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Technology-Based Education for Students with Disabilities: A Bibliometric Analysis

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ABSTRACT

This study aims to analyze the impact and significance of articles addressing technology-based education for students with disabilities by analyzing publications from 1964 to 2024 in Scopus. Using quantitative and qualitative methods, the study maps collaborations, key topics, and influential works via VOS viewer. Findings revealed the United States as the leading hub for international research collaboration. Quantitative analysis was conducted to highlight authorship, country contributions, and keyword trends, while qualitative reviews of 41 highly cited articles identified prevalent themes: the domination of review methodologies and key impacts, including ICT-assisted learning, assistive technologies, and virtual training, to enhance literacy, independence, and quality of life. It is important to mention here that top studies recommend technological, financial, and emotional support for effective implementation. The study provides a comprehensive overview of the field, guiding future research toward addressing gaps in technology-enabled education for disabled learners.

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Introduction

It has been observed that children with complex physical disabilities require constant care to attend school or communicate like other school children (Elmubark et al., 2017). Students with disabilities deal with various limitations in learning (Mantey, 2017). It is worth to mention here that school facilities to learners with disabilities are more limited and less accessible (Alu & King, 2024; Opoku-Nkoom & Ackah-Jnr, 2023). This is in addition to difficult access to infrastructure and classrooms due to the lack of facilities such as elevators (Abu-Sadat, 2023). Similarly, another issue is the lack of awareness regarding methods to support or accommodate students with disabilities. Tajeddini et al. (2022) also underscored this point about institutional awareness gap, specifically focusing on students facing disability. These disable students have often been victimized or marginalized in the school (Wood & Orpinas, 2020).

The environmental, structural, and attitudinal limitations, have vital impacts on the academic activities of students with disabilities, highlighting the importance of using technology-based education for this group of students. Fan et al., (2023) asserted that corporate tech adoption benefits have been found with educational needs for disable students. Hence, a major step forward in the development of different nations is to create suitable opportunities for providing education through advanced technologies and to improve the quality of life for children with disabilities (Petrunina et al., 2020). The study of Güngör et al., (2020) asserted that the improved quality of life, flexibility, and independence are some of the benefits of using technology in the community to accommodate certain needs of people with disabilities. Correspondingly, designing learning and teaching settings has also been linked with Information Technology (IT), as it provides opportunities for students with intellectual disability in special education schools in both developed and developing countries. W. Chen et al., (2019) suggested the cross-border tech adaptation models particularly for students with disability. It is worth stating that computer usage enriches teaching environments and customizes education, specifically for students with disabilities.

Additionally, the technological development has also been utilized to provide certain resources for promoting and reinforcing teaching and learning processes (Khlaisang & Songkram, 2019). However, it is evident that physical and motor problems, hearing, and visual impairments prevent students from attending in-person classes. The study found that virtual reality has also been useful to overcome these limitations. It enables individuals to be transported to totally different settings using images, audios, and videos while being in the same place, whether in classroom or at home (Fombona et al., 2017). Correspondingly, the study findings indicated that COVID-19 has further impacted individuals with disabilities, leading them to distance education due to their safety and health limitations as per health standards (Neece et al., 2020). Beyond these findings, bibliometric research enhances the cognitive skills of teachers and students by familiarizing them with different types of technology-based education, and provides the opportunity to compare educational outcomes for students with various disabilities.

Several studies on technology-based education for people with disabilities asserts the absence of a review study to comprehensively delineate the structure of papers by visualizing the scientific map of the related publications (Fan et al., 2023; Tajeddini et al., 2023); Chen et al., 2019). A review of the results of papers on the use of technology for better educating students with disabilities can provide useful solutions and measures of effectiveness for these methods. Since the 1980s, systematic review methodologies have sustainably increased in research evaluations and scientific policies (Petr et al., 2021). The rapid growth of scientific papers has complicated the examination of the existing studies and research trends in different domains. These studies specifically help scientists to conduct academic research. Review studies clarify the details of the domain under study (SÖNmez, 2020) and delineate the processes of knowledge development and structural relationships in a given field under discussion. The structure of these researches, mapping of scientific output, progress in this field, familiarization with key findings, and the recognition of highly cited studies have not been largely explored in developing countries.

This study aims to employ bibliometric analysis to measure technology-based education for students with disabilities. It has examined scientific collaborations, leading countries, high-impact journals, and sensitive research topics starting from 1964 to 2024. Therefore, this research seeks to provide a comprehensive overview of scholarly trends in the field of the study. Additionally, this study analyzed highly cited publications to identify effective methods, key findings, and strategies for

leveraging technology to enhance education for individuals with disabilities. The results of this research help future scholars identify research gaps and build upon successful models.

Hence, the attempt has been made to examine the articles published on the use of technology for school children with disabilities using bibliometric analysis. The following research questions have been addressed:

1. What types of Scopus subject categories (e.g., Education, Assistive Technology, Disability Studies) have the highest publication output in educational technology for students with disabilities?
2. How many countries and institutions exhibit the most frequent scientific collaborations in this field?
3. What are the most cited papers and influential journals in this domain?
4. What types of research methodologies (e.g., experimental studies, reviews, case studies) are most prevalent in highly cited publications?
5. What types of technologies (e.g., virtual reality, assistive tools, ICT) demonstrate the strongest impact on learning outcomes for students with disabilities?

Review of Literature

The scientific literature addressed children with disabilities, including those with autism spectrum disorder (Mubin & Poh, 2019), visual impairments, hearing impairments, intellectual disabilities, physical/mobility impairments, emotional and behavioral disorders, learning disabilities (Mubin & Poh, 2019), hyper activity disorder (Li et al., 2023) and other developmental delays. Theories on the use of technology in educating individuals with disabilities highlight improved educational conditions. For instance, the Universal Design for Learning is promoted as an inclusive educational approach to support all students and their potential needs (Capp, 2017). It provides a flexible curriculum and learning environment and recommends using technology to enhance the success of all students (Khetarpal, 2014), including those with disabilities.

In his social cognitive theory, Bandura (1989) explains that technological innovations meet numerous changes and expectations in social-economic life. He believes that learning is a complex process shaped by human interaction with its environment and society and that people can learn by observing models and the experiences of others. Researchers argue that empowerment consists of two stages: increasing an individual's choices, referring to agency, and the formal and informal contexts in which the individual operates, referring to structure (Alsop & Heinsohn, 2005). Similarly, several studies had been conducted in Chinese context to examine technological advancement for students with disability and found positive change in the society (Tajeddini et al., 2023; Chen et al., 2019; Fan et al., 2023).

Therefore, technologies can serve as empowering tools and assistive devices for individuals with learning disabilities. Information and Communication Technology (ICT) can be effective in supporting and addressing their challenges and helping them improve their position in society. According to Werfel et al. (2021), virtual environments aids in the education and assessment of children with hearing loss. Studies have proposed some solutions to help students with disabilities further benefit from education in virtual environments by different techniques. With their benefits over conventional materials, digital assets can be used to satisfy the needs of students with diverse requirements and develop auditory perception in individuals with disabilities (Avcı, 2009). According to teachers in special education schools, the effective use of digital technology is highly beneficial for educating students with intellectual disability (ID) (Arpacık, 2018). Vacca et al. (2023) stated that in the context of intellectual disabilities, game-based learning environments have resulted in improvements in cognitive development, adaptability and problem-solving skills in these students.

Ramdoss et al. (2011) argued that the use of computer applications is a successful approach for developing the daily living skills of students with IDs (Ramdoss et al., 2011). According to Morris et al. (2021), teaching math skills to students with disabilities through technology-based education and video modeling promotes communication and resolves the need for additional verbal skills training. Using technology, educated people with disabilities can better cope with their disability or show better performance (Bengtsson & Datta Gupta, 2017). Therefore, technology and digital inclusion in education help rehabilitate these individuals and promote their communication. Previous bibliometric studies have focused on the effects of technology-based education for students (Boateng et al., 2024; X. Chen et al., 2024; Conde-González & Rodríguez-Sedano, 2024; Moher et al., 2009; Phillips &

Ozogul, 2020). However, there are few studies on technology-based education for students with disabilities. Therefore, the present study specifically examines the types and effects of technology-based education for students with disabilities since enhancing their experiences and preventing dropout is of paramount importance. This study has been conducted using the Kitchenham et al. (2007) review method, which includes defining research questions, determining search keywords, identifying databases for data extraction, setting inclusion or exclusion criteria for studies, such as the link between the study and the research questions and high-quality articles, assessing the quality of the studies, and finally providing guidelines for extracting and writing key data. It is worth to mention here that the main concept of technology-based learning has been studied by several scholars, identifying it as an enabler to remove the main barriers to learning and to have equitable chances for students with multiple learning, cognitive, sensory, or physical challenges (Alsop & Heinsohn, 2005). Furthermore, the technological-based learning has emphasized on accessibility (using tools, such as screen readers, captioning, input devices, etc.), personalization (individual pacing, content adaptation as per learning styles, strengths, and needs), inclusivity (students with disabilities may participate alongside peers), empowerment (enhancing independence, engagement, and self-confidence through educational and assistive technologies), and bridging gaps (minimizing disparities in literacy, social interaction, skill development, miscommunications arising from disabilities).

Data and Methods

The papers published on technology-based education for people with disabilities were studied using the quantitative bibliometric method and quantitative analysis. Bibliometric studies aim to analyze the output of scientific documents and must be conducted with great sensitivity to have adequate validity (Franceschini & Maisano, 2011). Adding qualitative analysis to bibliometric research offers further insight into the intended scientific findings. Excel was used to export all the data for the following analysis. For this sample selection, the inclusion criteria consisted of being a high-quality paper with top authors and having the most relevant research topics and research categories. Therefore, in addition to the bibliometric study, the top-cited articles were qualitatively analyzed in the present study.

Keyword Selection: The research keywords were selected based on a review of literature, the researchers' knowledge on the subject, creating word clouds in different databases, and asking the opinions of experts in the field. Table 1 presents the keywords in three distinct parts.

Table 1. The Keywords Used for Searching the Articles

Search term	SCOPUS
TITLE: ("Virtual-training" OR "virtual-reality" OR "virtual-environment" OR "VR" OR "artificial-environment" OR "virtual" OR "virtual-worlds" OR "ICT" OR "Technology" OR "virtual-learning" OR "E-learning" OR "higher-education" OR "Teaching" OR "Online-learning" OR "Machine-learning" OR "electronic-learning" OR "artificial-intelligence" OR "digital-technology" OR "E-activities" OR "digital-teaching" OR "virtual-teaching" OR "virtual-reality-systems" OR "virtual-laboratory" OR "virtual-campus" OR "virtual-simulation" OR "smart-education" OR "virtual-service-learning" OR "virtual-mobility" OR "machine-intelligence" OR "computer") AND ("disability" OR "deaf" OR "dump" OR "disable" OR "defective" OR "Physical-defects" OR "Unable" OR "incapable" OR "disabled" OR "paralysis" OR "mental-disorder" OR "visually-impaired" OR "visually-disabled" OR "hard-of-hearing" OR "blind" OR "handicapped") AND ("student" OR "pupil" OR "school" OR "primary-school" OR "children")	2610

Data Selection Process: We selected Scopus since it is one of the largest databases of abstracts and citations with an extensive global and regional coverage of scientific journals, conference proceedings, and books, which are indexed with precise content selection and re-evaluation and provide the highest quality. Scopus differs from other databases mainly because all its content can be accessed without the chance of any modulations using the same subscription. It also allows for advanced search and filtering and is therefore an appropriate tool for integrating evidence in the form of systematic reviews.

***Inclusion and Exclusion Criteria*:** This study exclusively analyzed peer-reviewed journal articles indexed in Scopus. Conference proceedings, books, and dissertations were excluded due to variations in quality standards and peer-review rigor. The selection criteria were based on the followings;

- Published research documents starting from 1964 to 2024
- Articles with ≥5 citations (as high-impact publications)
- Works aligned with the study's core keywords and main idea on the subject
- Open Access or full-text available research documents/articles within the databases

For this study, the data files had been extracted from the Scopus on 8 February 2024. A total of 2,610 research documents were retrieved from this database based on title and subject search. Table 2 provides the lists of published papers, conference papers, books, and other references retrieved. Due to the abundance of scientific papers (n=1868) and the significant number of conference papers (n=366), it is concluded that research on technology-based education for students with disabilities is still in its infancy and has further layers to be explored. Following the initial search, titles and abstracts were independently screened by two researchers. Any discrepancies were resolved through discussion, with a third author to consult to reach consensus when needed.

Results and Discussion

This section provides the results and discussions based on the bibliometric analysis. The study findings revealed that the published documents were classified by their years of publication, countries of origin, journals, authors, organizational affiliations, and the cross-country maps of collaboration, which were systematically evaluated. A network analysis was also carried out on the frequency of the keywords extracted from the papers. Excel sheets were used for the descriptive analysis. Reference manager data, including the original pdf documents, were used for the qualitative analysis. The data were analyzed in two scientific visualization software, namely ©VOS viewer and ©Bibliometric.

Table 2. Distribution of the Published Documents by Their Type

Document type	Frequency
Article	1,868
Conference Paper	366
Review	135
Book Chapter	167
Note	22
Letter	15
Book	10
Erratum	09
Short Survey	09
Editorial	05
Total	2610

Subject-Based Research Domain Analysis: As illustrated in Figure 1, most of the studies on technology-based education for students with disabilities were in the field of social sciences (33.2%), followed by psychology (13.4%), and medicine (12.7%). The other domains are shown in Figure 1. The larger number of studies in social sciences indicates that topics related to virtual education are a matter of public concern and students with disabilities are important members of the society; as such, this topic is significant for social science scholars.

Distribution of Documents Based on Year and Trend of Growth

Based on Table 3 and Figure 2, the trend of research on technology-based education for students with disabilities is on the rise. The greatest growth pertained to the years 2023-2024, as 14 scientific articles have been published in 2024 and 205 articles were published in 2023, demonstrating the significance of this topic in this year. It is important to mention here that up to 1960, the trend of research has been insignificant, and documents were published several years apart. Since 1999, however, with the advances in different technologies, researchers have paid more attention to this topic, as mirrored in the rising trend of publications. Table 3 presents this trend by frequency, and Figure 2 visually displays the trend. It is worth to mention that the trends of published documents on the subject have been increasing yearly based on more than a single factor. These trends have been linked with multiple factors such as increase in technological gadgets, rapid revolutions in technology, advancement in latest trends of life, enhanced awareness to opt technology, and all other socio-economic and cultural factors. However, it has also been observed that technologies serve as empowering tools and assistive devices for individuals with learning disabilities. Information and Communication Technology (ICT)

has been found highly effective in supporting and addressing their challenges and helping them improve their position in society, as asserted by Werfel et al. (2021).

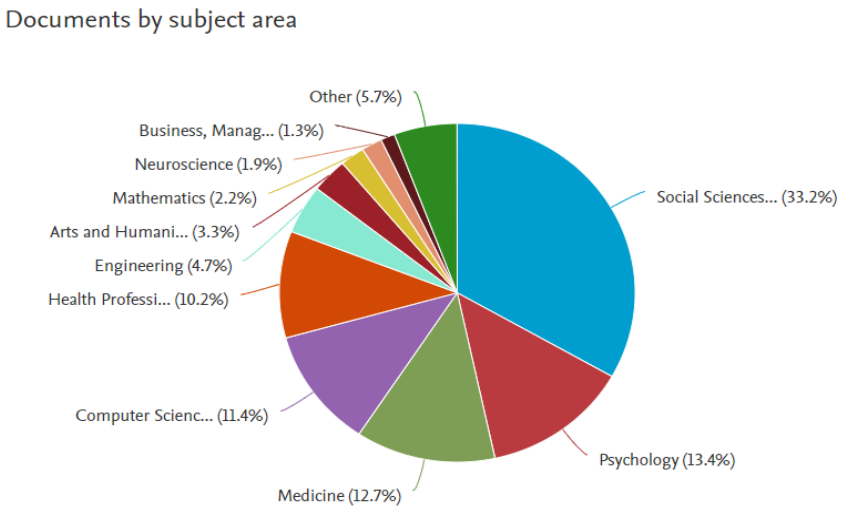

Fig. 1. Documents by Subject Area

Table 3. Distribution of the Published Documents by the Year of Publication

Year	*f*	Year	*f*	Year	*f*	Year	*f*
2024	14	2006	32	1988	11	1970	3
2023	205	2005	31	1987	20	1969	2
2022	175	2004	38	1986	24	1968	4
2021	184	2003	24	1985	15	1967	9
2020	153	2002	33	1984	16	1966	3
2019	155	2001	29	1983	15	1965	2
2018	128	2000	28	1982	13	1964	2
2017	89	1999	34	1981	17		
2016	98	1998	29	1980	15		
2015	108	1997	22	1979	7		
2014	78	1996	42	1978	6		
2013	96	1995	17	1977	4		
2012	67	1994	36	1976	10		
2011	76	1993	18	1975	5		
2010	76	1992	22	1974	9		
2009	44	1991	15	1973	12		
2008	54	1990	11	1972	9		
2007	50	1989	13	1971	7		

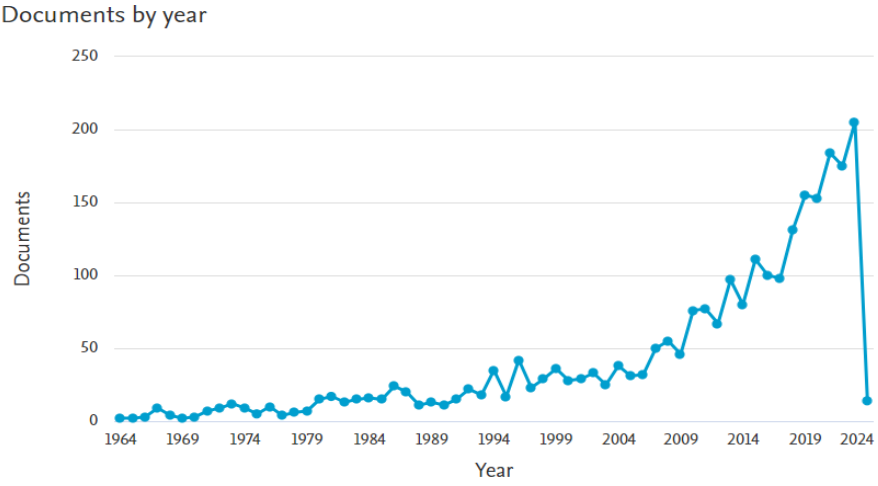

Fig. 2. Documents by Frequency per Year

Figure 3 depicts the three-field plot of technology-based education for students with disabilities, demonstrating the relationships between the top authors, top index keywords, and top sources/journals. Keywords Plus represents words or phrases that frequently appear in the titles of references cited in an article. The Keywords Plus "learning disabilities" and "multiple disabilities" are used by many top expert authors in technology-based education for students with disabilities (left column), as shown in the Figure 3.

Based on Figure 3, "higher education" (120 papers) has been an attractive keyword for journals but has been less frequently used by the top authors. Journals also found the keywords "disability" and "assistive technology" attractive. The keyword "learning disabilities" was more attractive both for the authors and the journals compared to other keywords. Among the journals on the right column, the Journal of Special Education Technology has published the most articles containing the keywords related to technology-based education for students with disabilities. Lecture Notes in Computer Science (including subseries lecture notes in artificial intelligence and lecture notes in bioinformatics) had publications with more diverse keywords. E. C. Bouck has been a prolific author in this field who has conducted more research on "virtual education" and "people with disabilities." J. Sigafoos has also been prolific in this domain.

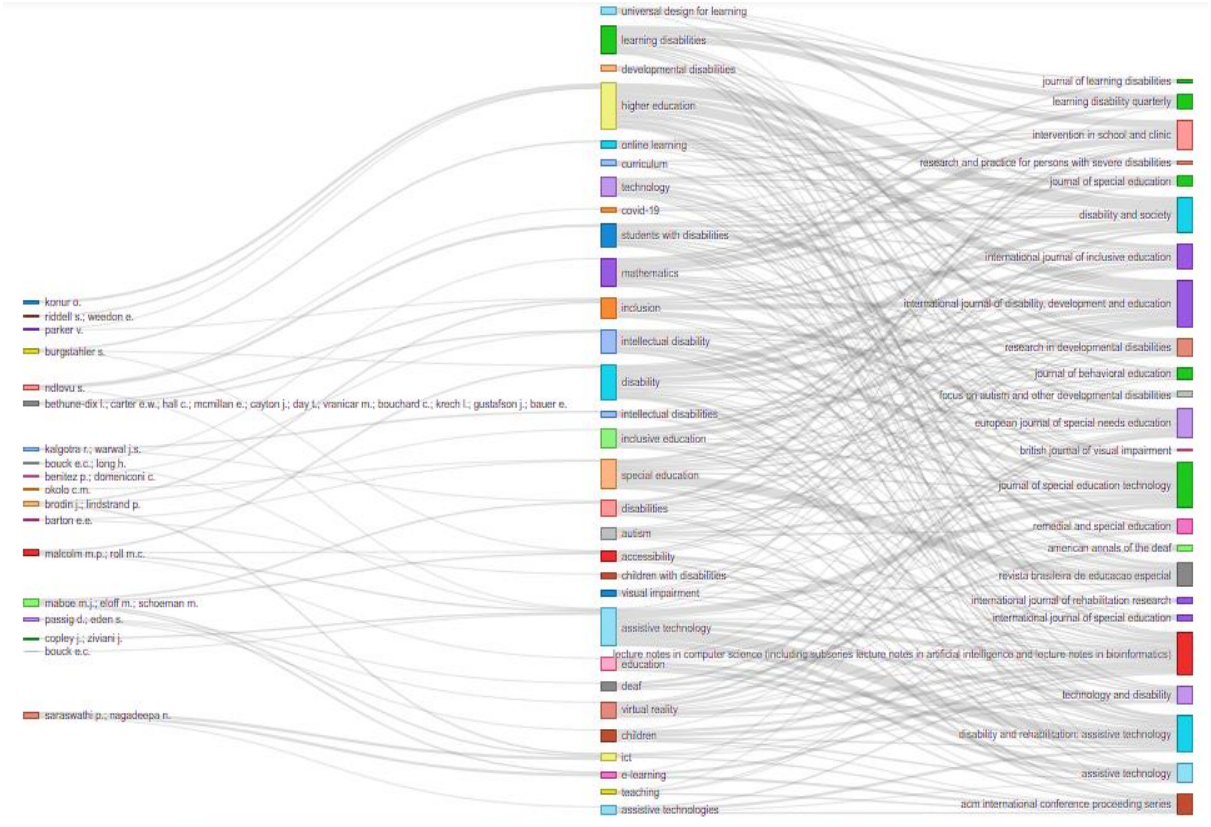

Fig. 3. The Three-Field Plot of the Top Authors, Top Index Keywords, and Top Sources

Figure 4 elucidates the keywords frequently used by the top authors, including "disabilities," "education," "technology," "teaching," "child," "computer," and "learning." The larger-size keywords suggest that there is a relationship between *technology-based education for students with disabilities* and *modern*, which is a noteworthy point.

Figure 5 also displays that the keywords related to virtual education are larger-sized; however, other keywords have emerged in this field in recent years that indicate the emergence of new topics in this area. The newly-emerged words are depicted in yellow, but they are not limited to "special education need," "manipulatives," "educational technology," and "discover," "human," and "student."

Based on Figure 6, the United States was the most prolific country in terms of the frequency of publications on technology-based education for students with disabilities, followed by England. Meanwhile, Australia and Brazil have also had a significant number of publications on this topic.

Figure 7 displays the scientific collaboration between the countries during different years by way of connected lines. The distribution analysis can be important to understand the spatial distribution of research articles. The highest number of collaborations were made with the US in different years, showing the significant amount of mutual scientific collaboration between the US and other countries. Mutual scientific collaboration between the US and England has been the most notable. In recent decades, however, Malaysia, North Africa, Brazil, and Portugal (shown by yellow lines) have also entered into mutual scientific collaborations.

Fig. 4. The Keywords

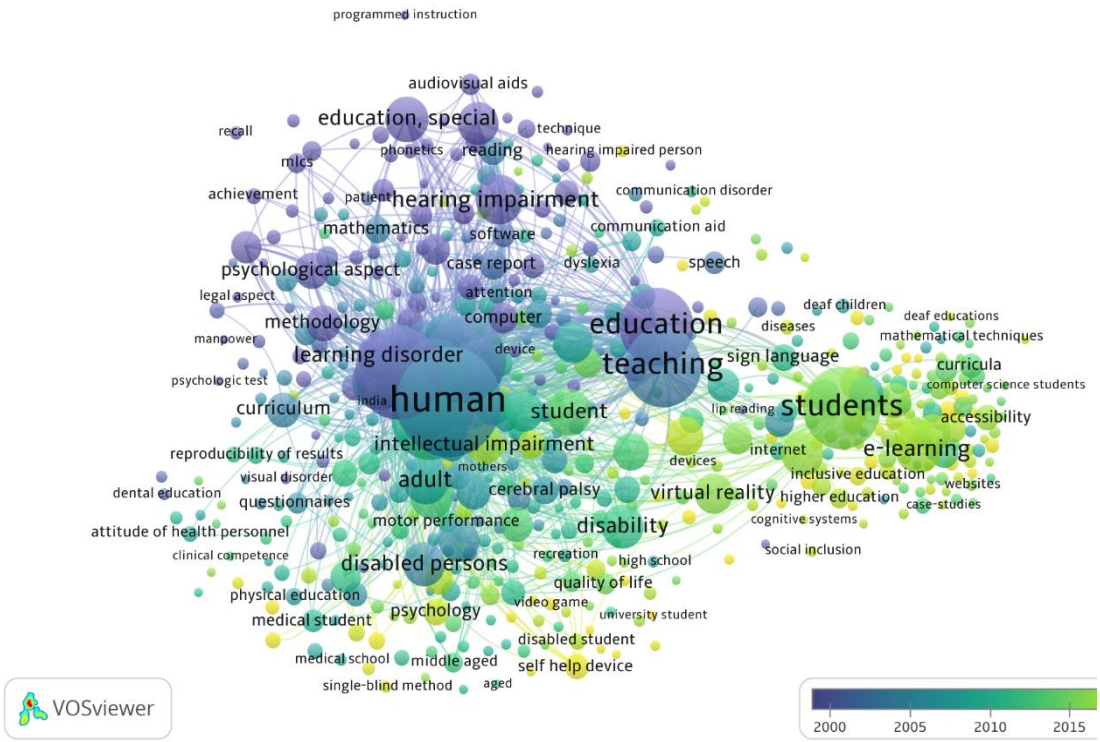

Fig. 5. The Concurrence of the Top Indexed Keywords

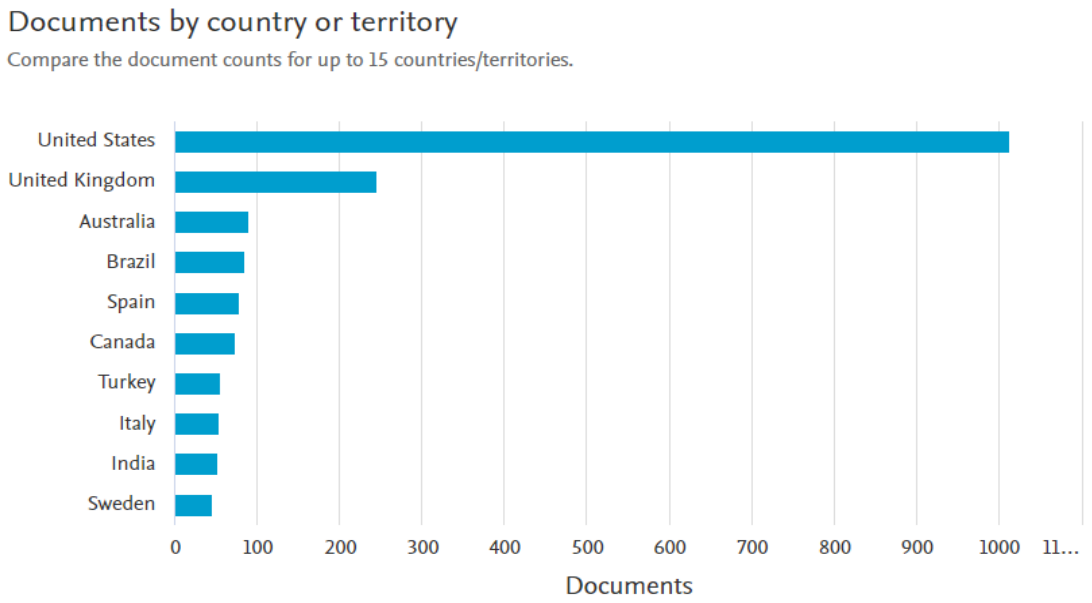

Fig. 6. Publications by Country

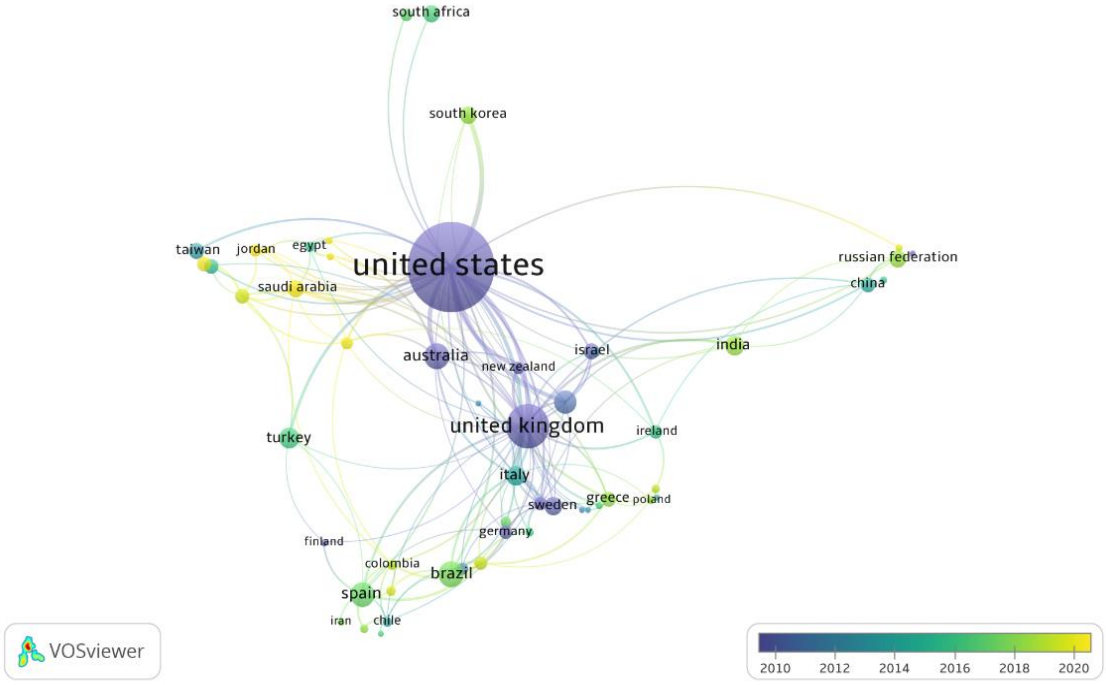

Fig. 7. The Map of Scientific Collaborations between the Countries

Figure 8 demonstrates which journals have published the most publications. One of the journals with a significant number of publications in this field in recent year is the Journal of Special Education, indicating a growing trend in the graph.

Statistically, the American Annals of the Deaf boasts the highest number of citations, but its publication rate in this field has declined in recent years. The Intervention in School and Clinic (shown in red) has been intermittently prolific on this subject in recent years. Moreover, the Journal of Special Education Technology shows a rising trend of publications over the last three years.

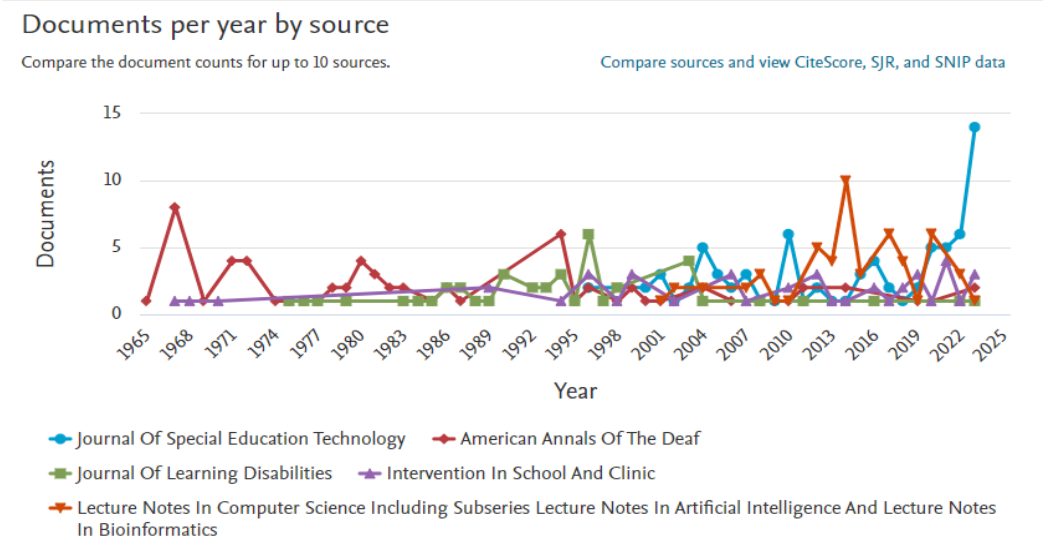

Fig. 8. The Trend of Publications by Journal

Qualitative Analysis of the Papers: After reviewing the Scopus-indexed papers, the extracted papers were saved in an Excel file and then ranked in the descending order of citations. The second criterion for selecting them was their similarity and relationship with the subject of the present paper (technology-based education for people with disabilities). At this stage, 125 top articles were examined based on their subject. Finally, the 41 top articles were selected for the qualitative analysis. The year of publication of these top-cited papers ranged from 1996 to 2024. The data of each paper was extracted and analyzed in terms of the authors' names, year of publication, citation rate, subject, research methodology, effects, solutions, and recommendations, as credible sources of information, and the data generated from the text of the papers can direct future research in this field.

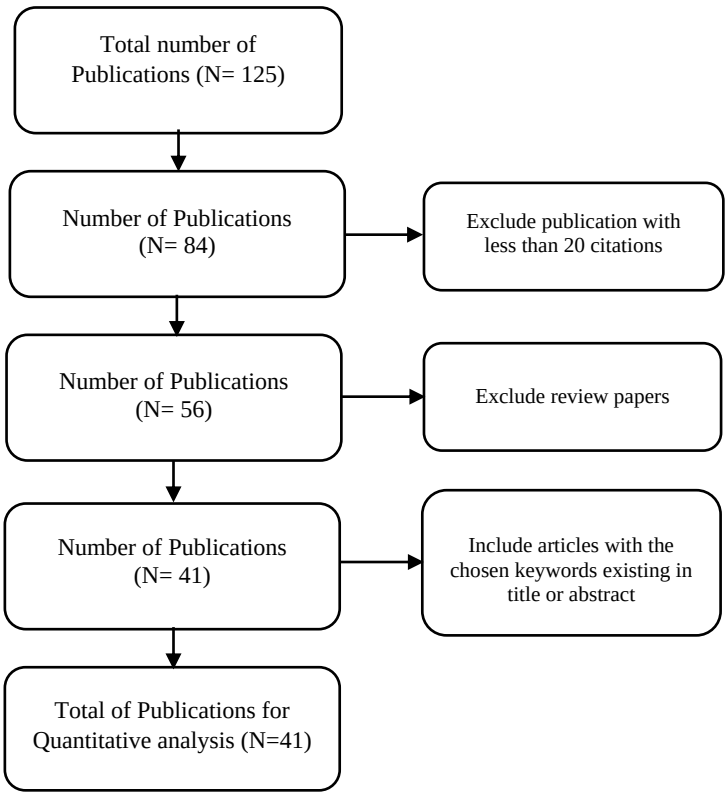

Fig. 9. Study Inclusion Diagram for Qualitative Analysis

Table 4. Qualitative Findings Extracted from the Top-Cited Papers

		1	2	3	4	5	6	7	8	9	10	11	12	13
	Author year	**Fernández Batanero et al. (2022)**	**Kim & Fienup (2021)**	**Iacono et al. (2021)**	**Bailey et al. (2022)**	**Jdaitawi and & Kan'an (2022)**	**Benton & Johnson (2015)**	**Ayres et al. (2013)**	**Saine et al. (2011)**	**Seale et al. (2015)**	**Satsangi & Bouck (2015)**	**Standen et al. (2001)**	**Ok et al. (2016)**	**L. C. Mechling (2007)**
Subject	Computer/Video-based								*					
	Mobile technology/App							*					*	
	Assistive technology	*	*			*				*				*
	Technology design			*			*							
	Virtual environment/Virtual manipulatives				*						*	*		
	Online learning		*			*								
Research Methodology	Longitudinal study								*					
	Review study	*		*		*	*	*		*		*		*
	Effectiveness evaluation				*						*			
	Questionnaire									*				
	Interview									*				
	Case study													
	Observation													
	Descriptive study												*	
	Pre- and post-measure design		*											
Effects / Conclusions	Enhanced knowledge of letters								*					
	Improved spelling								*					
	Improved life skills							*						
	Improved reading skills											*		*
	Students' independence													
	Assistance in writing													
	Simulation													
	Students' self-determination		*		*									
	Verbal response skills													
	Achievement of the educational goals	*		*										
	Enjoyment of learning	*	*	*	*									
Solutions / Recommendations	Enhancing knowledge of letters	*												
	Promoting the social inclusion of the students					*								
	Accurate problem-solving					*								
	Individualized education programs													
	Word processing						*							
	Disability rights											*		
	Involving children in designs				*					*		*		
	Software guidelines											*		
	Staff / service / financial support										*			
	Software accessibility				*									
	Using virtual manipulatives													
	Computer-based attribution retraining													
	Computer program teaching sight word recognition													
	Considering learner's characteristics													
	Rocket Reader application													
	Assessment of student's needs		*	*	*									
	Explicit and strategic instructions	*	*										*	
	Virtual manipulatives as instructional mathematical tools													

		14	15	16	17	18	19	20	21	22	23	24	25	26	27
	Author year	**Berninger et al. (2015)**	**Alper & Goggin (2017); MacArthur (1996)**	**L. Mechling & O'Brien (2010)**	**Bouck et al. (2017)**	**Drager et al. (2019)**	**Roberts et al. (2011)**	**Satsangi & Miller (2017)**	**Park et al. (2021)**	**Kellems et al. (2019)**	**Norman et al. (2001)**	**Seo & Bryant (2009)**	**(Ebrahim et al. (2020); Ok et al. (2020)**	**Hashey & Stahl (2019)**	**(Ebrahim et al. (2020); Konur (2007)**
Subject	Computer/Video-based	*		*	*		*					*			*
	Mobile technology/App							*						*	
	Assistive technology									*	*	*	*	*	
	Technology design		*			*	*						*		
	Virtual environment/Virtual manipulatives				*				*	*					
	Online learning														
Research Methodology	Longitudinal study														
	Review study		*					*		*					*
	Effectiveness evaluation	*		*	*	*			*	*	*			*	
	Questionnaire						*								
	Interview						*					*	*		
	Case study				*										
	Observation														
	Descriptive study														
	Pre- and post-measure design														
Effects / Conclusions	Enhanced knowledge of letters														
	Improved spelling														
	Improved life skills														
	Improved reading skills														
	Students' independence	*													
	Assistance in writing			*										*	
	Simulation				*										
	Students' self-determination		*							*					
	Verbal response skills										*				
	Achievement of the educational goals														
	Enjoyment of learning														
Solutions / Recommendations	Enhancing knowledge of letters				*			*	*			*	*		
	Promoting the social inclusion of the students												*	*	
	Accurate problem-solving														
	Individualized education programs		*												*
	Word processing														
	Disability rights														
	Involving children in designs														
	Software guidelines														
	Staff / service / financial support					*		*	*				*	*	
	Software accessibility						*								
	Using virtual manipulatives								*	*				*	
	Computer-based attribution retraining												*		
	Computer program teaching sight word recognition														
	Considering learner's characteristics														
	Rocket Reader application														
	Assessment of student's needs					*	*	*							
	Explicit and strategic instructions									*	*				
	Virtual manipulatives as instructional mathematical tools							*	*						

		28	29	30	31	32	33	34	35	36	37	38	39	40	41
	Author year	**Seo & Woo (2010)**	**Bouck (2016)**	**Garzotto et al. (2017)**	**Satsangi et al. (2018)**	**Kiru et al. (2018)**	**Taber-Doughty et al. (2011)**	**Standen et al. (2001)**	**Shin et al. (2017)**	**Fälth et al. (2013)**	**Wehmeyer et al. (2004)**	**MacArthur (1996)**	**Lee (2011)**	**L. Mechling et al. (2005)**	**Burgstahler (2015)**
Subject	Computer/Video-based	*					*							*	
	Mobile technology/App														
	Assistive technology		*							*	*	*	*		
	Technology design					*									
	Virtual environment/Virtual manipulatives			*	*			*	*						
	Online learning														*
Research Methodology	Longitudinal study		*							*					
	Review study					*	*	*	*		*	*	*		
	Effectiveness evaluation	*			*	*								*	
	Questionnaire														
	Interview														
	Case study			*	*										
	Observation														
	Descriptive study														
	Pre- and post-measure design												*		
Effects / Conclusions	Enhanced knowledge of letters														
	Improved spelling														
	Improved life skills														
	Improved reading skills							*		*					
	Students' independence						*					*			
	Assistance in writing														
	Simulation		*											*	
	Students' self-determination			*									*		
	Verbal response skills									*					
	Achievement of educational goals														
	Enjoyment of learning					*									
Solutions / Recommendations	Enhancing knowledge of letters	*													
	Promoting the social inclusion of the students														*
	Accurate problem-solving				*										
	Individualized education programs														
	Word processing														
	Disability rights							*							
	Involving children in designs							*							
	Software guidelines							*							
	Staff / service / financial support														
	Software accessibility														
	Using virtual manipulatives			*	*				*						
	Computer-based attribution retraining										*				
	Computer program teaching sight word recognition			*			*								
	Considering learner's characteristics														
	Rocket Reader application												*		
	Assessment of student's needs														
	Explicit and strategic instructions		*												
	Virtual manipulatives as instructional mathematical tools	*			*	*			*						

Research Subjects: The subject of the papers selected for the qualitative analysis was classified into six groups. The highest frequency pertained to "computer/video-based education" and "assistive technology" subjects. The study findings indicated that ten papers belonged to "computer/video-based education" for people with disabilities, including computer-assisted education, remedial reading intervention, teaching and assessment, reading, writing and spelling, computer-mediated instruction, and computer-based video teaching. The next category is "assistive technology" and 15 papers addressed this category and adopted technology to improve the learning skills of students with disabilities. Nine papers used the "virtual environment" to teach people with disabilities. Four papers

focused on mobile technology and apps. Twelve papers focused on technology design, and the study by Benton and Johnson (2015) was the top-cited paper in this domain that reviewed papers focused on techniques to involve students with disabilities in the process of technology design. Two papers had examined "online learning."

Research Methods: According to the review of literature, the majority of the papers (n=19) were review studies. Thirteen papers had used the effectiveness evaluation method. Three of the papers were longitudinal studies that had become top-cited.

The Effects Investigated in the Papers: Based on the review of literature, education in the virtual environment has affected students with disabilities, and their learning process of reading and writing has improved with the use of computers. Shin et al. (2017) attributed the students' improved vocabulary and pronunciation to the use of computers. The two papers by MacArthur (1996) and Berninger et al. (2015) also attributed writing support to assistive technology. Other major findings were reported by papers that evaluated the effectiveness of technology-based education for people with disabilities. According to these papers, the potentials for this mode of education include the improvement of life skills, the development of independence in the students, and the achievement of educational goals. For instance, L. Mechling and O'Brien (2010) evaluated the effectiveness of computer-based video instructions to teach three students with moderate intellectual disability to get a bus to stop and then get off it. The researchers trained these students using simulation and they managed to acquire this skill over the given time. The other effects of technology use in education included increased attention when solving a problem and the enhanced joy of learning.

Recommendations in the Papers: The reviewed literature had made certain recommendations to enhance the quality and effectiveness of education in students with disabilities. These recommendations included: (1) Training and offering instructions on the use of technology, (2) Financial support and accessibility, (3) Considering the learners' characteristics and needs; (4) Strategies for the application of technology in teaching students with disabilities. Students should be properly trained to use technology, and their needs and demands from the educational environment must be identified. The accessibility of software and support services is among the recommendations for facilitating students' use of technology. Six recommendations dealt with virtual manipulatives and teaching to improve mathematical skills in students with disabilities, which indicates the significance of math skills in these students.

Conclusion

The study concludes that technology-based education, the use of the virtual environment, and assistive computers for students with disabilities comprise a very important topic in the field of education and disability studies. This subject promotes educational justice and provides a relatively equitable condition for minorities. The study found that using technology to further link students with disabilities to a normal daily life increases their independence and the quality of life. The study of Fan et al. (2023) asserts that digital transformation creates systemic improvements across sectors in education; this manifests as sustainable learning ecosystems that benefit marginalized groups. The pre-requisites of the social participation of people with disabilities include their enhanced literacy, education, skills, and capabilities, enabling this group to contribute to the development of the society as its members. Assistive technology has been found to increase engagement among students with disabilities (Svensson et al., 2021). The organizational insights from Tajeddini et al. (2022) regarding diversity management's impact on innovative behaviors directly translate to educational settings, where inclusive policies similarly drive technological adoption and pedagogical innovation.

Collins' interaction ritual chain theory and Bourdieu's cultural capital theory offer interesting points of analysis for using technology. Students with disabilities can use technology in classrooms to create more integration (Manganello, 2020). From this perspective, technology-based education might add to the cultural capital and enable more students with disabilities to participate in new peer rituals. These students can thus be further included in classroom activities rather than participating on the sidelines (Mikropoulos & Iatraki, 2022). W. Chen et al.'s (2019) research on educational migration patterns offers important parallels for considering how assistive technologies might cross cultural and national boundaries to create global solutions for disability education. The study findings also outline that virtual and e-learning revolutionize the life of people with disabilities with their flexibility and

potential for integration with other educational subjects and even help this group earn money virtually. The study findings reveal that the major achievements of technology use in education include overcoming linguistic, perceptive, physical, sensory, and motor barriers.

From the reviewed literature, it can be concluded that a chain of human and structural factors (barriers and facilitators) has been discussed in the studies. Most articles focused on knowledge transfer methods. Video-based learning was emphasized for improving vocabulary pronunciation and writing skills, while simulations were evaluated and approved for developing motor skills. These research findings highlighted greater independence for students with disabilities, improved quality of life and relationships, and the creation of equal educational opportunities. Based on the classification proposed in this study, the findings of other studies may be better used to develop more practical programs for educating students with disabilities. Although these studies showed an increasing trend, the challenges of technological transformation for students with disabilities still require further investigation. There is also a need for more research on patented methods and informal innovations aimed at enhancing the capabilities of individuals with disabilities.

Implications

This study helps teachers by understanding the main effects of technology-based education. It helps identify researches, authors and the results of surveys on this type of education in students with disabilities. We advocate for adapted teacher training as a key aspect of any attempt to achieve inclusion within learning systems. It is necessary to change the curricula and teaching methods of students with disabilities (Bakhshi et al., 2017) and tailor the social environment to adaptation and successful learning. This study indicates that technology-based education has many positive outcomes for students with disabilities. The first outcome is the creation of educational equity. Familiarity with these technologies also enhances their practical use in the classroom. Second, technology-based education leads to increased capabilities for students with disabilities and their greater interactions and participation in the classroom. It also improves the quality of life for students with disabilities as assistive tools reduce their limitations. Finally, with increased knowledge and practical skills, students with disabilities can also generate an income for themselves.

The study had provided tables and charts to present keyword co-occurrence analyses, revealing dominant research trends in the field. The comparative analysis of publication statistics by country illuminated international collaboration patterns, while categorization of prevalent research methodologies highlighted existing methodological gaps.

These visual representations enable readers to grasp the followings:

- Rapidly identify complex research patterns
- Establish a robust foundation for future studies
- Discern emerging thematic clusters at a glance

Limitations and Directions for Future research

This study has some limitations. First, it relied on the Scopus database. Finding keywords for cover research topics was the second limitation. Using different keywords can change the nature and results of papers. This study has reviewed papers published up to 8 February 2024, and later publications have not been examined, which comprises the third limitation. There may have been valuable non-journal findings that were not included in this study. We could have also used interdisciplinary studies to find other constructive keywords in psychology, environmental sciences, or architecture. Furthermore, the policies of various countries to integrate technology into the education of students with disabilities also require further scrutiny. Despite these limitations, this study analyzes 2,610 documents to provide a comprehensive picture of research on educational technology for students with disabilities. The carefully designed tables (such as international collaboration tables) significantly contribute to understanding research patterns. The findings indicate that:

- The growth of research in developing countries represents an emerging trend.
- The most significant contribution of this study is identifying research gaps in adapting AI technologies to meet the needs of these students, which can guide future research.

Regarding future research, it is necessary to consider the specific needs resulting from technology-based education. The most effective practices must be identified considering different cultural and economic contexts. Furthermore, international collaboration for new researches must be promoted, and the barriers and the lack of efforts and resistance to implement different technology-based education for children with disabilities must be examined. Studies can also be conducted on the challenges of using technology-based education for students with disabilities. Another suggestion is to compare the experiences of different countries in the use of technology. Longitudinal studies should be conducted to understand the outcomes of technology-based education among students with disabilities. Finally, future studies are recommended to investigate how the social interactions of students with disabilities with their peers change and evolve.

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