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Research Trends and Educational Implications of Sensory-Based Learning for Children with Autism Spectrum Disorder: A Bibliometric Analysis

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ABSTRACT

The increasing emphasis on inclusive education has highlighted the importance of addressing diverse learning needs, particularly for children with Autism Spectrum Disorder (ASD), who often experience sensory processing challenges that affect learning and behavior. Despite growing research interest in sensory-based learning approaches, existing studies remain fragmented across disciplines, limiting their practical application in educational settings and reducing their usefulness for educators and policymakers. This study aims to examine the development and intellectual structure of research on sensory-based learning for children with ASD, with a focus on its educational and behavioral implications. A bibliometric approach was employed using data retrieved from the Scopus database. A total of 342 relevant publications were analyzed using descriptive statistical methods and visualization techniques through VOSviewer to identify publication trends, key contributors, institutional involvement, and thematic patterns within the field. The results reveal a significant increase in research output since 2005, indicating growing global attention to inclusive and adaptive learning environments. The findings also show that while the field is interdisciplinary, it is predominantly influenced by psychology and health-related disciplines, with comparatively limited emphasis on educational implementation. Core research themes include sensory integration, learning engagement, and classroom adaptation, while emerging areas focus on multisensory learning and technology-supported instruction. The study concludes that although sensory-based learning research is expanding, there remains a critical need to strengthen its integration within educational contexts. Greater emphasis on practice-oriented and context-sensitive research is necessary to support teachers and improve classroom application. This study provides a structured overview of current research trends and highlights key gaps, contributing to the advancement of knowledge in social and behavioral sciences and supporting the development of inclusive learning environments for children with ASD.

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1. Introduction

The growing emphasis on inclusive education has brought increased attention to the diverse learning needs of children with Autism Spectrum Disorder (ASD), particularly those related to sensory processing. These sensory differences can shape how children respond to their surroundings, influencing attention, behavior, and participation in classroom activities. Research has consistently shown that sensory processing challenges are a core characteristic of ASD and play a significant role in how learners engage with both instructional content and social environments [1,2]. As more schools move toward inclusive practices, understanding and addressing these challenges has become increasingly important.

In response, sensory-based learning approaches have gained attention as practical strategies to support children with ASD in educational settings. These approaches involve the use of structured sensory experiences, such as visual, auditory, tactile, and movement-based activities, to support engagement and behavioral regulation. Evidence suggests that such interventions can improve attention, participation, and adaptive behavior, particularly when they are carefully implemented [3,4]. However, their effectiveness is not always consistent, especially when applied in real classroom environments where conditions are less controlled than in clinical settings.

At the same time, research in this area continues to grow rapidly, but not always in a coordinated way. Much of the existing literature is spread across different disciplines, including psychology, health sciences, and education. As a result, many studies focus more on therapeutic outcomes than on practical classroom application, making it difficult for educators to translate research findings into everyday teaching strategies [5]. This lack of integration limits the usefulness of existing knowledge for supporting inclusive education.

Recent studies have begun to highlight this issue more clearly. Bibliometric analyses show that while autism-related research is expanding, there is still a need to better organize and synthesize knowledge across fields [6]. In addition, research on technology-enhanced learning suggests that multisensory and digital approaches may offer new opportunities for supporting children with ASD, although their use in real educational contexts is still developing [7]. These findings suggest that the field is evolving, but still lacks a clear and structured direction, particularly from an educational perspective.

Given these challenges, there is a need for a more systematic understanding of how research in this area has developed. Bibliometric analysis provides a useful way to map publication trends, identify key contributors, and explore thematic patterns within the literature. This approach is particularly valuable for interdisciplinary fields, where research is often scattered across different domains.

However, there is still no comprehensive bibliometric study that focuses specifically on sensory-based learning for children with ASD within educational and behavioral sciences. This gap makes it difficult to identify key research directions and to understand how the field can better support inclusive education. Addressing this gap is important not only for advancing academic knowledge, but also for improving the connection between research and classroom practice.

Therefore, this study aims to analyze the research landscape of sensory-based learning for children with ASD by examining publication trends, key contributors, institutional involvement, and thematic developments. By doing so, it seeks to provide a clearer and more structured understanding of the field, while also identifying gaps that can guide future research and support more effective educational practices.

2. Literature Review

2.1 Sensory Learning and Autism in Educational Contexts

Sensory learning plays a fundamental role in the development of children with Autism Spectrum Disorder (ASD), as it shapes how individuals perceive, process, and respond to environmental stimuli. A substantial body of research indicates that atypical sensory processing is highly prevalent among children with ASD and is closely associated with differences in cognitive functioning, emotional regulation, and social interaction [2,8,9]. These sensory differences can significantly affect learning and participation in educational settings, particularly in environments that are rich in sensory input. In classroom contexts, sensory stimuli can either facilitate or hinder learning depending on how well they are aligned with individual needs. Sensory-responsive strategies such as multisensory instruction, structured sensory activities, and environmental adaptations have been increasingly adopted to improve engagement and behavioral outcomes. For example, [4] found that multisensory environments that allow children with ASD to regulate sensory input can enhance attention and reduce repetitive behaviors, suggesting clear benefits for learning contexts.

The theoretical basis for these approaches is grounded in Sensory Integration Theory, which emphasizes the role of sensory processing in adaptive behavior and learning. Empirical evidence supports the effectiveness of sensory-based interventions, with studies showing improvements in functional outcomes such as participation, self-regulation, and goal attainment [3]. These findings highlight the importance of integrating sensory-informed strategies into educational practices to support inclusive learning environments.

2.2 Interdisciplinary and Technological Developments in Sensory Learning

Research on sensory learning has evolved into a multidisciplinary field, incorporating perspectives from psychology, education, neuroscience, and health sciences. While early work focused primarily on clinical and therapeutic applications, more recent studies have increasingly emphasized the translation of sensory-based approaches into educational contexts. This shift reflects broader developments in inclusive education, where teaching practices are adapted to support diverse learners and promote engagement.

Technological advancements have further expanded the possibilities for sensory-based learning. Digital tools such as virtual reality, augmented reality, and interactive learning platforms offer immersive and personalized experiences that can be tailored to individual sensory needs. These technologies have shown potential to enhance engagement and support behavioral outcomes, particularly through personalized and adaptive learning experiences. However, their long-term effectiveness and scalability in classroom settings remain under investigation [7, 10].

In addition, growing attention has been given to sensory-adaptive environments designed to reduce sensory overload and support positive learning experiences. A recent scoping review highlights the increasing use of sensory-adaptive environments across both clinical and educational settings, while also noting the lack of clear guidelines for effective design and implementation [8, 11]. This suggests that although innovation in this area is advancing, more structured and evidence-based approaches are needed to guide practice.

2.3 Research Gaps and Need for Bibliometric Analysis

Despite the expansion of research in sensory learning, several important limitations remain. The literature continues to be fragmented across disciplines, with inconsistent terminology and diverse

methodological approaches. Much of the existing research is still grounded in clinical or therapeutic contexts, which limits its applicability to classroom practice and educational policy.

Recent studies have emphasized the need for greater integration between sensory processing research and broader educational frameworks. For example, [5] highlighted gaps in both empirical evidence and practical application, particularly in translating sensory-based interventions into real-world educational settings. Similarly, while sensory integration interventions have demonstrated effectiveness in controlled environments, their implementation in diverse and complex classroom contexts remains limited [3].

Another key limitation is the lack of comprehensive synthesis of research trends across the field. Without a structured overview, it is difficult to identify leading contributors, dominant themes, and emerging directions. Bibliometric studies in related areas have shown the value of mapping research patterns to better understand knowledge development and guide future research [6].

Therefore, bibliometric analysis provides a suitable approach for addressing these challenges. By examining publication trends, collaboration networks, and thematic developments, it enables a clearer understanding of how sensory-based learning research has evolved. This study adopts such an approach to provide a structured overview of the field and to identify gaps that can inform future research and support more effective educational practice.

3. Methodology

3.1 Research Design

This study adopts a bibliometric research design to systematically analyze the development and structure of research on sensory-based learning for children with Autism Spectrum Disorder (ASD) in educational contexts. Bibliometric analysis is suitable for addressing the identified research gap, as it enables a structured and quantitative synthesis of fragmented literature across disciplines.

3.2 Data Source and Search Strategy

The data for this study were retrieved from the Scopus database, which is recognized as one of the largest and most comprehensive sources of peer-reviewed academic literature. Scopus was selected due to its broad coverage across social sciences, education, psychology, and related interdisciplinary fields.

A systematic search was conducted on 5 March 2025 using a structured Boolean query designed to capture relevant studies on sensory-based learning and autism within educational contexts. The search string was applied to the title, abstract, and keyword fields as follows:

TITLE-ABS-KEY

("sensory learning" OR "sensory integration" OR "sensory-based intervention*" OR "multisensory learning" OR "sensory activities")

AND

("autism" OR "autism spectrum disorder" OR "ASD")

AND

("child*" OR "children" OR "school-aged" OR "primary education" OR "elementary school")

This search strategy ensured comprehensive coverage of studies related to sensory-based approaches for children with ASD in educational settings.

3.3 Inclusion and Exclusion Criteria

To ensure relevance and consistency, the dataset was refined based on the following criteria:
Inclusion criteria:

- i. Studies focusing on sensory-based learning or interventions for children with ASD
- ii. Research conducted in educational or school-related contexts
- iii. Peer-reviewed journal articles indexed in Scopus
- Exclusion criteria:
 - i. Studies focusing solely on clinical or medical treatment without educational relevance
 - ii. Non-English publications
 - iii. Conference papers, book chapters, and editorials
 - iv. Duplicate records

After applying these criteria, a total of 342 publications were included for analysis.

3.4 Data Analysis Techniques

The analysis was conducted using both descriptive statistical methods and bibliometric visualization techniques. Descriptive analysis was used to examine:

- i. Publication trends over time
- ii. Most prolific authors
- iii. Leading institutions
- iv. Country contributions
- v. Subject area distribution

To explore relationships within the dataset, bibliometric mapping was performed using VOSviewer software. This tool was used to generate:

- i. Co-authorship networks (to identify collaboration patterns)
- ii. Keyword co-occurrence maps (to identify research themes)
- iii. Co-citation networks (to reveal intellectual structure)

These visualizations provide insights into how research topics are interconnected and how the field has evolved over time.

3.5 Validity and Limitations of the Method

While bibliometric analysis provides a systematic and objective overview of research trends, several limitations should be acknowledged. First, the analysis relies solely on the Scopus database, which may exclude relevant studies indexed in other databases. Second, bibliometric methods focus on quantitative indicators such as publication counts and citation patterns, which do not assess the qualitative depth or effectiveness of individual studies. Third, variations in keyword usage and indexing may affect the accuracy of thematic mapping.

Despite these limitations, the chosen methodology is suitable for achieving the study's objective, as it enables a comprehensive and structured understanding of the research landscape. It also

provides a foundation for identifying gaps and guiding future research in sensory-based learning within educational contexts.

4. Results and Data Analysis

This section presents the findings of the bibliometric analysis, focusing on publication trends, key contributors, institutional participation, and thematic developments in sensory-based learning research. The results directly address the research questions and reflect the structure outlined in the methodology.

4.1 Publication Trends in Sensory Learning

Figure 1 illustrates the publication trends in sensory learning research over time. Between 1977 and the early 2000s, publication output remained low and inconsistent, indicating limited academic focus. A clear upward trend begins around 2005, followed by rapid growth after 2010, with a peak in 2023. This trend reflects increasing global attention to inclusive education and sensory-based approaches for children with autism. The slight decline observed in 2025 is likely due to incomplete database indexing.

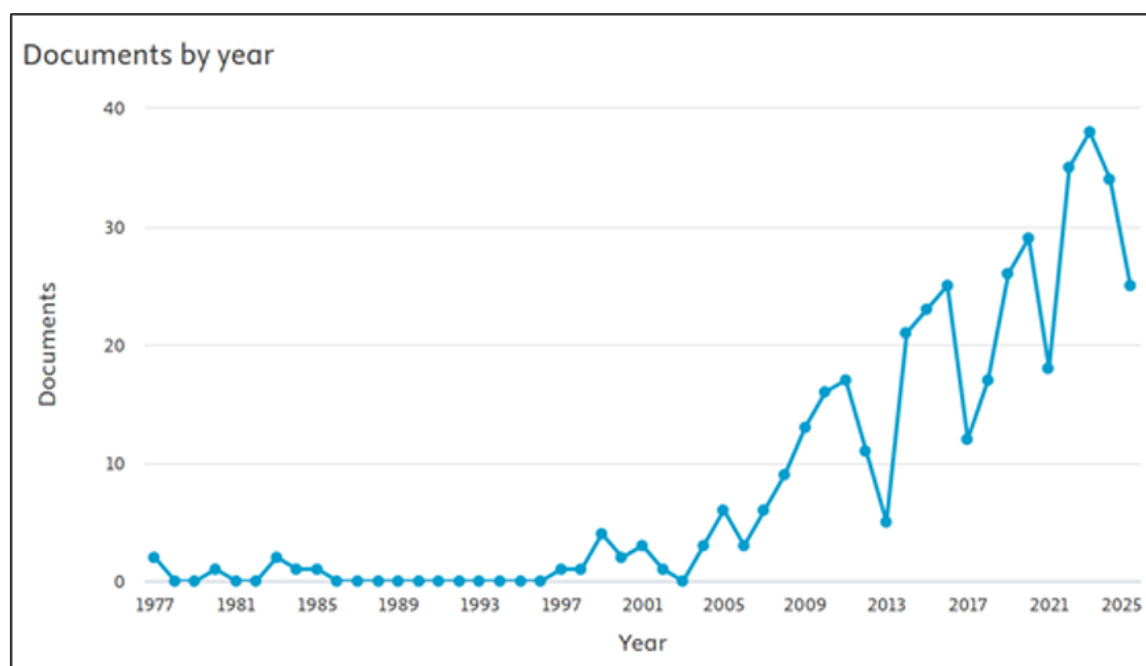


Fig. 1. Publication trends over time in sensory learning

4.2 Prolific Authors in the Field

Figure 2 identifies the most prolific authors in sensory learning research based on publication output. Schaaf, R.C. ranks as the leading contributor, followed by Mailloux, Z. and Watling, R. The concentration of publications among these authors indicates that a relatively small group of researchers has played a central role in shaping the field, particularly in sensory integration and autism-related interventions.

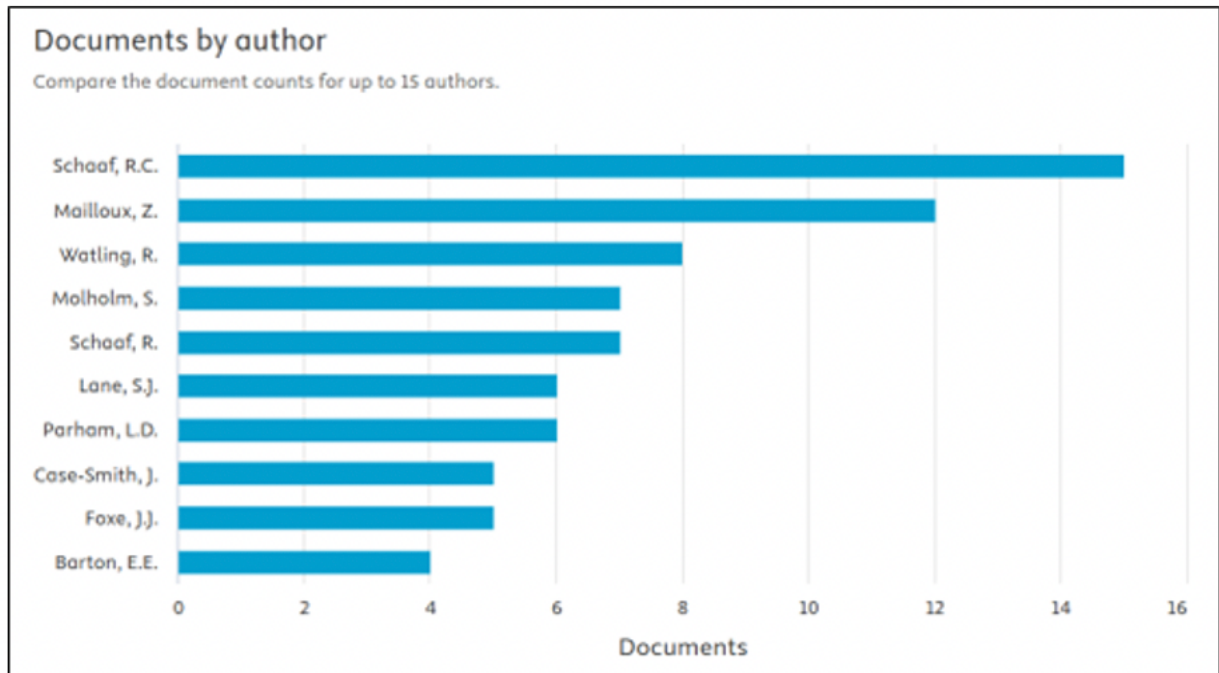


Fig. 2. List of prolific authors in sensory learning

4.3 Institutional Contributions

Figure 3 presents the leading institutions contributing to sensory learning research. Thomas Jefferson University ranks highest, followed by the University of Southern California and Vanderbilt University. These institutions demonstrate sustained research productivity, indicating strong institutional support and specialization in sensory-based interventions. The distribution also reflects an internationally connected but concentrated research network.

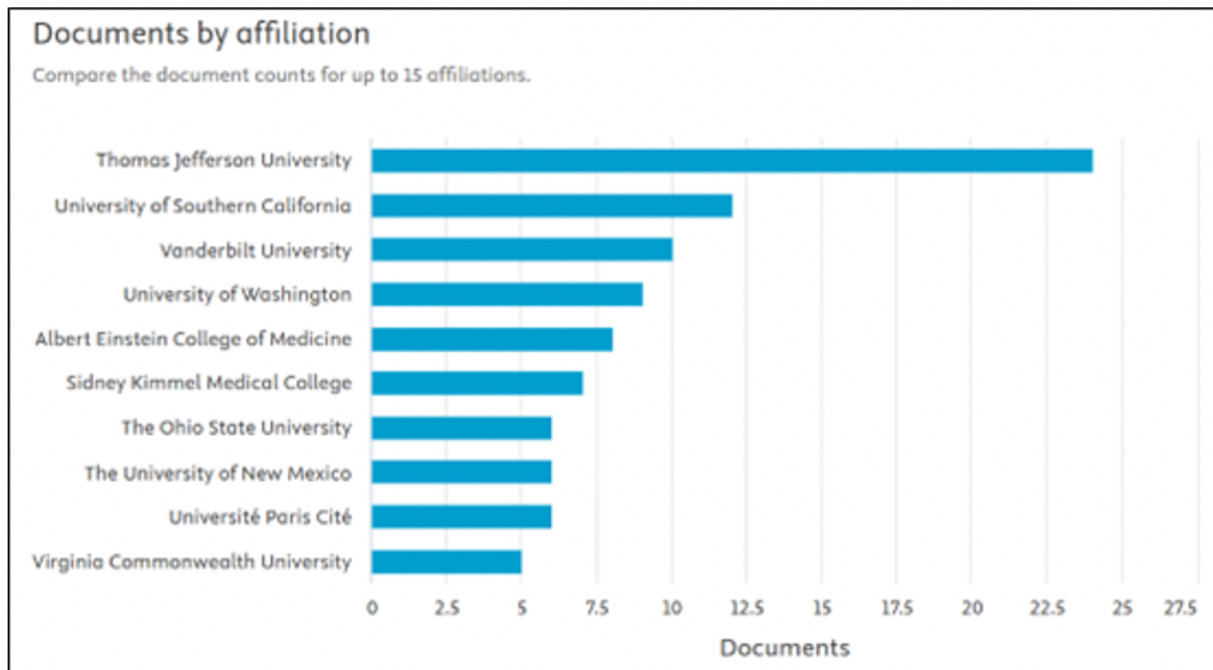


Fig. 3. Top contributing institutions in sensory learning

4.4 Leading Journals and Publication Distribution

Figure 4 presents the leading journals contributing to research on sensory learning, based on publication output and distribution over time. The results indicate that a small number of journals account for a significant proportion of publications in this field, reflecting a concentration of research within specific academic outlets. These journals are primarily associated with disciplines such as psychology, occupational therapy, education, and health sciences, highlighting the interdisciplinary nature of sensory learning research.

The analysis also shows that publication activity within these journals has increased notably after 2005, aligning with the overall growth of the field. Several journals demonstrate consistent contributions across multiple years, indicating their role as key platforms for disseminating research on sensory-based interventions and autism. The presence of both specialized and broader interdisciplinary journals suggests that sensory learning research is not confined to a single domain but spans multiple areas of social and behavioral sciences.

Overall, the findings emphasize the importance of these leading journals in shaping the development of the field and providing avenues for future research dissemination.

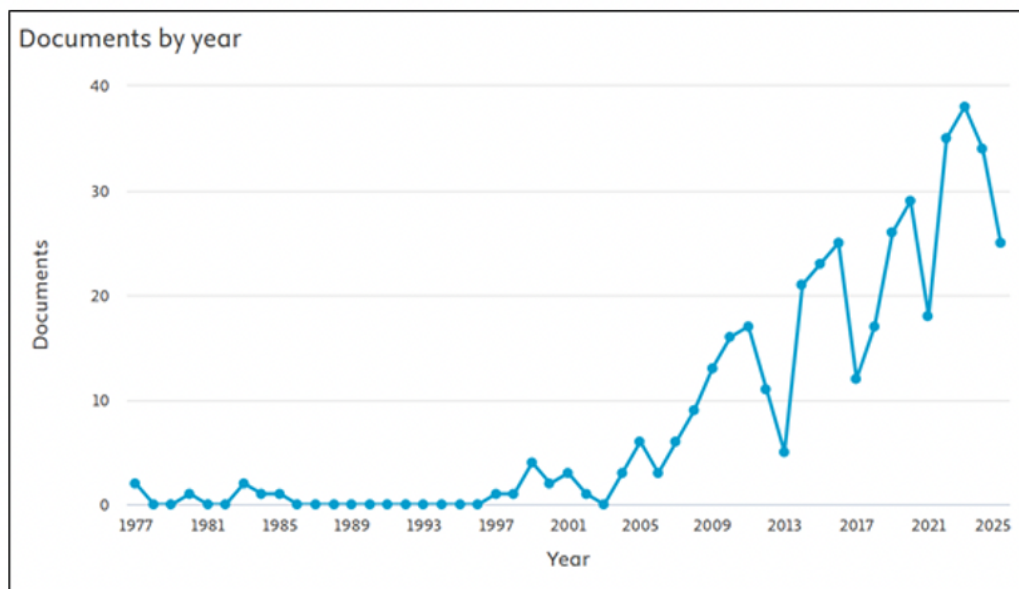


Fig. 4. Top journals in sensory learning with publication counts and years

3.5 Country Contributions

Figure 5 shows the distribution of publications by country, highlighting the global research landscape. The United States leads by a substantial margin, indicating its dominant role in advancing sensory learning research. Other countries, including China, Australia, India, and the United Kingdom, contribute moderately, reflecting growing international engagement. However, the concentration of research in high-income countries suggests an imbalance in global research representation.

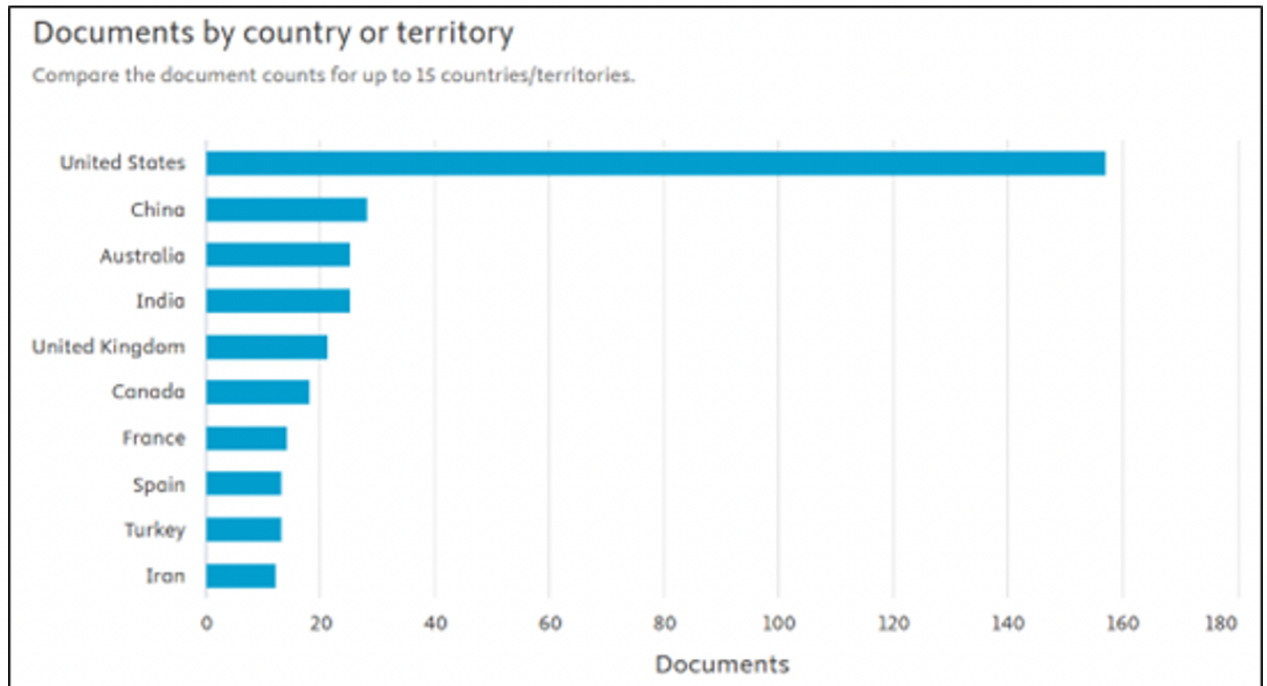


Fig. 5. Top contributing countries in sensory learning

4.6 Subject Area Distribution

Figure 6 presents the distribution of publications across subject areas, revealing the interdisciplinary nature of the field. Medicine (30.0%), Psychology (17.8%), and Health Professions (14.5%) dominate the research landscape, indicating a strong clinical orientation. In contrast, Social Sciences (7.7%) and Education-related fields are less represented, highlighting a gap between research production and educational application. The presence of Computer Science and Engineering reflects emerging interest in technology-supported interventions.

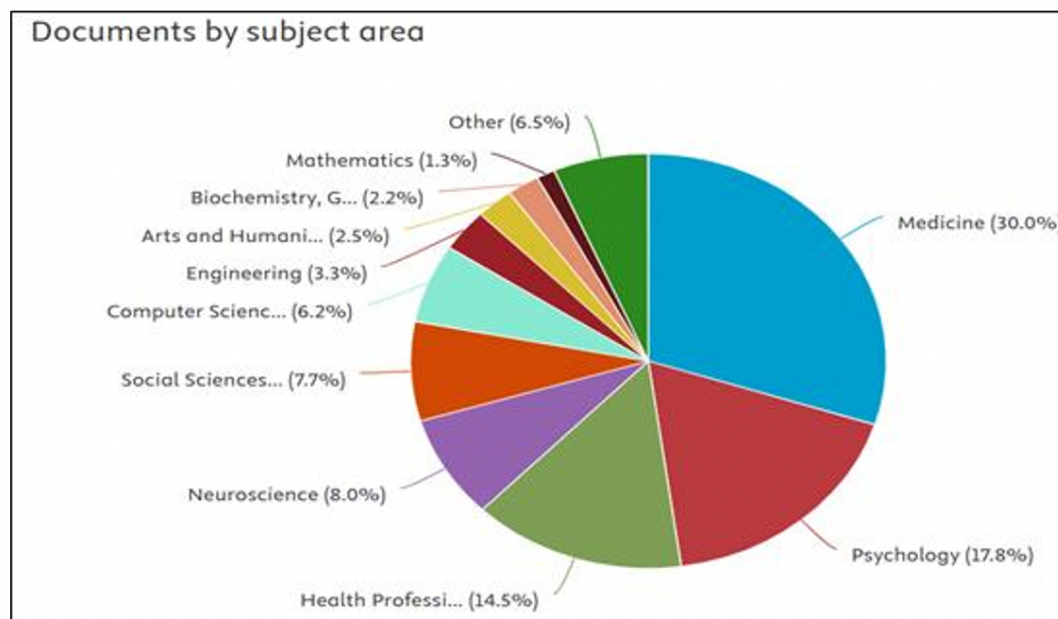


Fig. 6. Subject areas in sensory learning research

4. Discussion

The findings of this study provide a clearer understanding of how research on sensory-based learning for children with Autism Spectrum Disorder (ASD) has developed over time and how it relates to broader trends in inclusive education. The steady increase in publication output, particularly after 2005 and peaking in 2023, reflects growing recognition of the role sensory processing plays in learning and behavior. This pattern aligns with recent work highlighting the expanding focus on sensory-related challenges within autism research and intervention [5, 6].

At the same time, the results show that the field continues to be shaped largely by clinical and therapeutic perspectives. The dominance of subject areas such as medicine, psychology, and health professions suggests that sensory-based learning is still primarily framed as a clinical concern rather than an educational one. This is consistent with earlier findings that many sensory interventions are developed and tested in controlled clinical environments, where conditions differ significantly from real classroom settings [3]. As a result, there remains a gap between what research demonstrates and what can realistically be implemented in schools. Previous reviews have also pointed to this issue, noting that evidence for classroom-based application remains limited and inconsistent [12].

The patterns observed in authorship and institutional contributions reinforce this imbalance. A relatively small group of researchers, many with backgrounds in occupational therapy and clinical practice, continues to influence the direction of the field. While their work provides a strong foundation, the limited presence of education-focused researchers suggests that classroom perspectives are still underrepresented. This raises an important concern about whether current research is sufficiently grounded in what teachers actually need in practice.

The global distribution of research highlights a similar issue. The dominance of high-income countries, particularly the United States, reflects strong research infrastructure and funding. However, it also points to uneven global representation. Contributions from countries such as China, India, and Australia indicate growing engagement, yet many educational contexts remain underexplored. This pattern is consistent with broader trends in autism research, where knowledge production is concentrated in a limited number of regions [13]. Consequently, the applicability of findings across diverse cultural and educational settings remains uncertain.

The thematic analysis reveals both continuity and change within the field. Core concepts such as “autism” and “sensory integration” remain central, reflecting the ongoing relevance of foundational theories. At the same time, emerging themes such as “multisensory learning” and “sensorimotor processing” suggest a shift toward more integrated and learner-centered approaches. This shift is supported by empirical evidence showing that multisensory environments can enhance engagement and reduce behavioral challenges when applied in educational settings [4]. In addition, classroom-based studies indicate that sensory-friendly adaptations can improve participation and learning outcomes for children with ASD [14].

Another notable development is the increasing role of technology in sensory-based learning. Digital tools such as interactive platforms, virtual reality, and adaptive learning systems are being explored as ways to support individualized sensory experiences. These technologies offer promising opportunities for enhancing engagement and personalization, particularly for learners with diverse sensory needs. However, evidence regarding their long-term effectiveness and practical integration into classroom environments remains limited, particularly in real-world educational settings where contextual factors play a significant role [7, 8, 10]. This suggests that while technological innovation is advancing rapidly, research on real-world implementation is still catching up.

The co-citation analysis further illustrates the interdisciplinary nature of the field, with research spanning occupational therapy, developmental psychology, sensory processing, and neuroscience.

While this diversity strengthens the field, it also contributes to fragmentation. Educational research, in particular, is less prominent, reinforcing the need for stronger integration between clinical knowledge and educational practice, especially in translating intervention outcomes into classroom-based strategies [15].

Overall, the findings confirm the central issue identified earlier in the study. Research on sensory-based learning is expanding, but it remains fragmented and not yet fully aligned with educational needs. Sensory processing is widely recognized as a key factor influencing learning and behavior in children with ASD [1], yet translating this knowledge into effective classroom strategies remains a challenge.

Moving forward, there is a need to strengthen the connection between research, policy, and practice. Future studies should place greater emphasis on classroom-based research, teacher perspectives, and context-sensitive interventions. In addition, interdisciplinary collaboration should be expanded to ensure that insights from clinical, psychological, and educational research are effectively integrated. Addressing these challenges will be essential for advancing inclusive education and improving learning outcomes for children with ASD.

5. Conclusions

This study analyzed the research landscape of sensory-based learning for children with Autism Spectrum Disorder (ASD) using a bibliometric approach, with the objective of identifying publication trends, key contributors, institutional involvement, and thematic developments within the field. The findings show a significant increase in research output since 2005, with a peak in 2023, indicating growing global attention toward inclusive education and sensory-based approaches.

The analysis identified a core group of influential authors and leading institutions that have shaped the field, particularly within psychology and health-related disciplines. The results also reveal that research contributions are concentrated in high-income countries, with the United States leading in publication output, while emerging participation from other regions indicates expanding global interest. In terms of subject areas, the field remains dominated by medicine, psychology, and health professions, although contributions from education, computer science, and engineering are increasing.

Furthermore, the study identified key research themes centered on sensory integration, autism, and learning engagement, alongside emerging topics such as multisensory learning and technology-supported instruction. These findings demonstrate that while the field is evolving toward more interdisciplinary and adaptive approaches, there is still limited emphasis on educational implementation and classroom practice.

Overall, the findings of this study respond directly to the research objectives by providing a structured understanding of how sensory-based learning research has developed and where gaps remain. The study highlights the need for greater focus on education-oriented and practice-based research to support teachers and improve classroom application. Strengthening the integration between research, policy, and educational practice will be essential for advancing inclusive learning environments and improving outcomes for children with ASD.

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