropriate to local characteristics. Further research is also expected to expand the data sources and analysis period to obtain a more comprehensive mapping.

Practically, this research's contribution to the general public lies in raising awareness of dyscalculia as a learning disorder that requires appropriate pedagogical support, not simply a matter of academic ability. With a better understanding, it is hoped that parents, educators, and educational stakeholders can play an active role in creating an inclusive and equitable learning environment that supports the development of students with dyscalculia.

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