

Vibration Alert System as the Technological Assistance in Managing Deaf Students in Inclusive Education: Global Trends and Future Directions

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ABSTRACT:

Research on inclusive education has expanded rapidly over the past two decades, yet limited attention has been paid to the role of vibration alert systems in supporting deaf students. This gap restricts a comprehensive understanding of how diverse technologies contribute to accessibility and participation in inclusive classrooms. The purpose of this study is to present the global trend and future directions regarding the scholarly landscape of vibration alert systems for managing deaf students in inclusive education. A bibliometric approach was applied, incorporating performance analysis, citation analysis, co-authorship analysis, and co-word analysis. 511 eligible documents searched using the combinational keywords "Inclusive Education and Technology" in the Scopus database were selected to be included documents published in the period of 2006 - 2025. The findings show significant growth in publications and citations, with the United States and Europe leading in productivity and influence. Co-authorship analysis reveals both concentrated hubs and emerging global collaborations, while co-word analysis highlights five themes, such as vibrating alarm clocks and timers, vibrating fire and safety alarms, vibrating notification devices, wearable vibration devices, and desk-based vibration systems. These results imply that inclusive education research must balance institutional innovations with practical, personalized tools for learners. The study concludes that vibration alert systems offer both theoretical and practical contributions, but future research should address overlooked areas such as safety and global representation.

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INTRODUCTION

Inclusive education is recognized globally as a fundamental approach for achieving equitable learning opportunities for all students, including those who are deaf or hard of hearing. It ensures that deaf students are not merely placed in mainstream classrooms but are also given the tools to participate fully and meaningfully. Recent study emphasize that inclusion enhances academic performance, promotes social development, and improves emotional well-being for deaf learners (Kefallinou et al., 2020). Inclusive classrooms foster interaction between hearing and deaf peers, encouraging empathy, cooperation, and mutual respect (Florian, 2014). Exposure to real-world communication challenges within inclusive settings prepares deaf students for greater independence in adulthood. Schools that model inclusion also help communities embrace diversity and equity beyond the classroom. Participation in inclusive education boosts deaf students' self-confidence as they are treated as equal contributors. Academic progress in inclusive classrooms is linked to the availability of supportive resources and teaching strategies (Haug, 2016). Policies from UNESCO and the UN Convention on the Rights of Persons with Disabilities underline inclusive education as a non-negotiable right. The integration of deaf students in inclusive schools helps dismantle stereotypes about disability. **Inclusion allows deaf students** to develop the skills needed for employment and social participation (Thomas, 2013). For hearing students, learning alongside deaf peers builds communication flexibility and cultural awareness. The importance of inclusive education lies in its capacity to remove systemic barriers. When implemented effectively, it transforms learning environments into places of belonging for all. Therefore, inclusive education for deaf students is essential to equity, empowerment, and lifelong success.

Despite global advocacy for inclusion, deaf students encounter persistent challenges in mainstream classrooms. Communication remains the most significant barrier, as classroom instruction often relies heavily on spoken language. Even with interpreters or captioning, delays and inaccuracies can hinder real-time comprehension (Bell & Foiret,

2020). Teachers often lack training to adapt teaching strategies for deaf learners, leading to uneven learning experiences (Herring & Woolsey, 2020). The rapid pace of class discussions makes it difficult for deaf students to participate equally. Limited peer awareness about deafness can result in exclusion from social interactions. Feelings of isolation are reported frequently among deaf students in inclusive schools, affecting motivation and emotional well-being. Technological supports such as captioning or hearing aids are inconsistently provided across institutions. Accessibility gaps in digital platforms further disadvantage deaf learners (Ariani et al., 2024). A rapid review found that evidence supporting assistive technologies in higher education for deaf students is limited and fragmented (Bell & Foiret, 2020). Mainstream classrooms are also not acoustically or visually designed for deaf communication needs. Students may experience fatigue from constant lip-reading or reliance on visual cues. The absence of comprehensive support structures restricts academic achievement. These challenges demonstrate that inclusion in policy does not always translate into practice. As such, barriers persist that limit the full educational potential of deaf students.

Several interconnected factors explain why deaf students continue to face barriers in inclusive education. A primary factor is insufficient teacher preparation, as many educators report limited knowledge of strategies for supporting deaf learners (Campen et al., 2022). Professional development opportunities on inclusive pedagogy remain unevenly distributed. Limited school budgets restrict access to specialized resources and assistive devices needed for accessibility (Rodrigues et al., 2022). Even when devices are available, teachers may lack training to use them effectively in classrooms (Fernández-Batanero et al., 2022). Physical classroom environments also contribute to exclusion, with poor lighting, seating arrangements, and visual obstructions complicating sign language or lip-reading. Social attitudes remain another barrier, with stereotypes and low expectations persisting in some contexts (Jiang et al., 2015). Peer awareness programs about deafness are often absent or insufficient. Inconsistent policy enforcement across

regions leads to variable support levels. Accessibility guidelines are not always monitored or implemented with fidelity. Research has also shown that integration without proper support risks reinforcing inequality (Szymanski et al., 2012). The digital divide contributes to inequities, as not all students or schools have equal access to learning technologies. Furthermore, fast-paced curricular demands can leave little room for differentiated instruction. Families may also face difficulties in collaborating with schools due to lack of resources or awareness (Antia et al., 2011). Together, these factors create systemic obstacles that hinder effective inclusive education for deaf students.

Among recent technological innovations, vibration alert systems have emerged as promising tools for inclusive education. These systems rely on tactile signals to deliver information, making them accessible to deaf students without depending on auditory input. They can be used for classroom transitions, attention cues, or emergency alerts, ensuring equal access to important information. For example, wearable devices connected to Wi-Fi can deliver vibrations to notify students of schedule changes or warnings (Yağanoğlu & Köse, 2017). Such systems help deaf students remain engaged without constant reliance on interpreters or visual monitoring. In collaborative tasks, vibrations can signal turn-taking or task completion. Research shows that tactile feedback is processed effectively by deaf individuals, who may develop enhanced sensitivity through neural adaptation (Dim et al., 2022). The discreet nature of vibrations allows for integration without stigmatizing students. During emergencies, vibration alerts can quickly communicate danger, which is crucial for safety in inclusive settings. These systems expand accessibility beyond auditory or visual channels by introducing a tactile pathway (Otoom et al., 2022). Compared to amplification devices, vibration alerts provide a unique alternative that does not depend on residual hearing. By supporting independence, they empower deaf students to manage classroom demands. Study also indicate that vibrotactile systems can effectively transmit complex cues, such as musical rhythm or emotional tones (Mohammed & Cavus, 2024). The use of vibration systems therefore strengthens participation, safety, and

equality in inclusive education.

In the past decade, scholarship on learning technologies for deaf students has expanded rapidly. Advances in digital tools, captioning, and assistive software have broadened educational access. Research documents how digital platforms improve literacy and comprehension for deaf learners (Bell & Foiret, 2020). A systematic review highlighted increasing global interest in assistive technologies for inclusion (Fernández-Batanero et al., 2022). Studies on captioning systems show their effectiveness in supporting comprehension during lectures and multimedia learning. Mobile applications have also been developed to support sign language learning and communication. Emerging tools like augmented reality captioning are being tested in classroom environments (Mirzaei et al., 2021). Within this expanding landscape, vibration alert systems stand out as tactile solutions that complement auditory and visual tools. Their relevance lies in addressing classroom management and safety alongside communication. Vibrotactile systems originally explored for music education have been adapted to broader learning contexts (Araujo et al., 2017). Research shows that deaf individuals can accurately interpret tactile cues for timing and sequence (Mohammed & Cavus, 2024). Despite growth in general assistive technology research, studies focusing directly on vibration alert systems in inclusive schools remain limited. This indicates that the field is still emerging and underexplored. The growing recognition of multisensory approaches in learning highlights the potential for vibration systems. Their increasing visibility reflects a broader movement toward inclusive and accessible education.

Although assistive technology research has grown, there remains a striking absence of review studies on vibration alert systems for deaf students in inclusive settings. Over the last two decades, systematic reviews have addressed topics like captioning, cochlear implants, and hearing aids (Bell & Foiret, 2020). However, tactile-based systems like vibration alerts have received minimal scholarly attention. A systematic review emphasized rising publication trends in assistive technology but did not single out vibration systems (Fernández-Batanero et al., 2022). This omission reveals a gap

between existing technological innovations and their coverage in scholarly synthesis. Research on vibrotactile tools is emerging, but studies often remain small-scale or limited to experimental settings (Dim et al., 2022). Without review-level analysis, educators and policymakers lack consolidated evidence to guide implementation. Current literature offers scattered findings rather than comprehensive insights. Reviews focusing broadly on inclusive education for deaf students provide valuable information but omit vibration alerts as a category (Mohammed & Cavus, 2024). This gap risks underestimating the potential contribution of tactile systems. As vibration alerts grow more practical and affordable, the need for consolidated review becomes urgent. Without it, opportunities for innovation and adoption may be missed. The absence of reviews also reflects the relative novelty of tactile tools in education. Addressing this gap is critical to ensure that vibration systems are properly integrated into inclusive strategies.

This review study is addressed to present global trends regarding vibration alert system in managing deaf students in inclusive education, and highlight effective applications and outline future directions for research and practice. By consolidating recent evidence, the review provides a foundation for educators, researchers, and policymakers. It also compares vibration alert systems with other assistive technologies, clarifying their unique contributions. The study emphasizes how tactile feedback enhances classroom management, safety, and communication. It explores opportunities to embed vibration systems into teacher training and school policies. The contribution of this review lies in filling a critical gap in the literature. Unlike existing reviews, it focuses specifically on vibration alerts as educational tools. For educators, the findings offer practical strategies for classroom integration. For policymakers, the review provides justification for investment in tactile systems as part of inclusive infrastructure. For researchers, it identifies areas requiring further empirical investigation. By situating vibration alerts within the broader assistive technology landscape, the review elevates their status as legitimate educational tools. Its insights contribute directly to improving

inclusivity in mainstream classrooms. The study ultimately seeks to advance equity and participation for deaf students worldwide. By shaping future directions, it ensures that vibration alert systems become central to inclusive education practice.

The following research questions are constructed to get the purpose of this new review study. The research questions are such as: (1) How has the publication and citation trend of studies regarding the use of vibration alert system for deaf students in inclusive education over the last two decades? (2) Which documents, authors, institutions, countries, and sources have been the most productive and influential in studies regarding the use of vibration alert system for deaf students in inclusive education over the last two decades? (3) How have the social interactions among authors, countries, and institutions related to studies regarding the use of vibration alert system for deaf students in inclusive education evolved over the last two decades? (4) What are the emerging themes and novelties offered for future researches from studies regarding the use of vibration alert system for deaf students in inclusive education conducted over the last two decades?

METHODS

This study adopted a scoping review as its main method, complemented by bibliometric analysis to systematically examine metadata on research regarding the use of vibrating alert system for deaf students in inclusive education. A scoping review is well-suited for mapping broad fields of literature and detecting emerging trends (Putra et al., 2024; Sulistiawati et al., 2023), making it appropriate for assessing the development of studies regarding the utilization of vibration alert system for managing deaf students in inclusive education. Bibliometric analysis, which applies statistical and network-based approaches to publications, created a rigorous framework for uncovering research patterns, collaborations, and influential contributions (Donthu et al., 2021). Using both approaches provided a holistic view of the topic, enabling identification of past accomplishments and gaps that future studies can address. The bibliometric process followed five essential stages: (1) performing a structured search with a specific

keyword, (2) reviewing initial results to outline the scope of the corpus, (3) filtering results through inclusion criteria to refine the dataset, (4) exporting curated metadata in CSV and RIS formats, and (5) analyzing the dataset with specialized tools (Fuad et al., 2022; Suyanto et al., 2023). These steps guaranteed methodological consistency and transparency, ensuring that the analysis of mobile marketing research could be replicated and validated.

The initial search employed the combinational keywords, such as “Inclusive Education” AND “Vibration Alert System” within the Scopus database, which was selected because of its extensive coverage of peer-reviewed and high-quality academic literature. Scopus is widely regarded as a leading indexing platform, offering comprehensive records of journals, conference papers, and other scholarly materials across disciplines (Juandi et al., 2022; Susiyanti et al., 2022; Yunita et al., 2022). Its advanced search filters and export functionalities made it particularly suitable for bibliometric purposes. The search was conducted on September 1, 2025, at exactly 11:59 PM, capturing the most recent publications of the year and setting a clear cut-off point. This strategic timing ensured the dataset was exhaustive and temporally accurate. The search strategy was designed to maximize coverage of relevant materials while keeping the scope aligned with studies regarding the use of vibration alert system for managing deaf students in inclusive education.

The broad search produced results with diverse characteristics, spanning multiple decades and formats. Publications dated from 1983 to 2026, reflecting the historical scope of the database. Articles were available in numerous languages such as English, Spanish, Russian, Portuguese, Chinese, Ukrainian, Indonesian, Hungarian, and Belarusian, showing global interest in studies regarding the use of vibration alert system for managing deaf students in inclusive education. Source types included journals, conference proceedings, book series, trade publications, and books, reflecting multiple perspectives on the subject. Documents were categorized as either “final” or “article in press,” indicating different stages of publication readiness. The dataset also included various document types,

such as journal articles, conference papers, reviews, book chapters, books, and conference reviews, offering a wide range of scholarly formats. Subject areas consisted of Social Sciences, Computer Science, Engineering, Psychology, Arts & Humanities, Mathematics, Decision Sciences, Environmental Science, and Multidisciplinary. This diversity highlighted the necessity of refining the dataset to focus on high-quality, directly relevant contributions.

The refinement process applied strict inclusion criteria to maintain relevance and consistency. Only publications explicitly containing the term “*Inclusive Education AND Vibration Alert System*” were retained, and English-language documents were prioritized to ensure analytical uniformity. Finalized publications were selected over those still in press to guarantee reliability. The dataset was limited to journals and conference proceedings, which generally contain peer-reviewed and impactful studies. Document types were restricted to articles, conference papers, and review studies, as these provide substantial research contributions. The time frame was narrowed to 2006–2025, focusing on contemporary trends and avoiding outdated perspectives. Subject areas were further filtered to Social Sciences; Arts & Humanities, Multidisciplinary, Engineering, and Computer Science, reflecting the interdisciplinary scope of studies regarding the use of vibration alert system for managing deaf students in inclusive education. Selection followed a systematic procedure based on identification, screening, eligibility, and inclusion steps (Ariani et al., 2024; Fuad et al., 2023). The selection process is summarized in Figure 1.

Following refinement, metadata was exported in comma-separated values (CSV) and research information system (RIS) formats for subsequent analysis. CSV data were processed with VOSviewer version 1.6.20, a software tool for visualizing bibliometric networks such as co-authorship, keyword co-occurrence, and citation patterns (van Eck & Waltman, 2010). RIS files were analyzed with Publish or Perish (PoP) software version 8.19, which generates detailed citation metrics and performance indicators. The use of

both tools provided complementary insights: VOSviewer highlighted structural and relational patterns, while PoP offered quantitative citation metrics. Combining both approaches strengthened the robustness and multidimensionality of the bibliometric analysis.

The data analysis employed four major techniques, consisting of performance analysis, citation analysis, co-authorship analysis, and co-word analysis. Performance analysis identified trends in publication volume and citation counts between 2006 and 2025. Citation analysis revealed the most influential documents, authors, institutions, countries, and journals contributing to

the field. Co-authorship analysis explored patterns of scholarly collaboration across researchers and institutions, highlighting networks that drive innovation. Co-word analysis examined the frequency and co-occurrence of keywords, constructing thematic clusters and identifying emerging research directions (Donthu et al., 2021). Together, these four techniques provided a comprehensive picture of the research landscape regarding the use of vibration alert system for managing deaf students in inclusive education. The results offered not only a historical overview but also evidence-based directions for future scholarship.

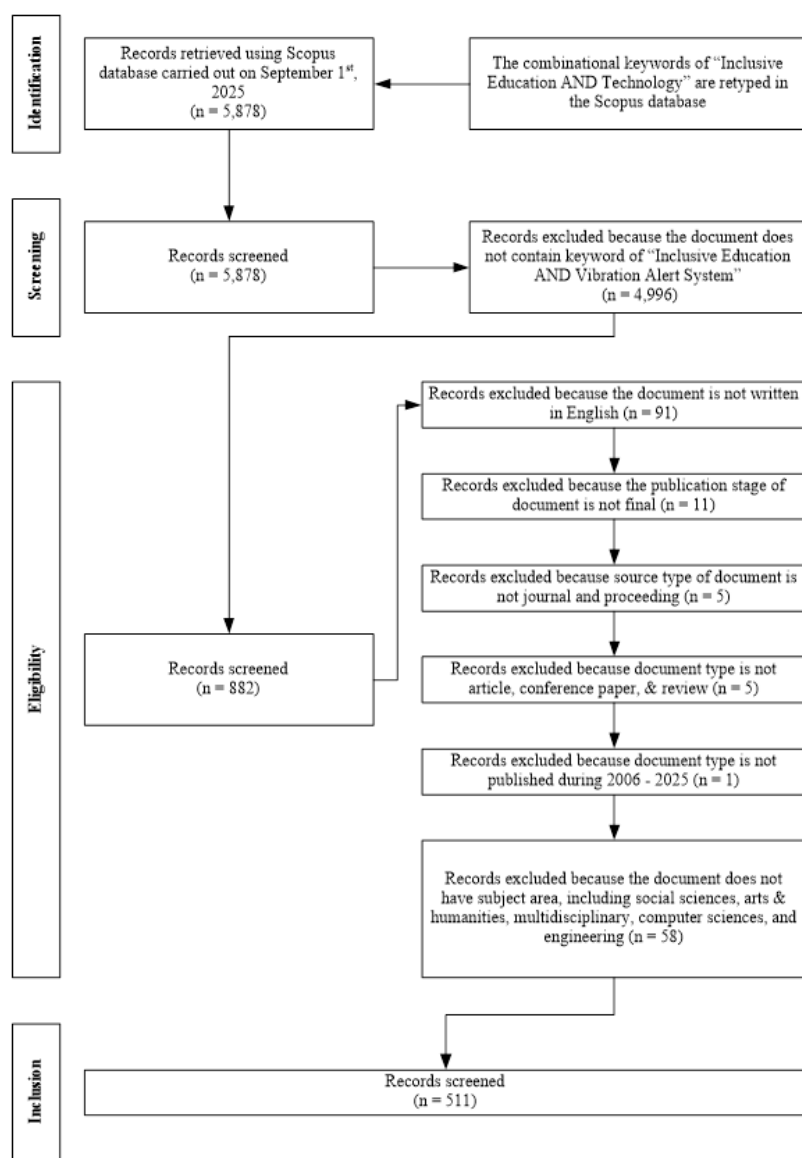


Figure 1. The process of document selection

RESULTS

Performance Analysis

This analysis was applied to highlight the development of publication and citation regarding the use of vibration alert system for managing deaf students in inclusive education from 2006 to 2025. Referring to the Figure 2, The performance analysis shows a steady yet uneven growth of publications and citations on vibration alert systems for managing deaf students in inclusive education from 2006 to 2025. In the early phase, publication numbers were minimal, reflecting limited awareness

and exploration of the topic. From 2014 onward, the rise in publications indicates growing consolidation of the research area. The peak in 2024 with 104 publications underscores its current relevance. Citation trends, although volatile, reveal a pattern of recognition influenced by a few highly impactful studies. The spike in citations in 2020 mirrors the global turn to digital and assistive technologies during the COVID-19 pandemic. Despite a decline after 2021, the research impact remains steady, signifying sustained academic interest.

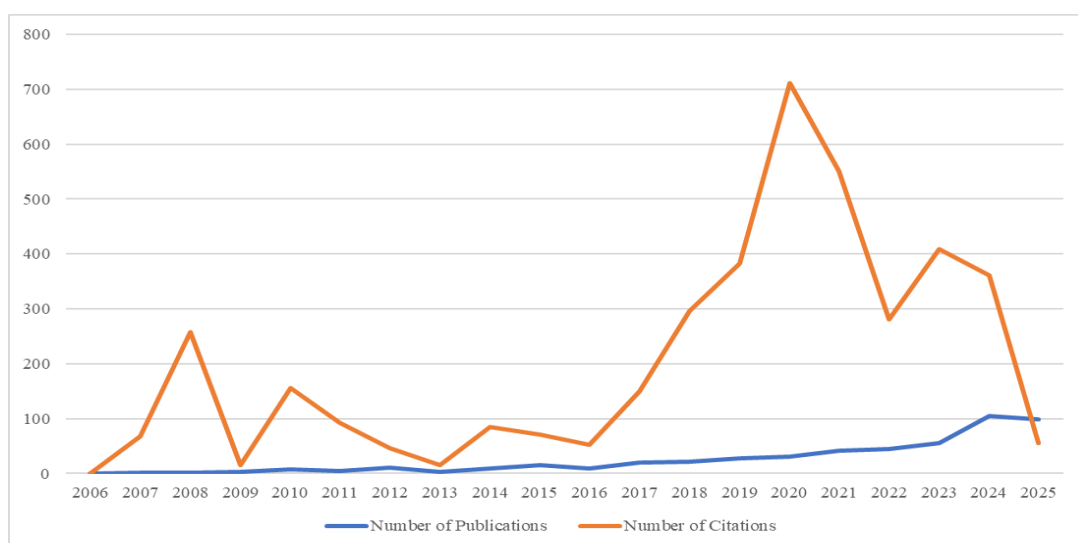


Figure 2. The trend of inclusive education studies in the last two decades

Citation Analysis

This analysis was applied to present the most productive and influential documents, authors, countries, institutions, and sources regarding the use of vibration alert system for managing deaf students in inclusive education during 2006 – 2025. The number of publications

(TP) represents the most productive authors, countries, institutions, and sources, while the number of citations (IC) represents the most influential documents, authors, countries, institutions, and sources (Putra et al., 2024). Firstly, the most ten influential documents regarding inclusive education studies in the last two decades are shown in Table 1.

Table 1. Top ten influential documents regarding mobile marketing studies

Cites	Authors	Title	Source
253	Ferguson	International trends in inclusive education: The continuing challenge to teach each one and everyone	European Journal of Special Needs Education
190	Druga et al.	Inclusive AI literacy for kids around the world	ACM International Conference Proceeding Series

153	Portillo-Berasaluce et al.	Self-perception of the digital competence of educators during the covid-19 pandemic: A cross-analysis of different educational stages	Sustainability (Switzerland)
113	O'Leary et al.	Creating inclusive classrooms by engaging STEM faculty in culturally responsive teaching workshops	International Journal of STEM Education
99	Khowaja et al.	Augmented reality for learning of children and adolescents with autism spectrum disorder (ASD): A systematic review	IEEE Access
95	Parmigiani et al.	E-inclusion: online special education in Italy during the Covid-19 pandemic	Technology, Pedagogy and Education
89	Hosseini et al.	An exploratory survey about using ChatGPT in education, healthcare, and research	PLOS ONE
71	Salas-Pilco et al.	Artificial Intelligence and New Technologies in Inclusive Education for Minority Students: A Systematic Review	Sustainability (Switzerland)
69	Bong & Chen	Increasing faculty's competence in digital accessibility for inclusive education: a systematic literature review	International Journal of Inclusive Education
64	Page et al.	Fostering school connectedness online for students with diverse learning needs: inclusive education in Australia during the COVID-19 pandemic	European Journal of Special Needs Education

Referring the Table 1, Ferguson's publication leads citations, emphasizing inclusive education's persistent global challenges and priorities worldwide. Druga and colleagues follow prominently, highlighting growing importance of inclusive artificial intelligence literacy. Digital competence during COVID-19 also appears significant, reflecting educators' adaptation across stages. Several studies address technological interventions, including augmented reality and artificial intelligence applications. Overall, influential documents emphasize inclusive education, digital innovation, and accessibility during global disruptions.

Secondly, the most five productive and influential authors who have contributed to inclusive education studies in the last two decades are shown in Figure 3. Ferguson records the highest citation count, significantly surpassing all other listed authors. Druga ranks second, demonstrating substantial scholarly influence within the research domain. Portillo-Berasaluce follows, indicating notable academic recognition and sustained citation performance. O'Leary and Khowaja maintain moderate citation levels compared with leading contributors. Parmigiani and Hosseini show respectable citation counts, reflecting meaningful scholarly engagement. Salas-Pilco, Bong, and Page present comparatively lower but still visible citation impact. Publication counts among remaining authors remain minimal, suggesting emerging or limited contributions.

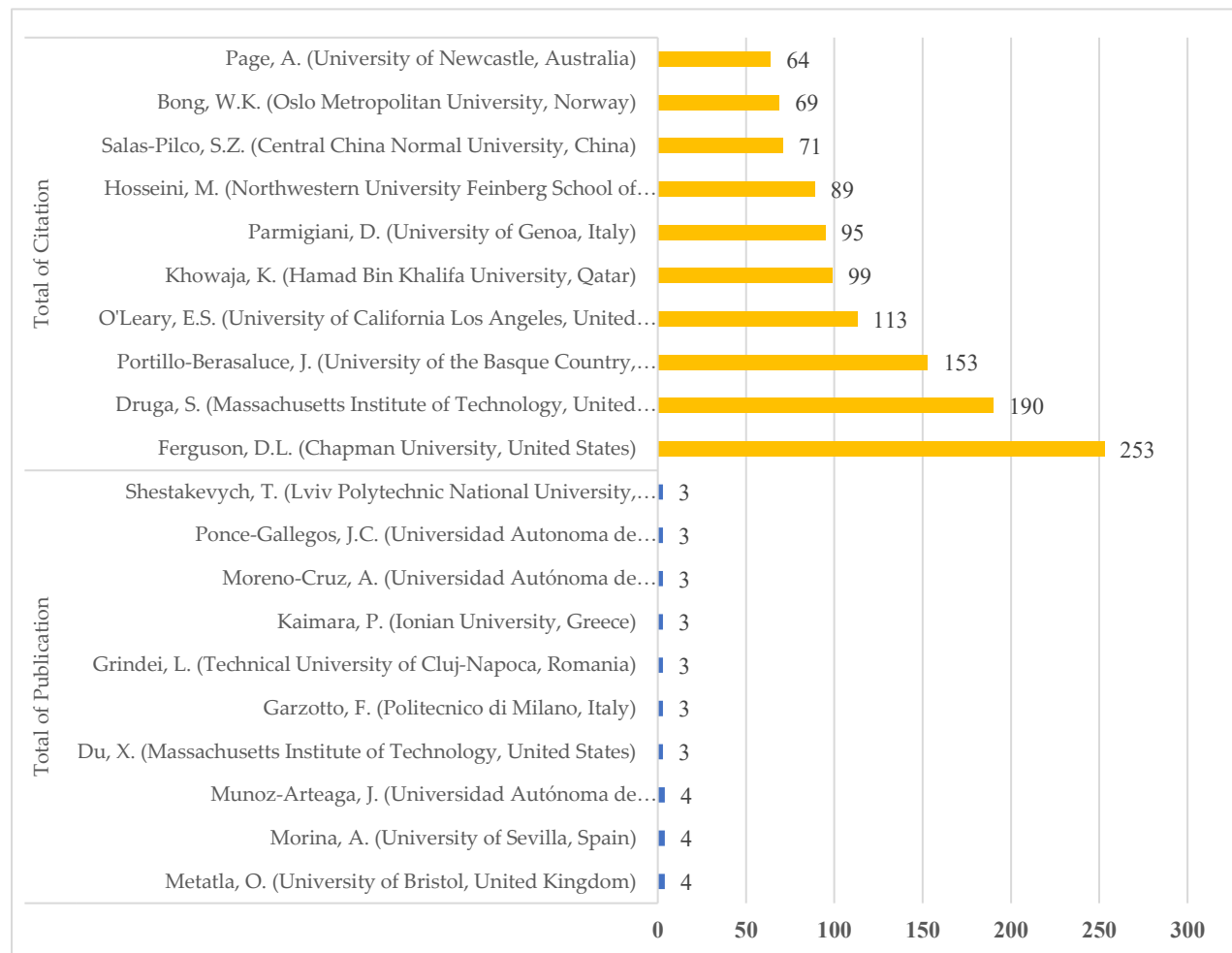


Figure 3. Top ten productive and influential authors regarding inclusive education studies

Thirdly, the most five productive and influential countries which have contributed to inclusive education studies in the last two decades are shown in Figure 4. The United States leads citations overwhelmingly, demonstrating dominant scholarly influence globally. Spain and the United Kingdom follow with substantial citation counts. China and Italy display moderate citation

performance compared with leaders. Australia, Greece, Malaysia, Japan, and South Africa show comparatively lower citations. Regarding publications, the United States again ranks first overall. Spain and the United Kingdom maintain strong publication productivity. Other countries contribute modest publication numbers, indicating developing research presence.

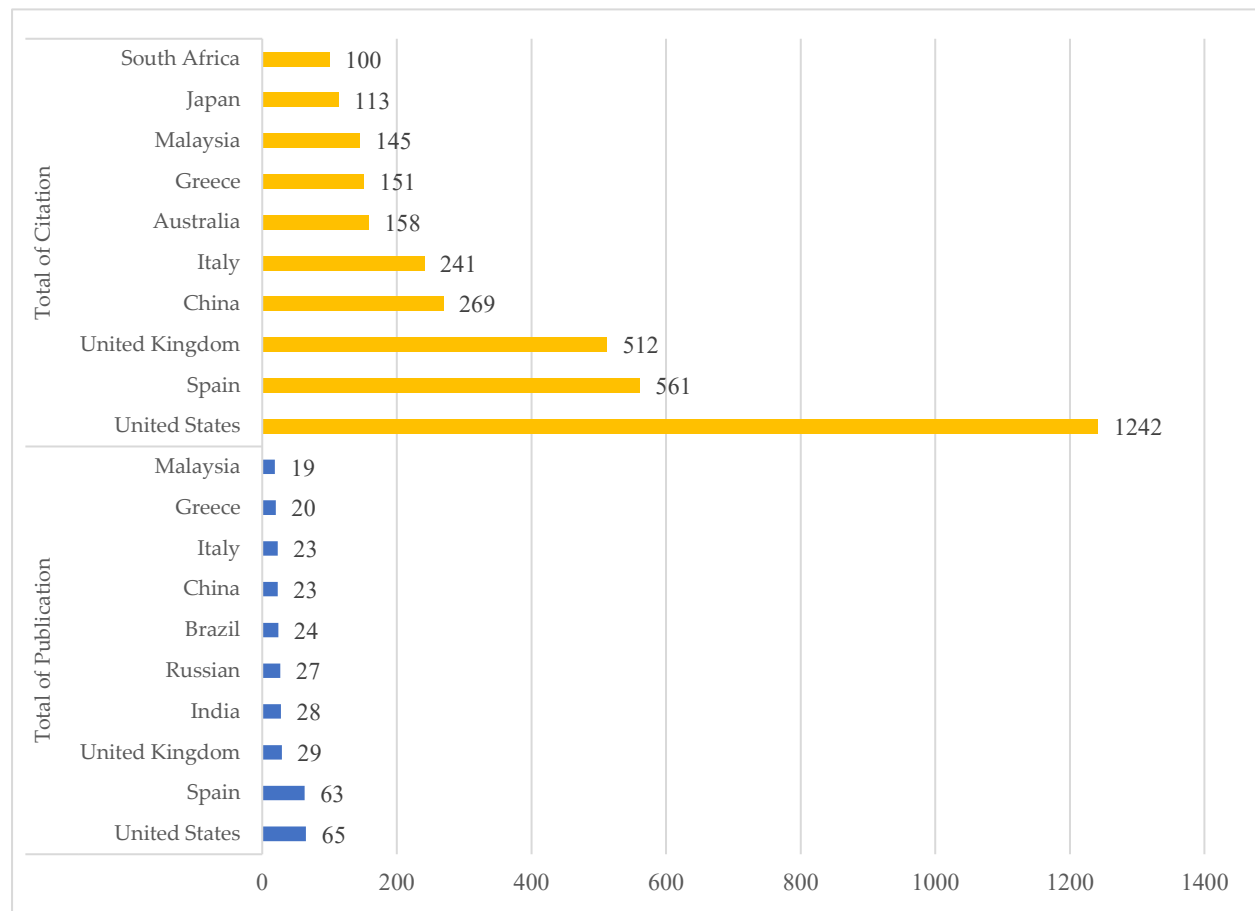


Figure 4. Top ten productive and influential countries regarding inclusive education studies

Fourthly, the most five productive and influential institutions which have contributed to inclusive education studies in the last two decades are shown in Figure 5. Chapman University records the highest citation count among listed institutions overall. Massachusetts Institute of Technology and Boston University follow with strong citation performances. University of Pais Vasco and University of Bristol demonstrate substantial scholarly impact. University of Sevilla also shows notable citations compared with others institutions.

University of California and University of Malaya maintain moderate citation levels. International Islamic University Malaysia and Hamad bin Khalifa University show comparable citations. Regarding publications, University of Sevilla leads with the highest output. Abai Kazakh National University demonstrates moderate productivity relative to peers. Kazan University and several institutions report modest publication numbers overall. Other universities contribute limited publications, suggesting emerging research development stages.

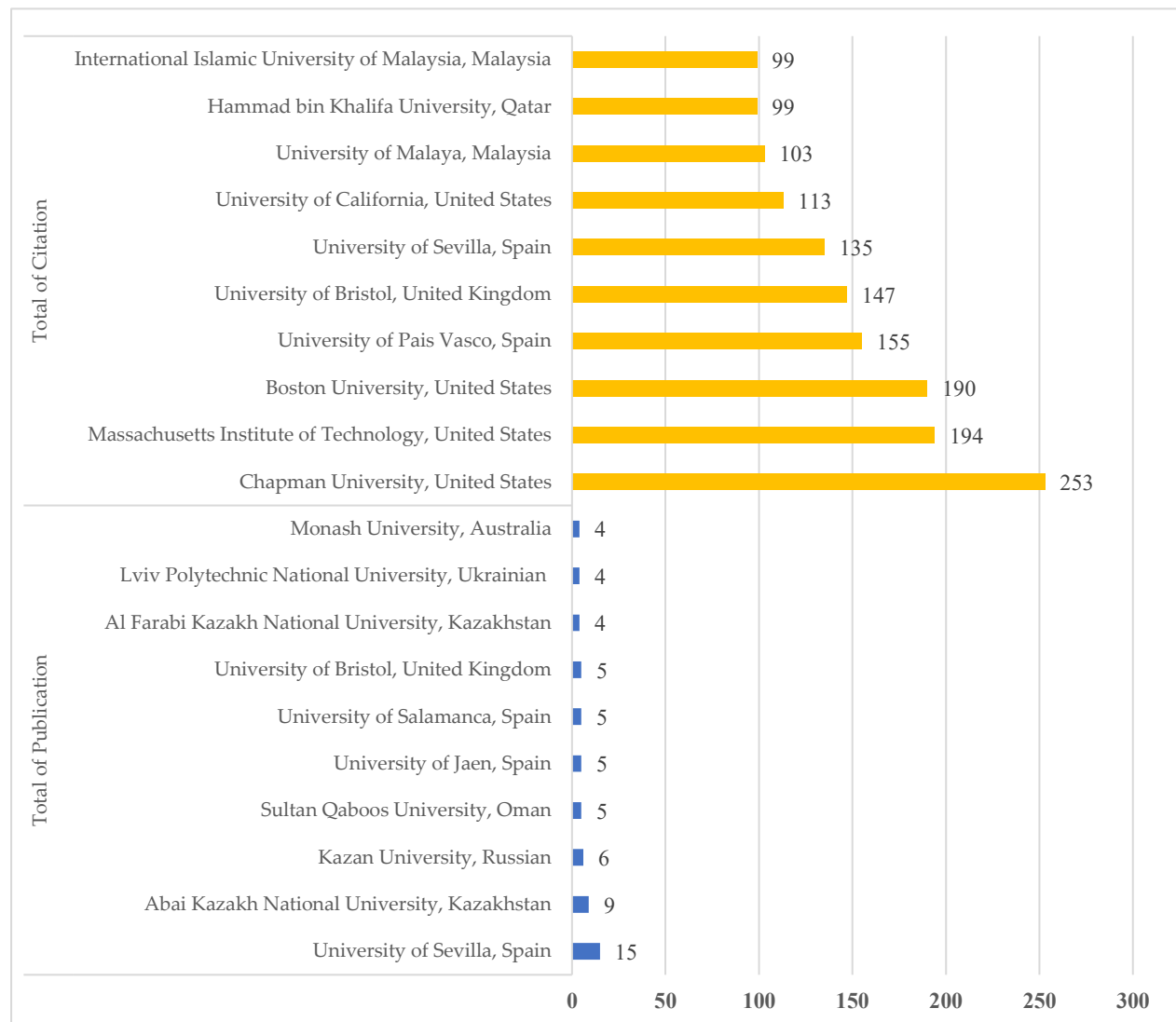


Figure 5. Top ten productive and influential affiliations regarding inclusive education studies

Fifthly, the most five productive and influential sources which have contributed to inclusive education studies in the last two decades are shown in Figure 6. Sustainability and European Journal of Special Needs Education receive the highest citations overall. ACM International Conference Proceedings also demonstrate strong citation performance among sources. International Journal of Inclusive Education and IEEE Access show substantial scholarly impact. Journal of Special

Education Technology and Education Sciences maintain moderate citation levels. PLOS ONE and Technology, Pedagogy and Education record comparatively lower citation counts. Regarding publications, Journal of Special Education Technology leads output among listed venues. Other journals contribute moderate publications, reflecting diverse dissemination across academic outlets.

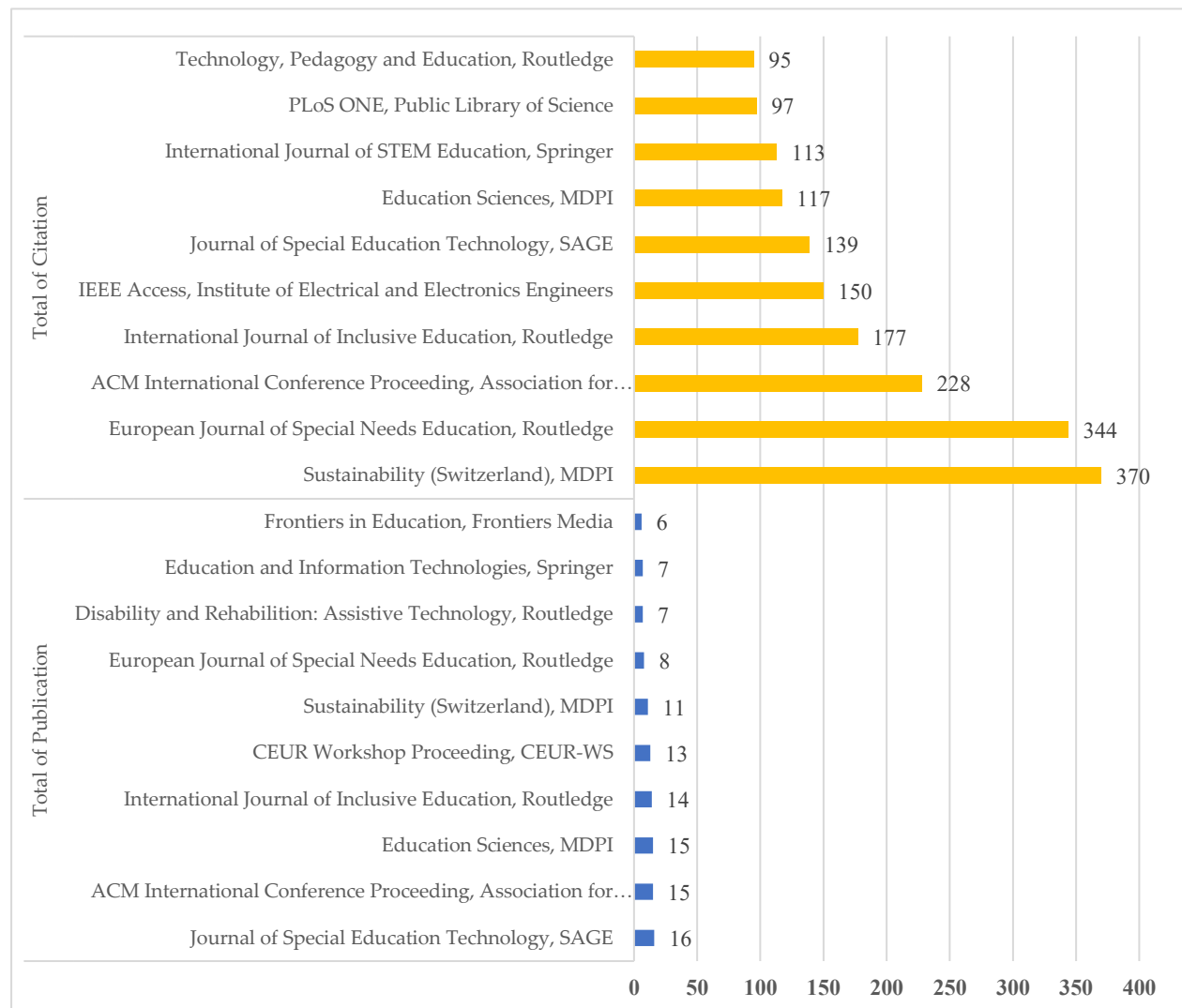


Figure 6. Top ten productive and influential sources regarding inclusive education studies

Co-authorship Analysis

This analysis was applied to highlight the social works between authors, institutions, and countries regarding inclusive education studies in the last two decades. Firstly, the social interactions among authors who have contributed to inclusive education studies during 2006 – 2025 are presented in the Figure 7. The network visualization displays collaborative relationships among influential authors within the research field. Nodes vary in size, indicating different levels of publication or citation impact. Author A appears centrally positioned, suggesting strong collaborative connectivity with

others. Author J forms another prominent cluster, representing a distinct collaborative group. Several smaller clusters surround the main nodes, indicating specialized research partnerships. Connections between clusters reveal interdisciplinary cooperation across different thematic areas. Author V leads a smaller yet cohesive collaboration cluster. Bridging authors connect major clusters, facilitating knowledge exchange within networks. Color variations represent different clusters identified through bibliometric mapping techniques. Overall, the figure highlights collaborative structures shaping knowledge production patterns.

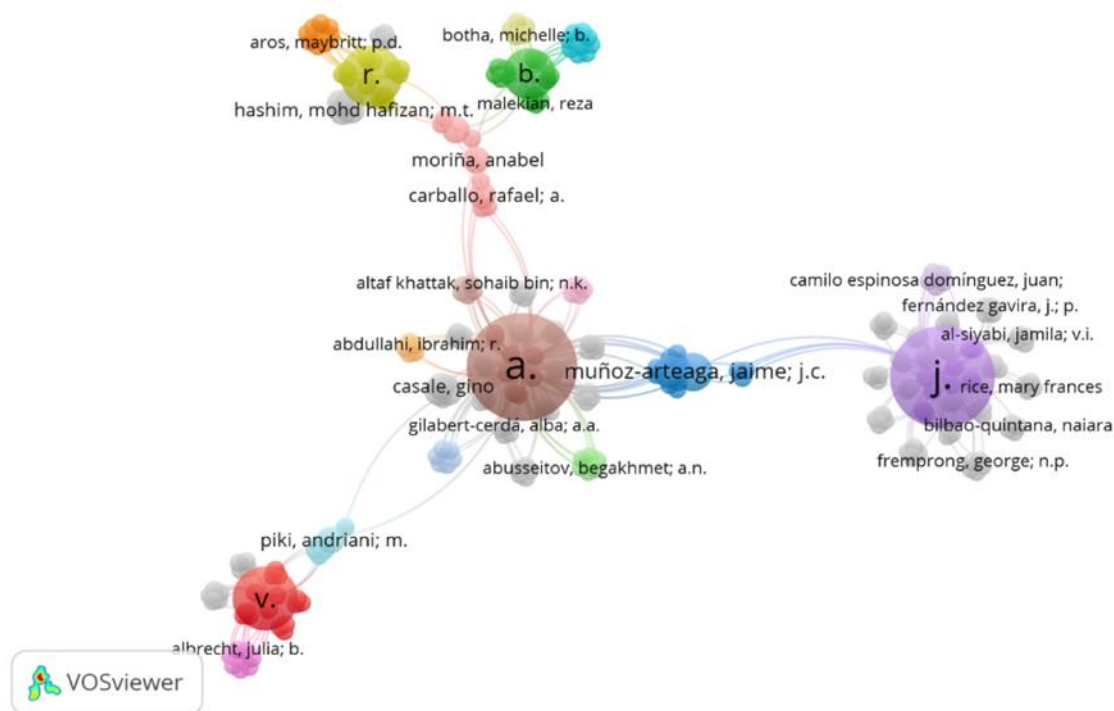


Figure 7. Social interactions among authors who have contributed to inclusive education studies

Secondly, the social interactions among institutions which have contributed to inclusive education studies in the last two decades are presented in the Figure 8. The visualization presents institutional collaboration networks within the examined research domain. Abai Kazakh National Pedagogical University appears as the central connecting institution. It maintains multiple collaborative links with regional and international universities. Al Farabi Kazakh National University forms a closely connected institutional cluster. Kazan Federal University demonstrates active

collaboration within this academic network. Khoja Akhmet Yassawi International Kazakh Turkish University connects distant institutional partners. Central Asian Innovation University also contributes to cross-institutional cooperation patterns. The Academy of Special Pedagogy maintains limited but visible collaborative connections. Node sizes indicate varying degrees of institutional productivity or influence. Overall, the figure highlights regional collaboration strengthening research integration efforts.

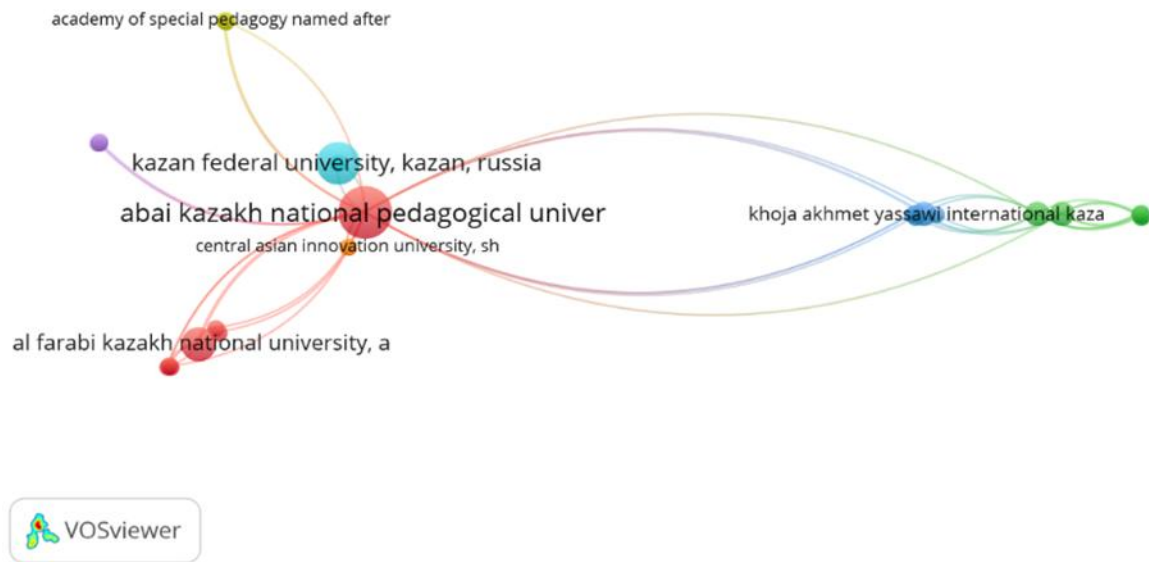


Figure 8. Social interactions among institutions who have contributed to inclusive education studies

Thirdly, the social interactions among countries which have contributed to mobile marketing studies in the last two decades are presented in the Figure 9. The visualization illustrates international collaboration patterns among countries within the observed global research network landscape. The United States appears centrally positioned, maintaining extensive collaborative connections across multiple continents and research partnerships worldwide. Spain demonstrates strong connectivity, effectively linking European nations with Latin American research collaborators and partners. The United Kingdom sustains significant relationships with several European countries within this collaborative

framework. Italy, Portugal, and Finland form interconnected European clusters contributing actively to shared research initiatives. India and Saudi Arabia represent a dynamic regional grouping with increasing collaborative engagement. Australia connects strategically with both Western countries and diverse Asian research partners. South Africa bridges African scholarship with broader international academic collaboration networks. Mexico and Venezuela extend transatlantic connections, reinforcing cooperation between Europe and Latin America. Greece remains comparatively peripheral, sustaining limited yet visible collaborative ties within the network.

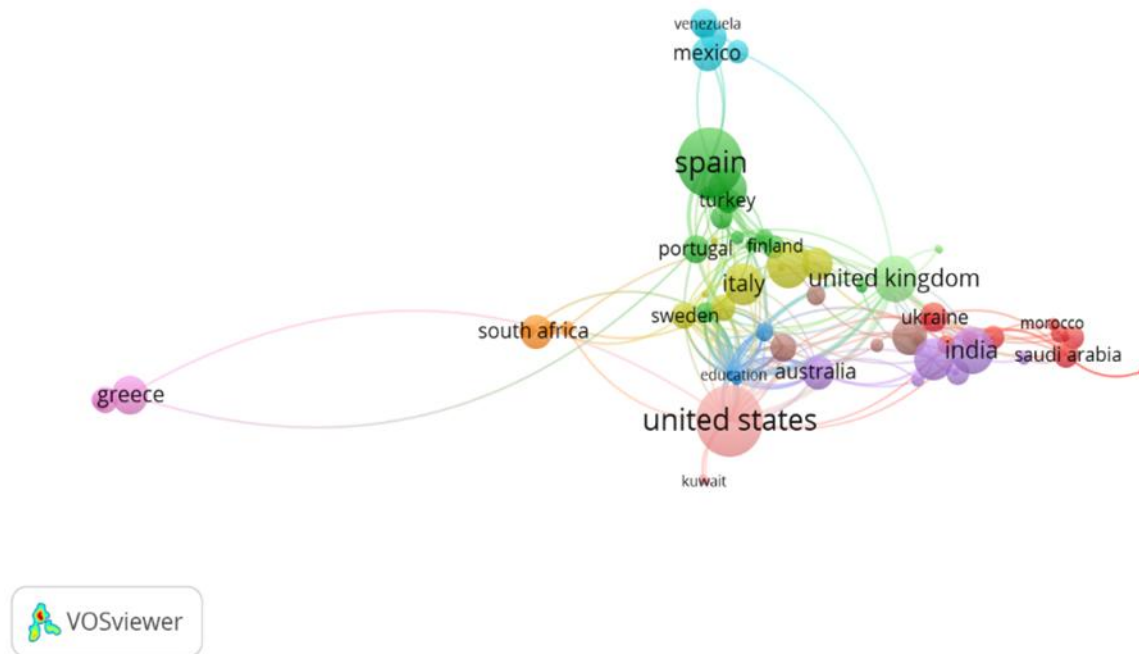


Figure 9. Social interactions among countries who have contributed to inclusive education studies

Co-Word Analysis

This analysis was applied to show the emerging themes related to inclusive education studies during 2006 – 2025, and construct the possible novelties for future studies regarding the use of vibration alert system for managing deaf students in inclusive education. By selecting the category of index keywords, with minimum number of occurrences of a keyword as many as one occurrence, there were 25 emerging keywords related to the use of vibration alert system for managing deaf students in inclusive education (See Figure 10). The visualization depicts keyword co-occurrence relationships within inclusive education research literature. Inclusive education appears as

the central and most prominent research theme. Special education forms a closely connected cluster around the main topic. Augmented reality and virtual reality represent significant emerging technological themes. Adaptive learning systems and tutoring systems support personalized inclusive learning environments. Robotics and cyber physical systems indicate technological innovation integration. Internet of Things and sensors highlight smart educational technology applications. Wearable computers connect peripherally, suggesting specialized yet relevant research interest. Massive open online courses link digital accessibility with inclusive practices. Overall, the network demonstrates technology-driven trends shaping inclusive education research directions.

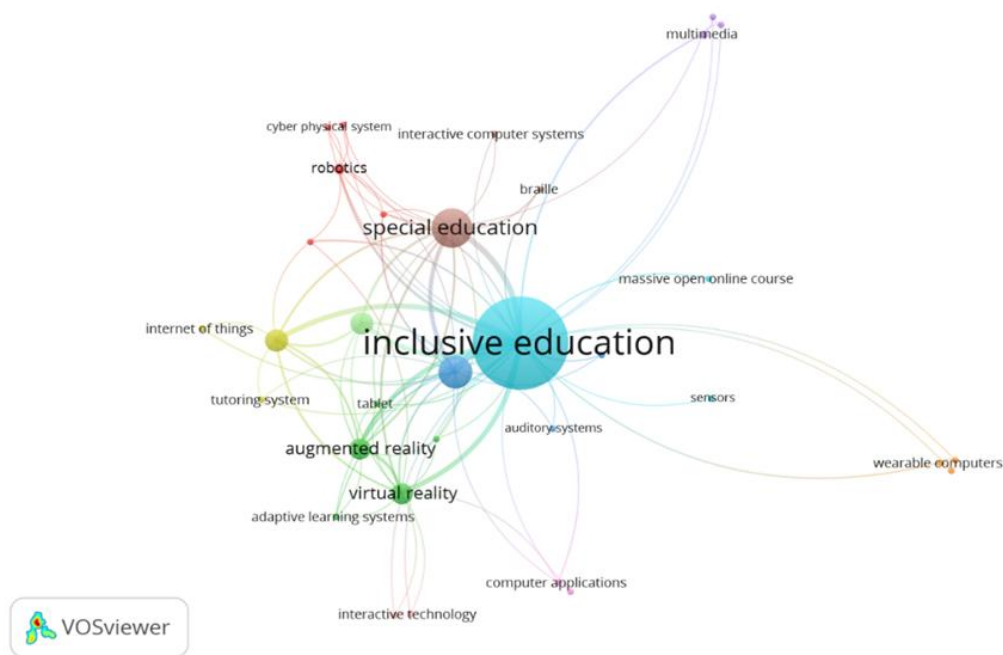


Figure 10. The emerging keywords regarding inclusive education studies

Using thematic analysis, 15 emerging keywords presented in the Figure 10 can be grounded to be some themes regarding inclusive education, such as vibrating alarm clock and timer, vibrating fire and safety alarm, vibrating notification device, wearable vibration device, and desk-based vibration system (See Table 2).

Table 2. The emerging themes regarding inclusive education studies during 2006 – 2025

Theme	Keyword	Frequency
Vibrating Alarm Clock and Timer	Mobile Application	3
	Tablet	2
	Adaptive Learning System	2
Vibrating Fire and Safety Alarm	Internet of Things	2
	Cyber Physical System	1
	Sensors	1
Vibrating Notification Device	Image Communication System	1
	Interactive Technology	2
	Learning Management System	2
	Interactive Computer System	2
Wearable Vibration Device	Wearable Computers	2
	Smartwatches	1
	Wearable Sensors	1
Desk-Based Vibration System	Assistive Technology	56
	Artificial Intelligence	27
	Auditory System	1
	Robotics	7
	Augmented Reality	24
	Virtual Reality	24

Referring to the Table 2, Desk-Based Vibration System dominates, highlighted by frequent assistive technology applications. Assistive technology records the highest frequency among all listed keywords. Artificial intelligence and augmented reality demonstrate substantial and growing research attention. Virtual reality similarly shows strong integration within inclusive educational contexts. Robotics contributes moderately, indicating expanding technological experimentation in classrooms. Wearable vibration devices emphasize wearable computers and smartwatch innovations. Wearable sensors appear less frequent yet relevant for accessibility support. Vibrating notification devices incorporate interactive technologies and learning management systems. Interactive computer systems further strengthen digital communication and engagement strategies. Vibrating fire and safety alarms integrate Internet of Things infrastructures. Cyber physical systems and sensors support environmental responsiveness and safety. Vibrating alarm clocks relate closely to mobile applications and tablets. Adaptive learning systems contribute to personalized inclusive educational experiences. Overall, emerging themes reflect technology-driven accessibility advancements supporting inclusive education practices.

DISCUSSION

The Use of Vibration Alert System for Managing Deaf Students in Inclusive Education

The performance analysis shows a steady yet uneven growth of publications and citations on vibration alert systems for managing deaf students in inclusive education from 2006 to 2025. In the early phase, publication numbers were minimal, reflecting limited awareness and exploration of the topic. As seen in similar educational technology fields, early studies often serve as groundwork without immediate widespread adoption (Bell & Foiret, 2020). From 2014 onward, the rise in publications indicates growing consolidation of the research area. The peak in 2024 with 104 publications underscores its current relevance, aligning with the broader expansion of inclusive

technologies in education (Dim et al., 2022). Citation trends, although volatile, reveal a pattern of recognition influenced by a few highly impactful studies. The spike in citations in 2020 mirrors the global turn to digital and assistive technologies during the COVID-19 pandemic (Fernández-Batanero et al., 2022). Despite a decline after 2021, the research impact remains steady, signifying sustained academic interest. This trajectory demonstrates that inclusive education research increasingly integrates vibration alert systems as a crucial component of accessibility. Thus, performance analysis confirms the progressive maturation of the field into a recognized domain of scholarly inquiry.

The citation analysis highlights the most influential documents, authors, institutions, and countries shaping the field of inclusive education with technology. Foundational study of Ferguson (2008) on global inclusive education remains the most cited, reflecting its lasting theoretical importance. Highly cited works by Druga et al. (2019) and Khowaja & Salim (2013) show how AI literacy and augmented reality drive contemporary inclusive practices. The presence of pandemic-era studies, such as Portillo et al. (2020), confirms the field's responsiveness to urgent global challenges. The United States leads in both publication and citation counts, demonstrating its central role in shaping research agendas. Spain and the United Kingdom follow closely, showing regional leadership in Europe. At the institutional level, Chapman University and MIT dominate citations, while the University of Sevilla leads in productivity, highlighting the diverse nature of contributions. Journals like *Sustainability* and *European Journal of Special Needs Education* emerge as central outlets for dissemination. The combination of education- and technology-focused sources underscores the interdisciplinary character of this research. Therefore, citation analysis affirms the strong academic foundations and diverse scholarly networks sustaining inclusive education studies.

The co-authorship analysis reveals that collaboration plays a central role in advancing inclusive education studies. Key figures such as Muñoz-Arteaga act as bridges across clusters, fostering interdisciplinary linkages. This finding

aligns with argument of Mohammed and Cavus (2024) that collaboration enhances both productivity and impact. Prominent groups led by Morina and Rice emphasize thematic specialization, while smaller teams diversify perspectives. Institutional collaborations are concentrated in Kazakhstan, with Abai Kazakh National Pedagogical University leading strong regional networks. Such networks demonstrate how regional hubs can nurture global visibility in niche areas. Internationally, the United States and Spain dominate, forming collaborative ties with multiple countries. European clusters display dense interconnections, while emerging contributions from Asia and Africa signal global diversification. The density of long-term collaborations indicates continuity in the field, while isolated nodes show room for integration. Overall, co-authorship analysis reflects both the concentration of influence and the expansion of inclusivity in research communities.

The co-word analysis shows that the theme of vibrating alarm clocks and timers, while modest in representation, highlights important accessibility functions. Keywords such as “mobile application,” “tablet,” and “adaptive learning system” suggest integration of digital learning supports. These tools align with prior studies emphasizing technology’s role in promoting self-regulated learning for students with disabilities (Lopez-Gavira et al., 2021). The presence of mobile and tablet-based systems indicates that researchers explore practical, portable solutions. Their application can help deaf students manage schedules and classroom activities independently. Adaptive learning systems extend this potential by tailoring content delivery to individual needs. However, the relatively low frequency suggests that such solutions remain underutilized in research. Compared with desk-based technologies, these tools appear more focused on personal assistance than institutional adoption. This underscores the need for further exploration into how everyday technologies can improve inclusivity. Thus, the vibrating alarm clock and timer theme represents a promising yet still emerging area.

The vibrating fire and safety alarm theme illustrates the importance of accessibility beyond

learning, extending to safety and well-being. Keywords such as “Internet of Things,” “cyber physical system,” and “sensors” highlight technological innovation. Prior studies emphasize that safety technologies are critical for deaf students in inclusive settings, ensuring equitable protection (Hosseini et al., 2023). However, the low research frequency shows this area has not yet received proportional scholarly attention. The use of IoT and sensor-based solutions could transform safety protocols in schools. Cyber-physical systems can ensure real-time alerts during emergencies, bridging communication gaps. This underexplored field presents a significant gap in inclusive education research. Safety remains a foundational right, and overlooking it undermines inclusive efforts. By integrating vibration-based alarms into school infrastructure, deaf students’ participation in education becomes more secure. Therefore, this theme highlights a crucial but insufficiently addressed aspect of inclusive education.

The vibrating notification device theme reflects efforts to enhance interactive and communicative inclusivity. Keywords such as “interactive technology,” “learning management system,” and “interactive computer system” suggest integration into broader digital ecosystems. This aligns with research highlighting the importance of multimodal communication in inclusive classrooms (Salas-Pilco et al., 2022). The theme indicates that vibration-based devices are being linked to interactive platforms. Such tools ensure that deaf students remain connected to classroom notifications and digital communication. The presence of learning management systems reflects integration into institutional education frameworks. Interactive technologies support participation by reducing communication barriers between students and teachers. Image communication systems also suggest experimental attempts to combine visual and tactile modalities. While still emerging, this theme demonstrates a balanced approach between pedagogy and technology. Thus, vibrating notification devices symbolize progress toward inclusive, technology-enhanced communication.

The wearable vibration device theme emphasizes the shift toward personalized and portable assistive technologies. Keywords such as

“wearable computers,” “smartwatches,” and “wearable sensors” demonstrate potential for real-time learning support. Prior research confirms that wearable technologies can foster independence for students with disabilities (Bong & Chen, 2024). Wearable systems are advantageous because they blend seamlessly into daily activities. Smartwatches, for instance, can provide discreet classroom alerts. Wearable sensors can also capture environmental changes and deliver immediate feedback. Despite this potential, the frequency of occurrences is still limited, indicating a developing research field. The integration of wearables requires careful consideration of usability and accessibility standards. Their adoption could significantly improve personalized learning experiences for deaf students. Therefore, wearable vibration devices represent an innovative yet underexplored path in inclusive education.

The desk-based vibration system theme dominates the research landscape, with the highest frequency across all categories. Keywords such as “assistive technology,” “artificial intelligence,” “augmented reality,” and “virtual reality” highlight advanced, immersive approaches. This dominance reflects the scholarly emphasis on high-impact, institutionally integrated technologies (Page et al., 2021). Virtual and augmented reality applications, in particular, have been shown to improve engagement for students with disabilities. Artificial intelligence extends this by offering adaptive and predictive learning supports. Robotics also appears, suggesting experimental approaches to tactile communication. The heavy focus on desk-based systems may reflect institutional priorities over personal convenience. However, this raises questions about accessibility beyond formal learning spaces. While impactful, this concentration may overshadow other equally important technologies. Overall, desk-based systems represent the forefront of inclusive education research but risk creating imbalances.

The Implications for Inclusive Education Researches

The results of this review present several theoretical and practical implications. Theoretically, they demonstrate how inclusive education is

evolving toward technology-driven, vibration-based assistive systems. This aligns with frameworks of universal design for learning, which emphasize multiple means of engagement and representation. Practically, the findings highlight the dominance of desk-based systems, suggesting institutional preference for advanced solutions. At the same time, the emerging presence of mobile, wearable, and notification devices indicates potential for broader application. For practitioners, these insights underscore the need to balance high-tech institutional tools with accessible, everyday solutions. Policymakers can use these findings to allocate resources more evenly across research themes. Educators can integrate diverse vibration alert systems to ensure comprehensive accessibility. The underrepresentation of safety alarms points to a critical area requiring urgent attention. Thus, this review contributes both conceptual clarity and actionable guidance for inclusive education.

Limitations and Suggestions

This review, while comprehensive, faces several limitations that must be acknowledged. Firstly, it is limited by the scope of the bibliometric databases used, which may exclude relevant studies. Secondly, the focus on keyword frequency may overlook nuanced thematic connections. Thirdly, the timeframe of 2006–2025, while extensive, does not capture earlier historical developments. Additionally, the heavy reliance on citation counts may privilege older studies while underrepresenting newer contributions. Another limitation lies in the uneven global distribution of research, with Western countries dominating outputs. This could obscure perspectives from underrepresented regions. Future research should expand database coverage to include gray literature and non-English publications. More qualitative approaches, such as content analysis, can complement bibliometric findings. Further studies should also emphasize cross-cultural perspectives on inclusive technologies. By addressing these limitations, future reviews can provide even more balanced insights.

CONCLUSION

In conclusion, this review synthesizes two decades of research on vibration alert systems for

deaf students in inclusive education. Performance analysis confirms gradual but significant growth, reflecting the field's increasing recognition. Citation analysis highlights foundational and contemporary works that shape scholarly discourse. Co-authorship analysis reveals collaborative patterns across authors, institutions, and countries, with central hubs and emerging nodes. Co-word analysis identifies five major themes, with desk-based systems dominating but wearables and mobile solutions showing promise. Safety-focused technologies remain underrepresented, pointing to

a critical research gap. Theoretical implications emphasize the role of technology in universal design for learning, while practical implications stress balancing institutional and personal tools. Limitations include database coverage and uneven global representation, but these can be addressed through broader and deeper methodologies. Overall, the findings reveal both achievements and gaps in supporting deaf students through vibration technologies. Therefore, this review offers a comprehensive foundation for guiding future inclusive education research and practice.

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