

Mapping the landscape of a decade: a bibliometric review of mobile assistive technology research for dyslexic children

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ABSTRACT

Dyslexia, a prevalent neurodevelopmental disorder affecting reading and writing skills, poses significant challenges to educational attainment. In recent years, mobile assistive technologies have emerged as promising tools to support dyslexic children in their journey. Despite the increasing focus on mobile assistive technology for dyslexic children, a comprehensive overview of the research landscape is lacking. The field is characterized by a proliferation of studies, diverse methodologies, and an expanding knowledge base. This bibliometric review leverages advanced analytical tools, with a primary focus on the VOSviewer software, to conduct a comprehensive analysis of the 53 literatures spanning from 2014 to 2024. A carefully curated dataset, comprising research articles sourced from reputable databases, forms the basis of the analysis. Anticipated outcomes include visually rich maps depicting the keyword co-occurrence patterns within the realm of mobile assistive technology for dyslexic children. We expect to identify key articles shaping the field, prominent clusters of research, and evolving trends. This bibliometric review aspires to contribute a panoramic view of the last decade's research landscape in mobile assistive technology for dyslexic children. The anticipated insights hold the potential to guide future research directions, technological innovations, and educational interventions, ultimately enhancing the support available to dyslexic children through mobile assistive technologies.

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1. INTRODUCTION

In the dynamic landscape of educational research, the integration of mobile assistive technology for dyslexic children stands at the forefront of innovative pedagogical endeavors [1]. Dyslexia, a learning disorder characterized by difficulties in reading and spelling, poses distinctive challenges that necessitate tailored educational interventions [2]–[8]. Within the educational context, the exploration of mobile assistive technology's efficacy in addressing these challenges represents a critical and evolving area of scholarly investigation. This bibliometric article is a systematic exploration of the extensive body of literature that converges on the intersection of mobile technology and educational support for dyslexic children [9], [10]. The title encapsulates the essence of our inquiry, reflecting a commitment to comprehensively analyze the growth, patterns, and impact of research within this specialized domain.

As we embark on this bibliometric journey, our objectives are multifold. We aim to trace the chronological evolution of research on mobile assistive technology for dyslexic children, identifying seminal works, influential authors, and pivotal turning points that have shaped the discourse. Employing robust bibliometric methodologies, our analysis seeks to uncover thematic clusters within the literature, unraveling

prevailing topics, research methodologies, and theoretical frameworks that underpin this field. Beyond its academic significance, this bibliometric study serves as a valuable resource for educators, researchers, and policymakers engaged in fostering inclusive educational environments. By synthesizing the existing body of knowledge, our goal is to inform evidence-based practices, identify gaps in research, and contribute insights that can shape future directions in both scholarship and practical applications. Ultimately, this bibliometric exploration endeavors to provide a nuanced understanding of the current state of mobile assistive technology research for dyslexic children, offering a foundation for continued advancements and innovations in the realm of inclusive education.

Mobile assistive technology has been identified as an effective approach to enhance the learning experience for students with dyslexia [2], [11]. In a systematic literature review on mobile applications for students with dyslexia, it was found that there are mobile applications available that can be used to enhance the learning experience for dyslexic children [2]. The research method used in this study involved a systematic literature review, and the results showed that the overall use of mobile learning was effective in enhancing the ability to read [11]. In another study, a mobile learning model for dyslexic reading was proposed, which focuses on delivering instruction to trigger learning and is linked to an instructional design model [12]. The proposed model also involves trained teachers giving feedback on the progress of dyslexic children using the mobile learning app [12], [13]. This suggests that teacher training and support are crucial for the successful implementation of mobile assistive technology for dyslexic children [14].

Dyslexic learners may face challenges with online learning, such as discomfort with technology and decreased motivation [2], [15]. To address these challenges and ensure the effective implementation of mobile assistive technology for dyslexic children, it is essential to consider factors such as teacher training, integration with traditional teaching methods, and the development of more accessible mobile learning applications [7], [12]. By addressing these challenges and exploring future directions, researchers and educators can work together to create an inclusive and effective learning environment for all students.

2. METHOD

Bibliometrics is the collection, organisation, and evaluation of bibliographic information obtained from scientific publications [16]. In addition to general descriptive data like publishing journals, publication year, and major author classification, it incorporates more complex techniques such as document co-citation analysis [17]. To perform a comprehensive literature review, create a bibliography, and achieve reliable results, a methodical methodology that includes the identification of relevant keywords, literature search, and analysis is required [18]. The next section discusses the adoption of search keywords, first screening of search results, and search result refinement. The study made an effort to restrict its reach to the best articles because they may aid in comprehending the theoretical perspective about the development of the research issue. Interestingly, Elsevier's Scopus, which is renowned for its broad coverage, made it easier to gather publications from 2014 to January 2024 for further examination. To identify the search phrases for article retrieval, the study used a screening sequence. Study was initiated by querying Scopus database with online TITLE-ABS-KEY ("apps" OR "mobile" OR "technology" OR "mobile learning" OR "assistive technology" OR "mobile application" AND dyslexi*) AND (LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2022) OR LIMIT-TO (PUBYEAR , 2023) OR LIMIT-TO (PUBYEAR , 2024)) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "cr") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English")) , thereby assembling 797 articles. The query string was then changed to concentrate on students as learners using the search phrases "mobile learning" OR "m-learning." 531 articles from the final refining of the search phrase were used for bibliometric analysis. All publications from the Scopus database that focused on students and mobile assistive technology as of January 2024 were included in the study.

3. DATA ANALYSIS

Visualisation of similarity viewer, or VOSviewer, is a potent software program made especially for bibliometric and scientific metric studies. Essentially, VOSviewer uses sophisticated algorithms to transform intricate bibliographic information into maps that are easy to understand. This provides scholars with a dynamic and intuitive platform to identify trends, correlations, and patterns in scholarly literature. We looked at datasets from the Scopus database that covered the years 2014-2024 and contained data on research publication year, publication title, author name, journal, citation, and keyword. VOSviewer software version 1.6.19 was used to analyse these datasets. This program made it easier to analyse and create maps using visualization of similarities (VOS) clustering and mapping algorithms. VOSViewer, in contrast to the multidimensional scaling

(MDS) method, concentrates on placing objects in low-dimensional spaces, making sure that the distance between any two objects appropriately represents their similarity and relatedness [19]. In terms of its goal, this is consistent with the MDS approach [20]. Unlike MDS, which computes similarity metrics like cosine and Jaccard indexes, VOS uses a more appropriate method for normalising co-occurrence frequencies) [21], called the association strength (AS_{ij}), which is computed as follows:

$$AS_{ij} = \frac{C_{ij}}{W_i W_j}$$

According to Eck and Waltman [19], this index has a direct correlation with the ratio of the observed and expected cooccurrences of *i* and *j*, assuming statistical independence. In order to place things on a map, the VOSviewer uses this index to minimise the weighted sum of squared distances between each pair of items. In accordance with the methodology proposed by Appio *et al.* [22], LinLog/modularity normalisation was used. Furthermore, patterns based on mathematical correlations were discovered by applying visualisation techniques in VOSviewer to the dataset, allowing for analyses like co-citation analysis, keyword co-occurrence, and citation analysis. Consequently, by using this index, the VOSviewer minimises the weighted sum of squared distances between every pair of elements, arranging them into a map. LinLog/modularity normalisation was used, as recommended by Appio *et al.* [20]. Additionally, patterns based on mathematical correlations were discovered by using visualisation techniques in VOSviewer on the dataset. This made a number of analyses easier, such as co-citation analysis, citation analysis, and keyword co-occurrence analysis. Keyword co-occurrence analysis [23], which is useful for determining hot subjects across many domains [24], can be used to examine how a research area has evolved over time. Citation analysis, on the other hand, is useful for identifying important research questions, patterns, and methods as well as exploring the historical relevance of a discipline's main area of interest [25]. A popular bibliometric technique [12], [18], [22] is document co-citation analysis, which maps the pertinent data structure using network theory [12].

4. RESULTS AND DISCUSSION

4.1. RQ1: what are the research trends in mobile assistive technology for dyslexic children according to the year of publication?

The bibliometric analysis of mobile assistive technology for dyslexic children as depicted in Figure 1 and Table 1, based on the number of documents published each year, reveals significant trends and patterns in research output. The data demonstrates a consistent growth in research output over the analysed years, showcasing an increasing interest and commitment to studying mobile assistive technology interventions for dyslexic children. The upward trajectory begins in 2014, with 29 publications, and culminates in 2022, which represents a peak year with 91 publications. This spike in 2022 suggests a particularly active and productive period, possibly driven by advancements in technology, heightened awareness of dyslexia, and the acknowledgment of mobile assistive technology's potential in addressing the educational needs of dyslexic children. The impact scores associated with each year indicate not only the quantity but also the influence of the research within the academic community. The high impact scores in recent years, especially in 2022 and 2023, suggest that the research conducted during these periods has had a significant impact and is widely cited by other researchers. This could signify the emergence of seminal works and influential studies during these years. The overall increasing trend in research output implies a maturing field, with researchers dedicating more attention to exploring the intersection of mobile assistive technology and dyslexia [2]. The consistent growth also reflects the recognition of the potential benefits of mobile assistive technology interventions in supporting dyslexic children's educational journeys [3]. In conclusion, the bibliometric analysis provides a comprehensive view of the dynamic landscape of research on mobile assistive technology for dyslexic children.

4.2. RQ2: who writes the most cited articles in mobile assistive technology for dyslexic children according to the year of publication?

Table 2 and Figure 2 provide valuable insights into the publication patterns of authors in the field of mobile assistive technology for dyslexic children, as analysed by Scopus analyzer. The columns indicate the author's name, the number of documents they have published, and the author's impact score [26], [27]. At the top of the list, we observe several authors, namely Benmarrakchi, Bucci, El Kafi, Peyre, and Svensson, each with five published documents and an impact score of approximately 0.94. This suggests that these authors have consistently contributed to the literature on mobile assistive technology for dyslexic children, and their work is associated with a relatively high impact. Following closely are Gustafson, Holz, Lindeblad, Richardson, Thelijagoda, and Ventura, each with four published documents and an impact score of approximately 0.75. While their impact scores are slightly lower than the top group, they still demonstrate a

significant contribution to the field. The third group, including Alsobhi, Balcisoy, Barela, and Benton, has three published documents each, with an impact score of approximately 0.56. Though their impact scores are lower than the previous groups, it's important to acknowledge their contributions to the field. Analysing the data, we can observe that a relatively small number of authors have produced a significant portion of the published documents in this area. This could imply a concentration of expertise among these authors or a focused research effort in specific subtopics related to mobile assistive technology for dyslexic children. The impact scores, representing the relative influence of an author's work, highlight the potential significance of certain researchers' contributions [28], [29]. In summary, the bibliometric analysis reveals a hierarchy of author contributions in terms of the number of documents published and their impact scores. This information can guide further exploration into the content of these publications, helping researchers understand the current landscape of the research.

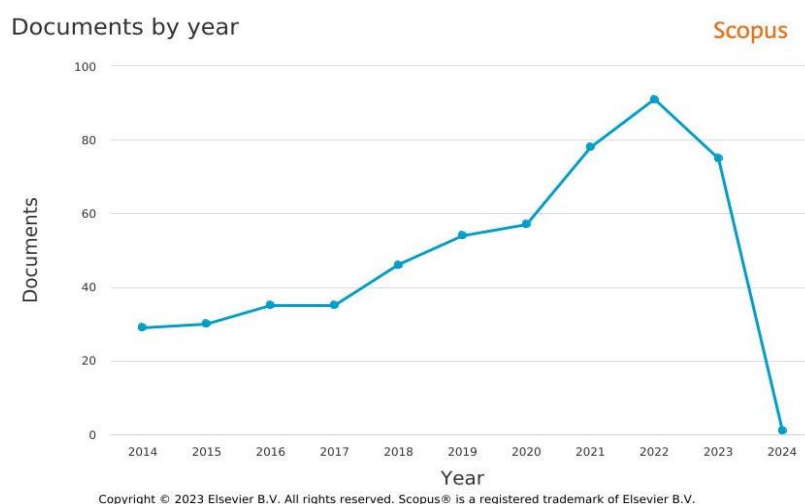


Figure 1. Documents by year in mobile assistive technology

Table 1. Percentage of documents in mobile assistive technology per year

Year	Number of documents	Percentage (%)
2024	1	0.18832392
2023	75	14.1242938
2022	91	17.1374765
2021	78	14.6892655
2020	57	10.7344633
2019	54	10.1694915
2018	46	8.66290019
2017	35	6.5913371
2016	35	6.5913371
2015	30	5.64971751
2014	29	5.4613936

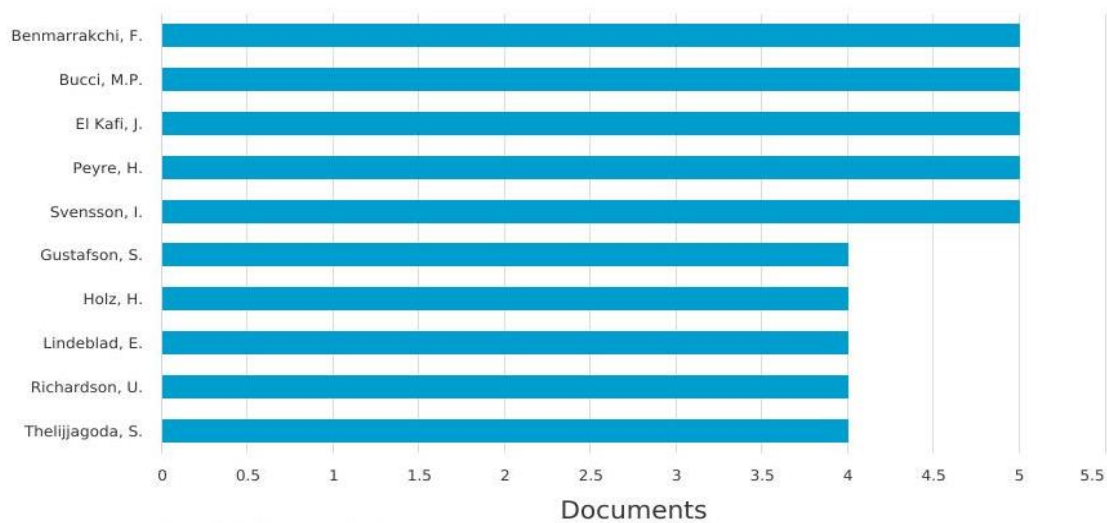
Table 2. Percentage of documents in mobile assistive technology per author

Authors	Number of documents	Percentage (%)
[26]	5	0.94161959
[27]	5	0.94161959
[28]	5	0.94161959
[29]	5	0.94161959
[30]	5	0.94161959
[31]	4	0.75329567
[32]	4	0.75329567
[33]	4	0.75329567
[34]	4	0.75329567
[35]	4	0.75329567
[36]	3	0.56497175
[37]	3	0.56497175
[38]	3	0.56497175
[39]	3	0.56497175

Documents by author

Compare the document counts for up to 15 authors.

Scopus



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Figure 2. Documents by author in mobile assistive technology

4.3. RQ3: what is the top 5 number of citations by research in mobile assistive technology for dyslexic children?

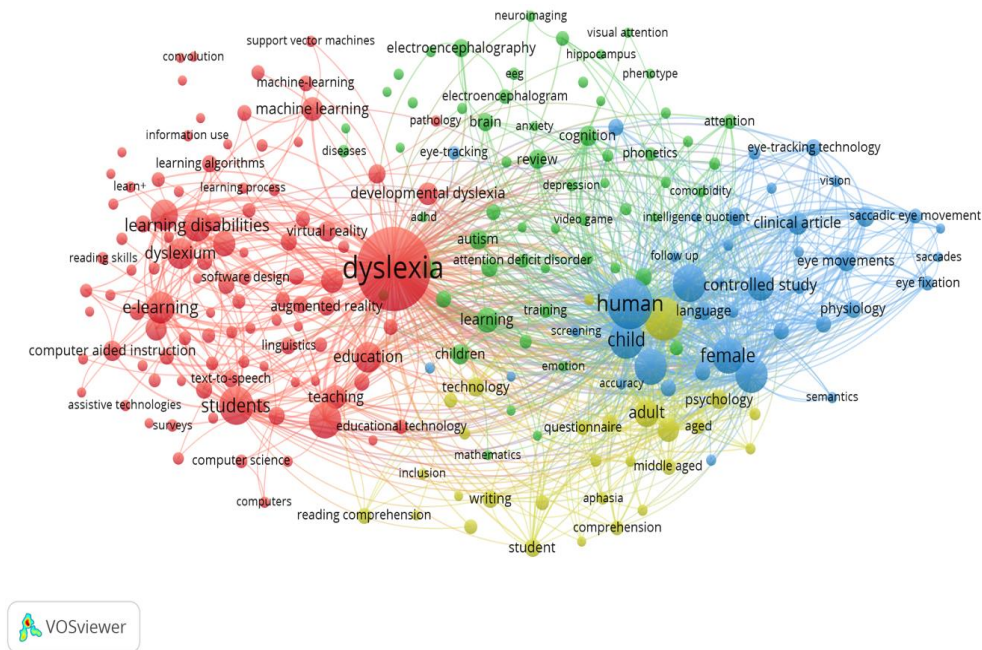
Table 3 brings attention to the leading five research articles with the highest citation counts in the realm of mobile assistive technology for dyslexic children. These studies have exerted a significant impact on academic discussions and have received considerable attention in the form of citations. Encompassing a broad spectrum of subjects related to mobile assistive technology for dyslexic children, these highly cited works indicate their pivotal role in scholarly references [40]–[44]. The substantial number of citations underscores the influence of these articles as fundamental resources for researchers, offering valuable perspectives and methodologies in the field.

Table 3. Top 5 number of citations by research in mobile assistive technology

Authors	Title	Year	Source title	Cited
[40]	“Does use of text-to-speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis.”	2018	Journal of Learning Disabilities	86
[41]	“The inclusion of students with dyslexia in higher education: a systematic review using narrative synthesis.”	2014	Dyslexia	82
[42]	“Diversity for design: a framework for involving neurodiverse children in the technology design process.”	2014	Conference on Human Factors in Computing Systems - Proceedings	80
[43]	“EasyLexia: a mobile application for children with learning difficulties.”	2014	Procedia Computer Science	76
[44]	“A survey on lexical simplification.”	2017	Journal of Artificial Intelligence Research	65

4.4. RQ4: what are the popular keywords related to the study in mobile assistive technology for dyslexic children?

Figure 3 shows a network of keywords that are connected based on how often they co-occur in the articles that you have analysed. The size of the nodes in the map corresponds to the frequency of the keyword, and the thickness of the edges between the nodes corresponds to the strength of the co-occurrence relationship. The Figure 3 shows keywords related to mobile assistive technology for dyslexia children [45]–[50]. Some of the most central keywords in the map include: i) dyslexia; ii) reading skills; ii) machine learning; iv) electroencephalography (EEG); v) eye-tracking; and vi) mobile apps. Overall, the VOSviewer map of keywords co-occurrence provides a valuable overview of the research on mobile assistive technology for dyslexia children. The map highlights the key areas of research in this field and suggests new directions for future research.



4.5. RQ6: what are co-authorship countries' collaboration in mobile assistive technology for dyslexic children?

Figure 4 shows a network of countries that are connected based on how often they co-occur in the articles that you have analysed. The size of the nodes in the map corresponds to the number of articles from that country, and the thickness of the edges between the nodes corresponds to the strength of the co-occurrence relationship. The figure shows that research on mobile assistive technology for dyslexia children is being conducted in a number of countries around the world [43], [44]. The United States, the United Kingdom, and China are the most active countries in this field, followed by India, Canada, and Australia. There is a number of clusters of countries that are working together on research in this field. For example, there is a cluster of countries in Europe that are working together on research on mobile assistive technology for dyslexia children. This cluster includes the United Kingdom, Germany, Sweden, and the Netherlands. There is also a cluster of countries in Asia that are working together on research in this field. This cluster includes China, India, and Japan. Overall, the VOSviewer map of keywords co-occurrence between countries provides a valuable overview of the global research landscape on mobile assistive technology for dyslexia children. The map highlights the countries that are most active in this field and the clusters of countries that are working together on research.

This study investigated the research trends of mobile assistive technology for dyslexic children, based on the number of documents published each year [45]–[50]. The data demonstrates a consistent growth in research output over the analysed years, showcasing an increasing interest and commitment to studying mobile assistive technology interventions for dyslexic children. The upward trajectory begins in 2014, with 29 publications, and culminates in 2022, which represents a peak year with 91 publications. The overall increasing trend in research output implies a maturing field, with researchers dedicating more attention to exploring the intersection of mobile assistive technology and dyslexia. The consistent growth also reflects the recognition of the potential benefits of mobile assistive technology interventions in supporting dyslexic children's educational journeys. This could imply a concentration of expertise among these authors or a focused research effort in specific subtopics related to mobile assistive technology for dyslexic children. The impact scores, representing the relative influence of an author's work, highlight the potential significance of certain researchers' contributions.

The bibliometric analysis reveals a hierarchy of author contributions in terms of the number of documents published and their impact scores. This information can guide further exploration into the content of these publications, helping researchers understand the current landscape of mobile assistive technology for dyslexic children and identifying potential directions for future research [40], [41]. The United Kingdom and the United States stand out as the leading contributors, with 66 and 65 published documents, respectively. Several other countries, including India, Italy, Malaysia, Spain, Brazil, Germany, and Greece, contribute significantly to the body of knowledge on mobile assistive technology for dyslexic children. The distribution of research across

these countries emphasizes the global collaboration and interest in addressing the challenges faced by dyslexic children through mobile assistive technology interventions. This bibliometric analysis highlights the widespread global interest and collaboration in the research on mobile assistive technology for dyslexic children.

We found that the data highlights the top 5 most-cited research articles in the field of mobile assistive technology for dyslexic children. These publications have significantly contributed to shaping the research landscape. The number of citations suggests that these articles serve as key references for scholars and practitioners alike, providing valuable insights and methodologies in the field [43], [44]. The keyword co-occurrence map unveils the thematic landscape of mobile assistive technology for dyslexia children. Central keywords include dyslexia, reading skills, machine assistive technology, EEG, eye-tracking, and mobile apps. This map serves as a comprehensive overview, suggesting avenues for future research and emphasizing key areas of focus. The country co-occurrence map reveals global research collaborations in mobile assistive technology for dyslexia children. The United States, the United Kingdom, China, India, Canada, and Australia emerge as active contributors. Clusters show regional collaborations, such as European countries and Asian nations. Our findings provide conclusive evidence that the map provides insights into international research landscapes and underscores the importance of global collaboration. Our study demonstrates that these VOSviewer maps serve as powerful tools to navigate the dynamic and evolving landscape of research on mobile assistive technology for dyslexia children, offering valuable insights and guiding future explorations in this important field [19], [20].

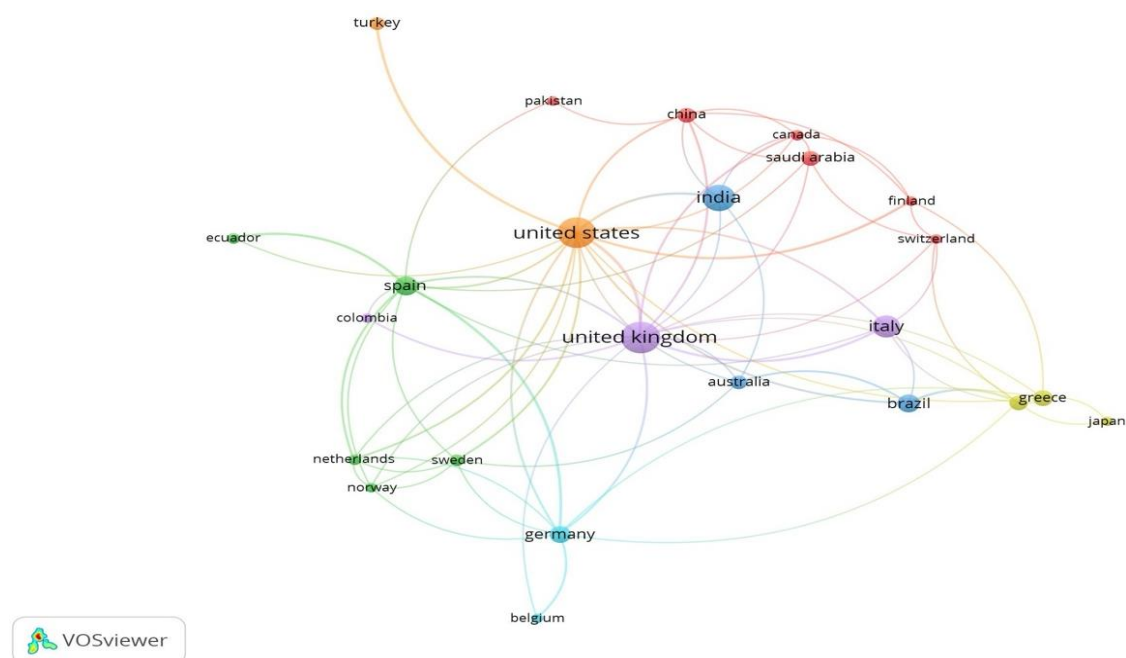


Figure 4. Network of countries collaborated in mobile assistive technology

5. CONCLUSION

The bibliometric analysis offers a thorough summary of the ever-changing field of study on mobile assistive technologies for kids with dyslexia. A thriving and developing field are shown by the noted rise in articles within the examined journal and the discovery of prolific authors. The complex character of research in mobile assistive technology is shown by the interplay among journal popularity, the focus of output from particular researchers, and the investigation of multiple topic areas. Researchers, legislators, and educators can all benefit from the insights provided by these trends. The distribution of research across subject areas highlights the interdisciplinary character of mobile assistive technology research, while the concentration of output among particular authors suggests potential thought leaders influencing the field. In order to address any gaps, guide future research goals, and contribute to a thorough knowledge of the impact and consequences of mobile assistive technology research for dyslexic children, it is imperative that these insights be used as the field develops. To sum up, our analysis provides a solid basis for additional investigation and debate within the scholarly community, facilitating well-informed decision-making for those involved in the direction of assistive technology research.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
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C : Conceptualization

M : Methodology

So : Software

Va : Validation

Fo : Formal analysis

I : Investigation

R : Resources

D : Data Curation

O : Writing - Original Draft

E : Writing - Review & Editing

Vi : Visualization

Su : Supervision

P : Project administration

Fu : Funding acquisition

CONFLICT OF INTEREST STATEMENT

No conflict of interest.

INFORMED CONSENT

Informed consent not related.

ETHICAL APPROVAL

Ethical approval not related.

DATA AVAILABILITY

Data availability is not applicable to this paper as no new data were created or analyzed in this study.

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