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Multisensory teaching and learning research: a bibliometric analysis using R-Biblioshiny

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ABSTRACT

Multisensory teaching and learning have emerged as an important pedagogical as well as instructional approach to enhance students' engagement, comprehension, and retention. The study shows how the multisensory teaching and learning research area develops through existing research patterns and intellectual patterns. The study has obtained bibliographic information from the Scopus database. The first identification process detected 688 documents, which were examined according to preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, finally 148 documents being selected for bibliometric assessment after a screening process. For this study the investigator has used R Studio software with the Bibliometrix package and Biblioshiny interface to conduct data analysis. Research on multisensory teaching grew exponentially from a sparse, peripheral interest between 2000 and 2026, peaking at 29 articles in 2025. The United States has the largest overall output, but the highest average citation impact is in Germany and Australia. The intellectual structure of the field is composed of three clusters of sensory mechanisms, learning theories, and educational applications. Technology-enhanced learning, inclusive education, and multimedia strategies are identified as priority areas that are underdeveloped. The findings highlight the importance of interdisciplinary collaboration, methodological rigor, and equitable use of knowledge globally to advance multisensory approaches in educational practice. It also highlights the importance and necessity of adopting multisensory instruction for enhancing the students' understanding of different subjects related concept.

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1. INTRODUCTION

Recent trends in pedagogical practices emphasize the use of learner-centered teaching methods as an important factor for increasing student engagement through multisensory experiences. Multisensory instruction is defined as the use of several senses (i.e., visual, auditory, tactile, and kinesthetic) to create a meaningful learning experience. These multisensory instructional approaches are based on cognitive psychology and neuroscience. It shows the areas of the brain develop stronger connections if senses are used together when learning occurs. If students use several senses when interacting with content, it creates stronger connections in the brain; therefore, it results in higher levels of understanding, retention, and application of knowledge. The literature highlights different studies conducted in numerous educational

settings that have proven the increases in student achievement and engagement through multisensory instructional strategies. Numerous studies have shown that students who have the opportunity to participate in multisensory learning experiences exhibit increased levels of academic achievements. It has developed more positive attitudes towards learning when compared to the accomplishments of students who were taught using traditional instructional methodologies [1]. Some studies have shown that at-risk students' decoding skills, letter knowledge, and phonological awareness have improved significantly with a structured multisensory tutoring program [2].

The use of multiple senses in both the teaching and learning processes within a classroom is grounded in a number of key theoretical concepts that help to explain how individuals take and store information via different sensory channels. The dual coding theory of Paivio [3] defines that oral and written forms of data will produce much better performance and retention of said information when presented together. when only one channel is used. For example, in terms of classroom instruction, being able to present an explanation verbally and visually (such as by using pictures, charts, or written materials) will support greater levels of comprehension by the student than if only one channel had been used. The cognitive theory of multimedia learning [4], [5] also supports a multisensory instructional approach to student learning by indicating that students utilize separate but limited channels for visual and auditory processing. Both the dual coding and multimedia learning theories justify the use of multimedia tools like animations, videos, and interactive presentations in teaching literacy and numeracy skills to students. Using these methods can significantly improve students' ability to learn via multiple sensory channels. The embodied cognition theory [6], [7] argues that physical activity and sensory experiences provide a strong basis for how students learn and build new knowledge; therefore, students will build knowledge through movement, tactile sensation, and interaction with the environment.

The use of multiple sensory modalities in teaching and learning has also been extensively researched in the areas of literacy development, language learning, and classrooms designed for special education students. Research findings indicate that multisensory methods used in reading intervention programs have positive impacts on letter recognition, word reading, and spelling of children with dyslexia, as well as in developing children [8]. In the area of early childhood education, a phonics-based, multisensory approach to learning has produced greatly improved pre-reading skills in 4-5-year-old children compared to traditional approaches [9]. Engaging multiple sensory pathways during instruction will support deeper cognitive processing; it is resulting in improvements to early literacy development. There are several other educational fields that utilize multisensory instructional strategies, including science education, medical training, and technology-enhanced learning environments. In medical education, multisensory methods of training have improved knowledge acquisition and procedural skills while also building learners' confidence in their skills as health care providers [10]. In addition, tactile learning tools and models have been shown to assist in concepts of abstract science in the chemistry education [11].

Technological development has extended the boundaries of what can be done with multi-sensory learning. New technology has created a variety of new ways to learn, including augmented and virtual reality (VR), as well as multimedia and interactive digital content. All of these materials provide learners with multiple opportunities for multisensory input at the same time. Research incorporating augmented and VR into language teaching has found positive effects for both vocabulary development and sentence structure among learners [12]. This research provides further evidence of the influence of multisensory-based teaching in the present education system. While the current literature related to multisensory teaching and learning is steadily increasing. It is essential to conduct a systematic examination of the intellectual structure, current research trends, and seminal works within the multisensory teaching and learning domain. The study is guided by the following research questions:

- What are the publication trends and countries' scientific production in multisensory teaching and learning research from 2000 to 2026?
- Which are the most cited authors and countries contributing to research on multisensory teaching and learning?
- What are the dominant research themes, most relevant keywords, and co-occurrence networks among keywords in multisensory teaching and learning research?

Methodologically, bibliometric analysis is an excellent way to investigate the development of the scientific knowledge of a research area. Therefore, the present study aims to explore the growth, intellectual structure, and global research trends in multisensory teaching and learning.

2. LITERATURE REVIEW

The past studies have found that the multisensory approach is helpful for increasing student attentiveness, understanding, and memory retention. In the multisensory instructional methods, students

receive instruction through multiple sensory channels. A student's learning occurs through visual, auditory, tactile, and kinesthetic channels of experience. The multisensory instructional approach is especially helpful for addressing the varying learning preferences of learners, as well as getting learners to participate actively in the instructional process. The early studies conducted on the use of multisensory instruction found it to be effective in the improvement of academic performance by engaging students. It is also demonstrated that students who were instructed using a multisensory approach possessed a more positive attitude toward learning than students who received traditional instruction. For example, Farkas [1] explored that multisensory-instructed students had significantly higher performance academically and were more positively affected by the learning experience compared to students who received traditional instruction. These findings substantiate the potential for a multisensory instructional approach to enhance both cognitive and non-cognitive components of the learning experience.

The multisensory approach to teaching and learning can significantly enhance student understanding, engagement, and retention of knowledge, while also influencing learning across multiple subjects and settings, according to researchers. Saputra and Nugroho [13] concluded that a combination of visual, auditory, tactile, and kinesthetic activities, created through the use of multisensory applications, improved reading achievement among dyslexic children. In addition, Agustia and Arifin [14] found that the visual, auditory, kinesthetic, and tactile (VAKT) model was successful in improving alphabet and number learning in students with intellectual disabilities. The touch math multisensory method improved the early math skills of children with mild intellectual disabilities [15] and computer-based multisensory training helped increase primary students' arithmetic skills as well as their spatial understanding of numbers [16]. In science classrooms, Magana *et al.* [17] found that use of haptic and visual support enhanced student conceptual understanding of physics. According to Alwashmi *et al.* [18], using VR for multisensory training has been found to help with learning by stimulating specific areas within the brain that are used in multisensory integration. Kucirkova and Kamola [19] highlights how engaging children through multisensory storytelling resulted in their enhancement of creativity through visual and tactile experiences. The study by Ferrando *et al.* [20] also shows that using multisensory technologies can increase the amount of interaction and participation between students in the classroom. Alenizi [21] found that these strategies significantly helped students who have faced difficulty in learning by increasing their ability to perceive visually and comprehend written text. Furthermore, Covaci *et al.* [22] argued that utilizing modern multisensory technologies to create immersive learning environments is beneficial, as it provides a much richer and engaging educational experience compared to traditional methods of using multimedia. With these studies all demonstrating that multisensory instruction is an essential method of delivery within today's educational settings, supporting inclusive education, improving academic performance, promoting student engagement, and developing higher-order thinking and problem-solving abilities across all content areas.

Some studies show a structured multisensory language approach helps children with reading difficulties as well as typical learners in the areas of phonological awareness, decoding skills, word recognition, and spelling skills [8]. The experimental research conducted on tutoring programs using multisensory models has also demonstrated a significant gain in letter knowledge, phonological awareness, and decoding skills among children at risk for reading difficulties [2]. In the area of early childhood education, multisensory instructional strategies have been found to be supportive of building the foundational literacy skills among students. A study of phonics-based multisensory learning showed that preschool children who were taught with these methods made significantly more gains in their pre-reading skills than children who were instructed in a traditional teaching method [9].

Multisensory teaching methods have been utilized in a variety of language learning contexts. Research has shown that when students use visual cues, sounds, and motor actions, their ability to learn new vocabulary in a different language can be greatly improved. In the area of inclusive education and special education, research on the use of multisensory teaching methodology has been conducted. The use of multisensory instruction techniques has been shown to improve the vocabulary development and communication skills of students with speech and hearing impairments, field [23]. Multisensory phonological intervention programs have been shown to improve phonological processing and reading comprehension in deaf students [24]. The importance of multisensory instruction can be seen by the impact. It has been made for diverse learners. In other areas of education, such as science and higher education, there are numerous applications for the use of multisensory learning techniques. For example, tactile models have been used to help students to visualize complex molecular structures and the forces interacting between them in the study of the chemistry [11]. In medical education, there have also been applications of multisensory teaching techniques.

With advancements in technology, the development of multisensory learning has evolved over time. These multisensory platforms use immersive technologies such as VR along with multimedia learning tools to create opportunities for experiential and engaged ways of learning. For example, Chen and Liu [12] show

that the immersive VR environments can dramatically enhance vocabulary development, comprehension, and engagement levels among language learners. Additionally, within the realm of storytelling, multisensory storytelling experiences have been shown to have positive effects on listening comprehension and further motivate students toward learning to tell stories. From a cognitive standpoint, the application of brain research supports the value of multisensory-based learning experiences. Research has confirmed that the brain's process in response to multisensory learning enhances and creates new neural synapses within the various areas of the brain required for processing sensory information [25]. This further supports the rationale of using multisensory teaching practices within educational settings.

While there is an expanding amount of research on multisensory teaching and learning, gaps still exist within the research. There is no systematic bibliometric analysis to provide an overview of the intellectual structure and global trends of the research, but there is also a lack of highlighting of key contributors and key themes of the evolution of multisensory teaching and learning research. Therefore, a comprehensive bibliometric review of the current literature is needed to synthesize previous research and identify fundamental research patterns and emerging lines of inquiry within this domain.

3. METHOD

3.1. Research design

A bibliometric design was selected because it allows systematic, quantitative mapping of publication trends, influential contributors, and thematic evolution in a fragmented research field. This study employed a bibliometric analysis approach, a quantitative methodology that systematically measures patterns within large sets of publications [26], [27]. Bibliometrics, a branch of scientometrics, enables evaluation of scientific output and activities within particular research fields [28]. The method constructs a general overview of scholarly disciplines according to publications, journals, and authors [29]. This study adopted a two-phase approach integrating performance analysis and science mapping to comprehensively examine the global research trend and intellectual landscape in multisensory teaching and learning across the world. For this study, the bibliometric analysis was conducted using Biblioshiny, the web interface of the Bibliometrix package in R [30]. The bibliographic data for this study have been collected from the Scopus database, which is one of the largest and most comprehensive databases of peer-reviewed literature. The Scopus database has been selected because of its wide coverage of high-quality academic publications across multiple disciplines and its suitability for bibliometric analysis. As it is a reputed database and the sources in the Scopus database are reliable for this study.

3.2. Search string

The search conducted in the Scopus database by using the TITLE-ABS-KEY field with the string ((“multisensory teaching” OR “multisensory instruction” OR “multisensory learning” OR “multisensory approach” OR “multisensory education” OR “integrated sensory teaching”)) on 12 March 2026 retrieved 688 documents related to multisensory teaching and learning. The use of multiple synonymous terms ensured broad coverage of the topic. The researcher has used the Scopus database because it acts as a high-quality “map” of global scientific research. It combines a massive collection of articles with specific tools that help people see which research is the most influential and where new ideas are growing.

Figure 1 depicts the preferred reporting items for systematic reviews and meta-analyses (PRISMA) flowchart, illustrating how the systematic study selection process was conducted in this study. For the identification phase, a total of 688 records were found using the Scopus database. Of these, two duplicates were removed from screening, leading to a total of 686 records available for analysis. All 686 records were screened for title and abstract, resulting in the exclusion of 444 records that did not meet the inclusion criteria. After screening, attempts were made to retrieve the full report of the remaining 240 articles; all 240 reports were successfully retrieved. The 240 full-text articles were evaluated for eligibility. After going through this evaluation process, 75 of the studies evaluated were excluded from this report because they were either review articles, conference papers, or book chapters; 10 were published in a language other than English; and 7 had not been published yet, as these articles are in processing. Finally, 148 studies were included in this review, as they met all of the inclusion criteria.

3.3. Information overview (R Studio)

Figure 2 shows that multisensory teaching and learning is an emerging field in social science research with an 11.76% annual average growth rate of the number of multisensory teaching and learning studies published between 2000 and 2026. This rapid growth indicates a greater number of researchers are becoming interested in this area of study from a wide range of research disciplines. The fact that 148 documents have been published in 118 different sources indicates that multisensory teaching and learning is an interdisciplinary area of study that is fragmented and dispersed throughout different fields such

as educational psychology, educational technology, mathematics, and pedagogy. The multisensory teaching and learning researchers tend to collaborate on their studies with a total of 416 authors publishing a total of 148 papers (2.87 co-authors on average), but the percentage of international collaboration among multisensory teaching and learning researchers are moderate at only 18.92%. The 622 keywords used to describe the multisensory teaching and learning studies also reveal that there are many different themes being studied. Additionally, researchers have mostly published multisensory teaching and learning studies within the past 5.82 years (average document age), and the number of times multisensory teaching and learning studies have been cited has been moderate (8.946 citations per document). All of this data suggests that multisensory teaching and learning is a growing area of research.

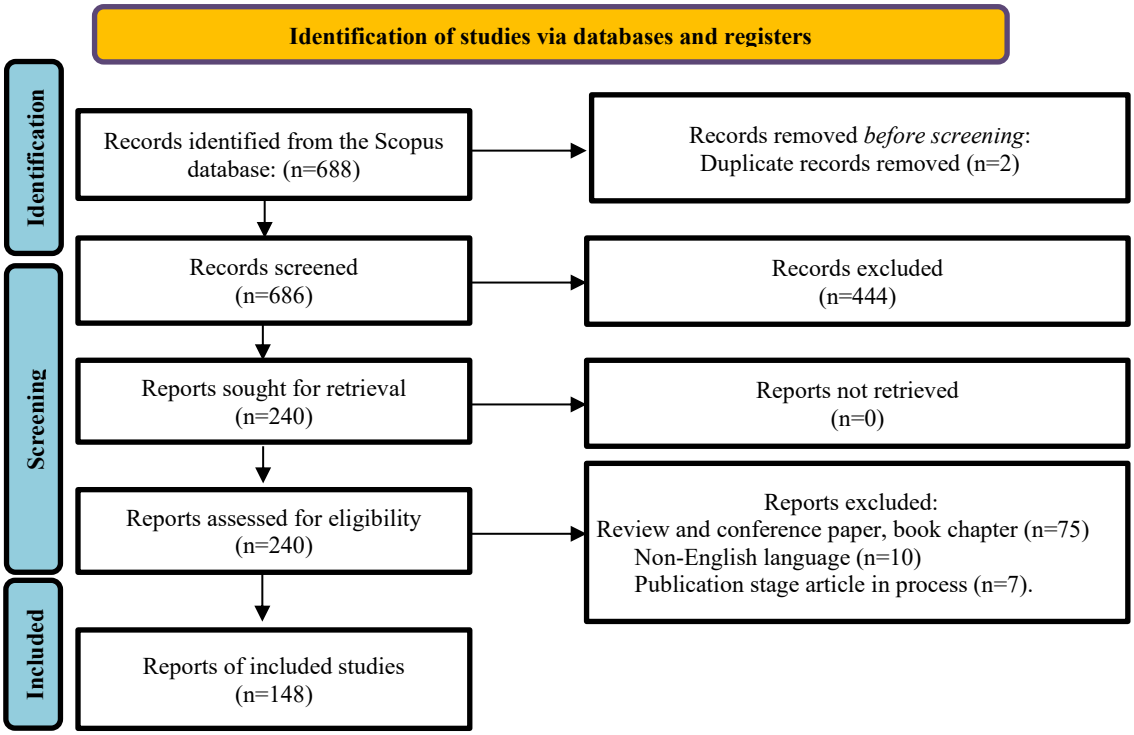

Figure 1. PRISMA flowchart for article inclusion and exclusion criteria

Figure 2. Information overview (R Studio) on multisensory teaching and learning research

4. DATA ANALYSIS

Bibliometric analysis is widely used to examine the structure, trends, and development of scientific research within a particular field [31]. Bibliometric analysis has been performed using the bibliometrix package in R [30]. The analysis comprised two main components: Performance analysis to evaluates the productivity and impact of authors and country-based publications and citation impact [31]. Performance analysis was conducted using bibliometric techniques implemented in the bibliometrix R package [30].

4.1. Publication and citation analysis

4.1.1. Publication trend over time

Figure 3 illustrates that there was far less research done on the topic of multisensory teaching and learning in the first decade (2000-2011). Publications during these years were predominantly between 0 and 3 articles per year, with no publication output during 2006 and 2007. From 2012 to 2019, there was a slow, yet fluctuating, increase in research output, as evidenced by, for example, six articles published in 2012 and 2017, creating a trend for increasing recognition and use of multisensory teaching and learning; however, research output continues to be sporadic. The impact of these fluctuations creates an overall trending of increased recognition and utilization of multisensory education. From 2020 onward, there was a clear and significant increase in research output on multisensory teaching and learning, as demonstrated by the doubling of articles published per year to double digits (e.g., 13 articles published in 2020) along with a consistent pattern of increased articles published per year through subsequent years (e.g., 29 articles published in 2025). Although there is a slight drop from 29 to 18 articles published in 2026, the overall pattern of research output shows that multisensory teaching and learning have significant ongoing research attention in recent years and have developed into a significant and well-studied subject.

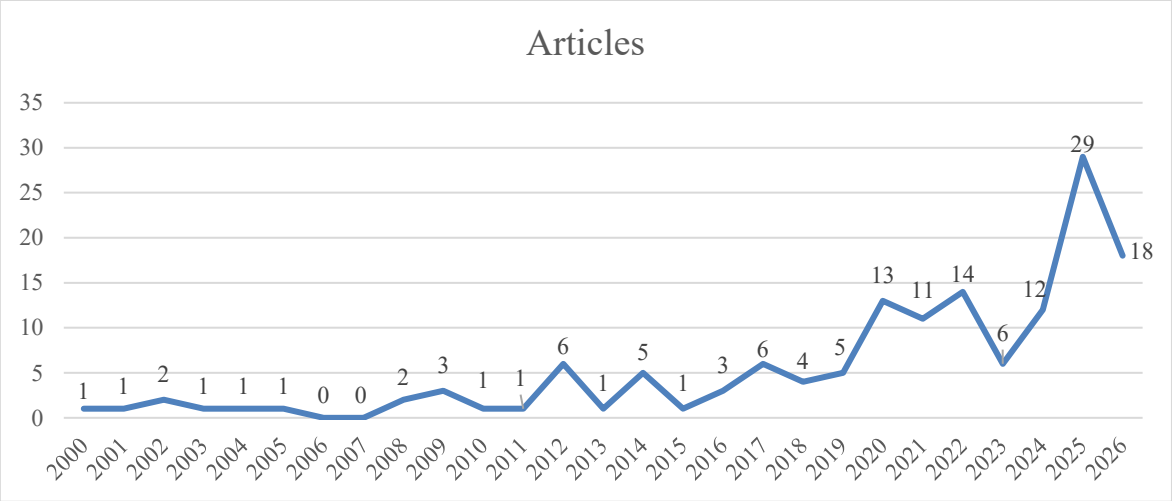

Figure 3. Publication trend over time

4.1.2. Countries' scientific production

Table 1 describes the distribution of publications on multisensory teaching and learning by country and indicates an unequal distribution; however, there are publications available from around the world. The United States of America (USA) had the most publications (70). The USA's large number of publications indicates that multisensory teaching and learning is well researched and supported in the USA. This may be due to larger amounts of funding for research, established research infrastructures associated with education, and a strong emphasis on developing innovative and inclusive pedagogical approaches. The United Kingdom (UK) ranked second with 24 publications, which illustrates that while the UK contributed relatively few publications compared to the USA, they have produced a significant number. Other developing countries such as Indonesia (17) continue to have strong representations in this area, and their success indicates an increasing need for multisensory learning approaches in many educational contexts around the world.

The European countries of Germany, Italy, and Spain (16, 12, and 9, respectively) all have evidence of continuing involvement in this field of research. The degree of interest in improving learning and teaching through use of multisensory strategies is steady across all three European countries. China also has significant involvement with 15 publications, suggesting that this area is not only the domain of Europe and the USA but also of Asia, which is rapidly emerging as a strong contributor to research globally. Jordan (8) and Saudi Arabia (7) are representative of new involvement coming from the Middle East, and their early successes indicate that multisensory teaching will continue to develop as a popular method of instruction in these countries as well. Canada's contribution (6) to this body of literature is much smaller than that of the USA; however, its presence helps to show that North America is becoming a strong contributor to the international research associated with multisensory teaching and learning.

Table 1. Countries' scientific production

Country	Frequency
USA	70
UK	24
Indonesia	17
Germany	16
China	15
Italy	12
Spain	9
Jordan	8
Saudi Arabia	7
Canada	6

4.1.3. Most influential authors

Table 2 depicts the distribution of multisensory teaching and learning publications by author, showing a relatively even distribution with no one author dominating the discipline. There are nine authors who have published two times each [8], [32]. Each of these authors has shown a similar and consistent amount of involvement in this field, suggesting multiple researchers are creating research on this subject area at the same time instead of a few prolific researchers dominating the discipline. Many of these authors may also be working together on different studies, indicating there are many interprofessional and collaborative researchers working on this subject, which is typical in multisensory teaching and learning research. It draws upon the ideas from education, psychology, neuroscience, and linguistics. In addition, the presence of Khazaleh *et al.* [33] as an occasional contributor highlights the larger pool of contributors providing future growth and diversity for the field of multisensory learning. There is a relatively equal distribution of top authors; therefore, they provide evidence that the field is continuing to grow and develop, rather than being dominated by a select group of eminent researchers. This is evident in the multisensory teaching and learning. The research community is a collaborative and developing research environment with many researchers from many disciplines continuing to build upon the body of work being generated by this community.

Table 2. Most influential authors

Author	Articles
Andrä C.	2
Macedonia M.	2
Mareschal D.	2
Mathias B.	2
Nikielska-Sekuła K.	2
Osborne T.	2
Pishghadam R.	2
Schwager A.	2
Von Kriegstein K.	2
Abzakh Hom	1

4.1.4. Author-wise citation impact and productivity

Table 3 elucidates data from author-wise citation impact and productivity related to the field of multisensory teaching and learning. It is showing distinct patterns in the collaboration of authors, time-related impact of publications, and how citations move through time. Evidence emerges from the analysis of multiple authors ('core' author group) [33], [34], the combined data for the cluster show identical values for 2020 (total citation (TC)=70, total citations per year (TCpY)=10) and again for 2022 (TC=20, TCpY=4). The number of collaborative authors on multiple highly cited studies demonstrates strong evidence of co-authorship among the authors. The peak of impactful research within this core group was in approximately 2020, representing a time of high-quality published works. The declining number of TCpY from 2020 through 2022 is expected as older works continue to receive citations; therefore, newer works like those of Nikielska-Sekuła [35] (2024 and 2026) are beginning to receive citation recognition as they are currently in the early stages of being cited. While both Broadbent *et al.* [36] demonstrate consistent collaboration over the years, the collaborative work of the two authors differs. Specifically, the 2018 publication produced a greater impact (TC=27, TCpY=3) than the 2020 publication (TC=13, TCpY=1.85); this demonstrates that the earlier work of the authors allowed them to positively influence their colleagues in the field at an earlier time than is currently possible for more recent publications by Nikielska-Sekuła [35].

Table 3. Author-wise citation impact and productivity

Author	year	freq	TC	TCpY
Andrä C.	2020	1	70	10
Macedonia M.	2020	1	70	10
Mathias B.	2020	1	70	10
Schwager A.	2020	1	70	10
Von Kriegstein K.	2020	1	70	10
Nikielska-Sekuła K.	2024	1	18	6
Andrä C.	2022	1	20	4
Macedonia M.	2022	1	20	4
Mathias B.	2022	1	20	4
Schwager A.	2022	1	20	4
Von Kriegstein K.	2022	1	20	4
Nikielska-Sekuła K.	2026	1	4	4
Mareschal D.	2018	1	27	3
Osborne T.	2018	1	27	3
Mareschal D.	2020	1	13	1.85
Osborne T.	2020	1	13	1.85
Pishghadam R.	2019	2	14	1.75
Abzakh Hom	2024	1	0	0

Jajarmi and Pishghadam [37] stand out in the research contributions, with a total of 2 publications and 2 citation impacts, but with the TC impact per publication being lower (i.e., 1.75). This indicates that while Jajarmi and Pishghadam [37] has contributed steadily, they have not yet had an extensive influence within each publication he has produced. Khazaleh *et al.* [33] appears to be a new author who is highly likely to have very few citations because of this publication date. New authors will typically take time to build up their citation records, so zero citations for Khazaleh *et al.* [33] would be expected during this relatively early stage of their publishing history. The findings indicate that multisensory teaching and learning research is characterized by collaborative research clusters and is timed. Higher citation counts are consistently achieved by co-authored publication groups, which tend to be published before the current year in the past year, allowing for them to become more visible and build up a larger number of citations over time. Also, it shows that although new contributors are being added to this body of research and multiple smaller publications are occurring, the new author's contribution has a time requirement before it can gain influence. Overall, the field reflects a collaborative and evolving body of research with high levels of concentration among major research groups, while at the same time, new contributors to this area will continue to emerge to contribute to the rich body of multisensory instructional and learning literature.

4.1.5. Most cited countries

Table 4 explains country-by-country citation analysis of multisensory teaching and learning studies in Scopus. It shows notable variations in citations, as indicated by both TC and the number of average article citations (AAC), and therefore, both how much impact and how much quality are reflected in the research and how it influences studies produced in those countries. The USA has a total of 253 TC and an average of 13.3 article citations, which demonstrates a high overall contribution and has a lasting influence on research. Other countries with higher average citations per article include Australia, with an average of 32.5 article citations, and Germany, with an average of 28.4 article citations. Both countries produce fewer articles on multisensory teaching and learning than the USA; however, given the greater numbers of AAC per article produced in Australia and Germany, their research generally yields more impact and visibility for that individual article. Thus, these countries are contributing very high-quality and very high-impact research to the field.

Table 4. Most cited countries

Country	TC	AAC
USA	253	13.3
Germany	142	28.4
Australia	130	32.5
UK	101	11.2
China	60	6.7
Switzerland	50	16.7
Canada	49	16.3
Italy	49	7
Norway	29	7.2
Spain	29	5.8

The UK shows a TC of 101 and an AAC of 11.2, which indicates average total and AAC. Similarly, Switzerland (16.7) and Canada (16.3) also have high AAC and relatively low TC, indicating efficient and impactful research output in these countries. Conversely, China (6.7), Italy (7.0), Norway (7.2), and Spain (5.8) have lower average AAC to date, indicating that these countries are producing research on multisensory teaching and learning; however, the global impact and recognition of that research in terms of citations per article are not currently reflecting total impact on citations. The analysis indicates that leadership in multisensory teaching and learning research is not only measured by the volume of publications but also by the impact of published articles' citations. Although the USA has the highest total impact across multisensory education research, there are countries like Australia and Germany that have substantially higher AAC.

4.2. Science mapping

Science mapping techniques are widely used to visualize relationships among research themes, authors, and keywords within a scientific domain [38]. Science mapping is widely used in bibliometric studies to visualize collaboration networks, keyword co-occurrence, and citation relationships [31].

4.2.1. Thematic map

Figure 4 describes this thematic map, showing two measures: centrality and density. The measure of centrality indicates importance or relevance to the overall research field, whereas density indicates the degree of development of each topic. Ultimately, using both measures, the related learning and dyslexia research topics are organized into four quadrants demonstrating different roles for each of the themes across the overall research field. Located in the upper-right quadrant. Motor themes have both high centrality and high density, indicating they are both the most important and developed themes. This quadrant contains topics related to dyslexia and learning processes for children. Because they are high in centrality, they connect strongly with the entire research area. Because they are high in density, they also connect as well-researched or developed topics. However, certain terms within this quadrant are very general (i.e., "human" or "article") and thus cannot be used to accurately assess the overall significance of this quadrant. Niche themes are located in the upper-left quadrant and are low in centrality but high in density. Examples include topics such as hands-on learning and laboratory instruction.

Due to being high density, these topics are well developed with considerable research; however, they are low in centrality, in that they have little connection to the primary research area. The basic themes (higher degree of centrality/lower degree of density) are identified in the lower right quadrant. They include multilayered/multimedia teaching techniques, enhanced technologies for teaching, and inclusive teaching. These areas are highly relevant to the overarching theme of education (higher degree of centrality/degree of density) and thus have many connections to other areas of study, but they have not been thoroughly researched (lower density). Therefore, they are still evolving and have significant opportunities for additional research growth. The newly emerged themes (lower degree of centrality/lower degree of density) are defined in the lower left quadrant of the graph. Phonemic awareness and a multisensory approach to specific learning difficulties as well as distance learning are two examples. Since these themes have a low degree of centrality, they are not closely associated with the literature covering the education field; in addition, since they do not possess a high degree of density, they are also poorly researched. Thus, the new themes may still represent a developing concept or an older theme losing its research value; however, phonemic awareness is highly significant in dyslexia research. Therefore, its position on the model reflects that it has less representation in the data and not that it lacks value to the education field.

4.2.2. Most relevant words

Figure 5 elaborates on the frequency distribution of keywords, it is showing that the research field is primarily focused on multisensory learning as a key instructional approach. The frequency of the terms present in the total of 148 articles included in this analysis suggests that multisensory learning is the main topic of the research studies in this area. Multisensory learning, which occurs 21 times, is the most frequent term found in the total corpus; hence, it is the most important aspect of research on learning and dyslexia. Researchers generally advocate for the use of multiple sensory modalities (i.e., visual, auditory, and tactile methods) to improve learning. In addition, the next most frequent terms in the dataset, "human" (16), "humans" (13), and "child" (10), indicate that the majority of the research has been conducted with human subjects; the majority of the subjects were children. This finding is not surprising because most of the research focuses either on the development of learning, such as dyslexia, or ELL, an area of study that is generally focused on developing a child's ability to read and learn. The presence of dyslexia, which was found 12 times in the overall dataset, further confirms that the majority of research articles are related to reading and learning disabilities.

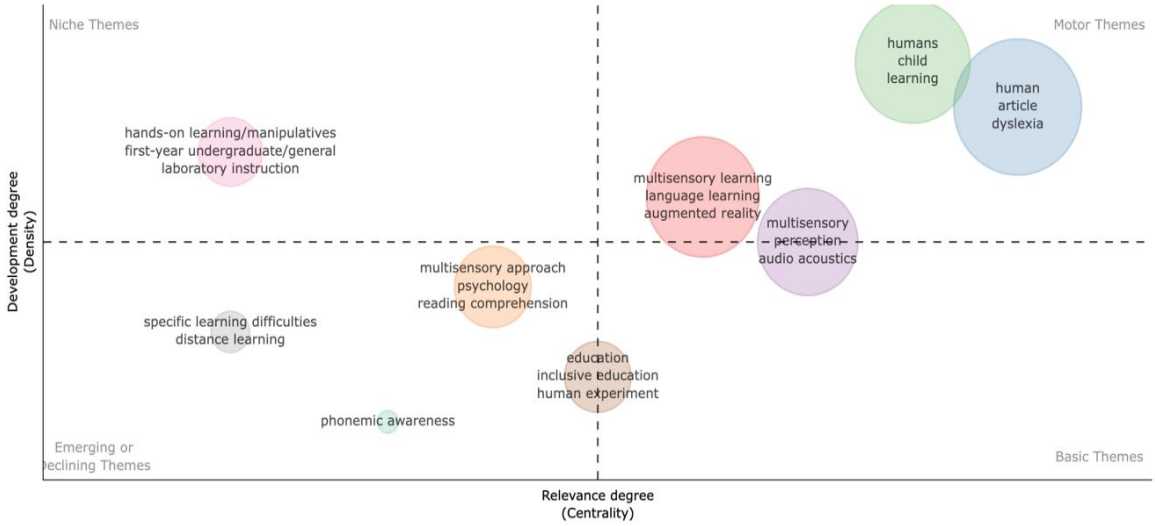

Figure 4. Thematic map

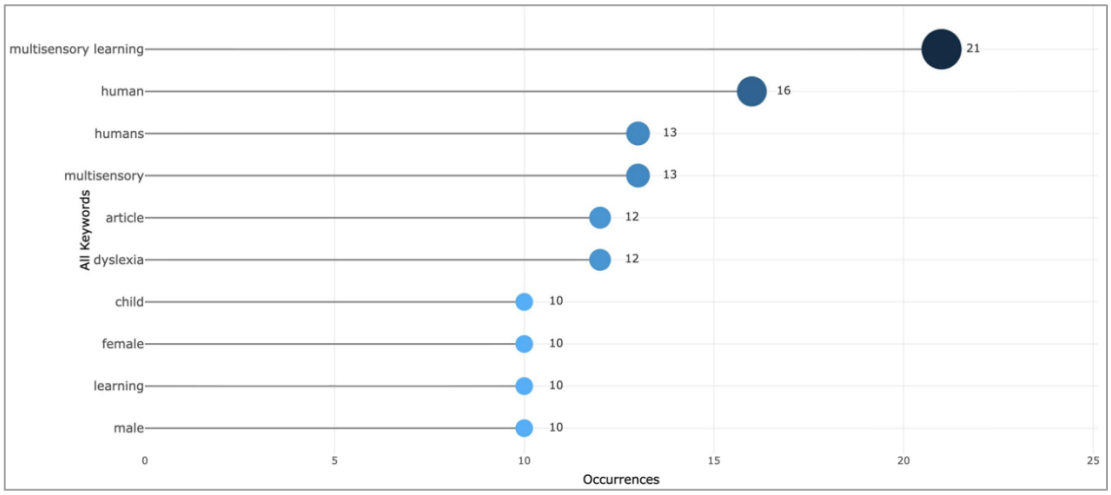

Figure 5. Most relevant words

Multisensory techniques are employed as intervention techniques when working with a child with a reading or learning disability. Furthermore, the presence of the term "learning" (10) reinforces the educational aspect of the corpus as a whole, although there are a number of general words (i.e., "article"=12) that might indicate more noise when indexing than provide any useful conceptual information. Moreover, the data support both gender indicators (i.e., female=10 and male=10) as well as finding evidence of sufficient representation of both gender variables in the sample of research articles included in the overall dataset. Overall, the keyword frequency data strongly suggest that the majority of research in the field is primarily focused on the topic of multisensory learning and the connection between multisensory learning and dyslexia in children and that the research is largely focused on children as participants.

4.2.3. Co-occurrence network

Figure 6 clarifies three major clusters can be found in the co-occurrence networks of research within the landscape and are colored red, blue, and green. The co-occurrence network visualization represents the conceptual structure and thematic relationships among keywords in the selected body of literature. The network was generated using the Louvain clustering algorithm with association normalization, automatic layout, 50 nodes, repulsion force of 0.5, removal of isolated nodes, and a minimum edge threshold of 2. These parameters helped identify strongly connected themes and improve the readability of the network. Within the three clusters, all represent different but related research themes. "Red" nodes refer to general learning types of research, with main nodes being human, learning, and multisensory learning. These main

clusters indicate that the research related to these main areas is predominantly theoretical and conceptual as to how humans learn using more than one sense (i.e., multisensory) to acquire knowledge. “Blue” nodes are the largest and have the most central level of density in terms of research and therefore serve as the primary research area. The main nodes contained in blue refer to human, child, male, article, reading, phonetics, dyslexia, literacy, and controlled studies; therefore, much of the research conducted in this area is empirical, focused primarily on child development in reading. While it is exhibiting strong correlation with other main nodes found in the blue cluster, which means that people are frequently researching terms related to blue in studies related to literacy and language acquisition. “Green” nodes indicate sensory and cognitive foundations of learning and have the following main nodes: multisensory, auditory stimulation, acoustic, audiovisual, hearing, vision, perception, association, and cognition. Research in this area is significantly dispersed when compared to the red and blue clusters in terms of the level of correlation exhibited; therefore, the research contained in the green clusters is predominantly focused on different aspects of how sensory input can affect cognitive functions when learning occurs.

Connections between clusters help clarify the field’s structure: red and blue clusters are strongly connected, indicating that general theories of learning are applied closely to the study of reading and literacy of children; green and blue clusters have moderate connections, indicating that the sensory processes provide support for the applied areas of phonetics and dyslexia. The green and red clusters present relatively weak but still significant connections that stem from shared concepts (e.g., multisensory learning). The overall network indicates a progression from sensory and cognitive mechanisms (green) to theories of learning (red) to applied research in the areas of literacy and child development (blue). Collective data suggest that the relationship among all three types of clusters forms a multidisciplinary framework in which the sensory component of research serves as a foundation upon which the theoretical understanding is developed and later converted into practical applications in education, with the blue cluster being the most central and influential area of research.

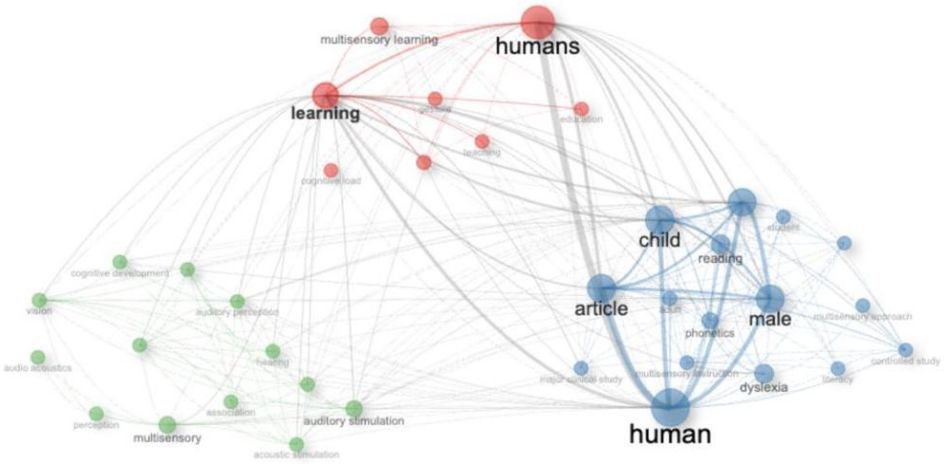

Figure 6. Co-occurrence network

5. DISCUSSION

The study performed a bibliometric analysis of multisensory teaching and learning research using the Scopus database for publications between 2000 and 2026 to outline the intellectual structure, research expansion, and global publication trend(s) of this body of knowledge. The authors’ goals for the analysis of the data were supported by performing a performance analysis and science mapping of the data using the bibliometrix package in R. The report provides a thorough overview of how the body of knowledge in multisensory teaching and learning has transitioned over time from a previously little-practiced pedagogical method to an area of significant growth within an interdisciplinary field of research. The results are in keeping with the conclusions of previous bibliometric-type studies that indicate many scientific areas of research evolve from fragmented areas of exploration into an ordered and collaborative network of accumulated knowledge over time [30], [31].

Analysis of publication trends reflects a significant shift in the research of multisensory teaching and learning that has occurred over the past two decades. Publications ranged from one to six per year between 2000 and 2012, with no publication occurring in 2006 or 2007. The low level of research in the early

21st century may indicate that multisensory instructional approaches were largely unexamined or viewed as peripheral by mainstream educational research at that time. This supports previous research showing that teachers' focus has historically been on developing and implementing instructional methodologies based on the use of texts, which may limit access for diverse students [8]. The period from 2012 to 2019 was characterized by moderate but uneven growth in publication output. In 2020 and 2026, the highest levels of articles were published, with six during each of those years. This uneven growth pattern suggests that there is increasing recognition of the value of multisensory teaching and learning research, but that the body of research generating a consistent level of scholarly interest has not yet occurred. This fluctuation in publication amounts likely reflects the disconnected nature of early research in multisensory pedagogies, most of which were conducted within separate academic disciplines, with little to no cross-pollination or collaborative effort among different fields of study. One of the most notable things is the high growth of research output from the year 2020. Since that time, there have been a lot of published results with numbers reaching double digits each year, peaking at 29 articles published in 2025.

The comparison of scientific productivity by authoring country identifies the US as the leader in the number of articles published, with total publications for the US (~70). This is likely due to several structural advantages, such as access to a large and varied range of funding sources, a well-established educational research system, and an emphasis at the policy level on developing innovative and inclusive approaches to pedagogy. The TC count from published articles (253) provides further strength to the United States' leadership position; however, average citations per article (13.3) suggest that there is variability in the individual article impact despite the high volume of published research [23]. While the second-ranked UK published 24 articles in this area, its publication history demonstrates a sustained involvement of Europeans in multisensory teaching research. However, due to the disparities in the number of publications by both per region, it has raised some significant questions about the linguistic bias present in scholarly publishing and, thereby, the potential for non-English contributions to the body of multisensory teaching literature to be marginalized. Additionally, Indonesia's publication count of 17 articles in this study shows that the emerging economies of the world are beginning to explore multisensory methods of teaching as a response to some of their educational challenges, such as large class size, limited resources, and the need to accommodate a range of diverse learner profiles. The citation impact analysis reveals that research leadership in multisensory teaching and learning is multidimensional. While the United States demonstrates the highest total impact, countries such as Australia and Germany exhibit substantially higher AAC, indicating that smaller research communities can produce disproportionately influential work. This pattern suggests that research quality and strategic focus may be as important as raw publication volume in advancing the field [25].

Multisensory teaching and learning research have a widely distributed authorship base, i.e., nine authors: Andrä C., Macedonia M., Mathias B., Schwager A., Von Kriegstein K., T. Osborne, D. Mareschal, Nikielska-Sekuła K., Pishghadam R., all with two publications, illustrating that there are many collaborators instead of a few dominating authors. Citation analyses indicate that five authors, Andrä C., Macedonia M., Mathias B., Schwager A., Von Kriegstein K. make up a very strong co-authorship cluster. Their co-authored works published in 2020 had very similar high citation impacts characterized by TC=70 and TCpY=10 which clearly represents a benchmark year. Looking ahead, TCpY values will continue to decline post-2020 as publications will experience longer citation windows. However, newer publications by Nikielska-Sekuła [35] (2024/2026) will continue to receive citations. Notably, the 2020 publication by Broadbent *et al.* [36] have a greater citation impact (TC=27; TCpY=3) than their 2020 publication (TC=13; TCpY=1.85), indicating that early-stage publications have an advantage in terms of citation opportunity as well as potential for novelty. Additionally, Pishghadam has been moderately but consistently influencing citations (TCpY=1.75), likely due to his research areas (e.g., emotion-based instruction) being too specialized with narrower networks. This is unsurprising, as Khazaleh *et al.* [33] has not yet received any citations.

A thematic analysis of the literature for this study outlines the intellectual structure of multisensory teaching and learning research through two dimensions of centrality and density using the established science mapping method [31], [38]. Motor themes characterized by dyslexia and childhood academic learning processes have both high centrality and high density, suggesting that multisensory teaching and learning as a method for teaching children with reading difficulties represents the intellectual centerpiece of the multisensory teaching and learning arena; there is an overwhelming evidence base that supports multisensory structured language instruction [8], [39] as well as decades of qualitative and quantitative research, including multiple meta-analytic studies [40], [41]. However, extreme caution in interpreting broad terms such as "human" or "article" that have appeared in this quadrant is warranted since they may artificially inflate centrality without specificity to a topic. Niche themes characterized by hands-on learning and instruction using laboratories have high density but low centrality, signifying that they are sufficiently developed within their subdomains (e.g., model-based tactile instruction for chemistry education, Lee and Beggs [11] but remain relatively disconnected to the broader framework of multisensory teaching/learning theory [42]. The basic themes (lower right quadrant, high centrality, and low density) are multimedia teaching strategies,

technology enhancement, and inclusive education. These three areas are all relevant yet underdeveloped and are dynamic frontiers of development. New emerging technologies, such as augmented reality [12], VR [43], and tangible user interfaces [44], provide a wealth of opportunities for developing new and innovative platforms for multi-sensory instruction, which have significant potential for future theoretical and empirical development. The emerging or declining themes are phonemic instruction and distance learning. Phonemic intervention for individuals with dyslexia is of significant importance [24], yet phonemic research is not producing significant new activity, indicating phonemic study is fully developed and no longer offers new avenues for research. The field of distance education research, which has accelerated due to the impact of the COVID-19 pandemic, continues to be developing and lackluster [7], [24], [45].

The co-occurrence networks offer evidence of three conceptual clusters, such as red, blue, and green nodes that combine together to provide a multidisciplinary representation of the field that relates sensory mechanisms to learning theories and educational applications. The red cluster (i.e., human, learning, and multisensory learning) accounts for the underlying theoretical groundwork from which sensory mechanisms are grounded, including the embodied cognition [6], [7], the dual coding theory [3] and the cognitive load theory [4], [5]. The blue cluster is the largest and most centrally located cluster that concentrates on applied empirical studies to child development, reading, phonetics, dyslexia, literacy, and levels of control in experimentation and represents the field's resolve to use evidence-based practices [40], [46]. The sensory and cognitive foundations are represented in the green cluster (i.e., multisensory, auditory input, audio-visual, perception, and cognition), with a greater degree of spread of individual senses indicating that sensory research is often conducted separately rather than as part of an integrated framework [47], [48]. The strong red-blue ties represent the application of learning theories to the development of literacy; the moderate green-blue ties represent a connection between research that concerns sensory studies on phonetics and interventions for dyslexia, while the weaker green-red ties represent a connection between the two using multisensory learning as a conceptual foundation. Collectively, the tripartite structure indicates that sensory mechanisms (green) lead into and combine with learning theories (red) and applied research in education (blue), as represented by the blue cluster being the most significant and predominant area.

The present study has given new contributions to the literature on multisensory approaches to teaching and learning. First, while there are prior studies that examined the efficacy of certain multisensory teaching and learning strategies [8], [33], [39], and some studies focused on only one narrow area of multisensory teaching (e.g., dyslexia instruction) [25], there has not been a previous study that provided a comprehensive bibliometric analysis of all of the published literature across authors, disciplines, years, and geographical areas. In the current study, this gap is addressed by conflating the publication trends, citation statistics, co-authorship patterns, and thematic structures of these publications within a single, coherent framework. Second, the identification of three unique clusters of conceptually similar studies using co-occurrence network analysis provides the first empirical basis for describing the intellectual structure of multisensory research. The presence of these three clusters: i) sensory processing and sensory opportunities for learning; ii) learning theories and strategies; and iii) application of multisensory approaches to educational settings—provides an organizing structure for linking research conducted in different areas and may lead to increased integration of fragmented areas of multisensory research. The findings of the study indicate that the areas of technology-enhanced multisensory learning, inclusive education, and multimedia teaching methods are either basic/transversal themes that require additional development or are in need of further investigation. This shifts the assumption that multisensory teaching research has matured to an understanding of specific areas for future research; these include augmented reality [12] and VR [43] environments and AI-enhanced adaptive learning systems. The study's time frame also captures a transition within the field, from a very low level of research activity (2000-2011) to a slower level of activity (2012-2019), and then to extremely high levels of activity over the next seven years (2020-2026). This historical picture provides important contextual information to understand the present knowledge within the field and to predict how global events will affect research priorities.

6. CONCLUSION

A bibliometric study of multisensory teaching and learning provides insights into its evolution from an area of sporadic and peripheral interest (2000 to 2026) to an exponentially developing area with recognized significance. The US ranks highest for publication output; Germany and Australia produce articles that are highly impactful relative to their output. Collaborative research teams produce the highest-impact research within the core area of dyslexia and children's literacy; they have established dominant positions in this field.

The intellectual architecture of the field comprises three interconnected areas of research or clusters: sensory mechanisms, theories of learning, and educational use. The area of technology-enhanced learning

and teaching has been identified as a priority area for continuing research into multisensory teaching and learning. The results of this bibliometric analysis will be useful for researchers, educators, and policymakers and provide a factual basis for both the current state and future directions of multisensory teaching and learning research. As the field continues to develop, it will be critically important to have a focus on methodological rigor, interdisciplinary collaboration, and globally equitable use of knowledge to support the maximization of multisensory approaches to improved educational practice.

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AUTHOR CONTRIBUTIONS STATEMENT

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

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CONFLICT OF INTEREST STATEMENT

Authors have no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL CONSIDERATION

This study used publicly available bibliographic data and did not involve human subjects.

DATA AVAILABILITY

The data that supports the findings of this study is available from the corresponding author, [DS], upon reasonable request.

REFERENCES

[1] R. D. Farkas, "Effects of traditional versus learning-styles instructional methods on middle school students," *The Journal of Educational Research*, vol. 97, no. 1, pp. 42–51, Sep. 2003, doi: 10.1080/00220670309596627.

[2] M. Bøg, J. Dietrichson, and A. A. Isaksson, "A multi-sensory tutoring program for students at risk of reading difficulties: evidence from a randomized field experiment," *The Journal of Educational Research*, vol. 114, no. 3, pp. 233–251, May 2021, doi: 10.1080/00220671.2021.1902254.

[3] A. Paivio, "Dual coding theory: retrospect and current status," *Canadian Journal of Psychology/Revue canadienne de psychologie*, vol. 45, no. 3, pp. 255–287, Sep. 1991, doi: 10.1037/h0084295.

[4] R. E. Mayer, "Cognitive theory of multimedia learning," in *The Cambridge Handbook of Multimedia Learning*, R. E. Mayer, Ed., New York, NY: Cambridge University Press, 2005, pp. 31–48, doi: 10.1017/CBO9780511816819.004.

[5] R. E. Mayer and R. Moreno, "Nine ways to reduce cognitive load in multimedia learning," *Educational Psychologist*, vol. 38, no. 1, pp. 43–52, Jan. 2003, doi: 10.1207/S15326985EP3801_6.

[6] L. W. Barsalou, "Grounded Cognition," *Annual Review of Psychology*, vol. 59, no. 1, pp. 617–645, Jan. 2008, doi: 10.1146/annurev.psych.59.103006.093639.

[7] M. Wilson, "Six views of embodied cognition," *Psychonomic Bulletin & Review*, vol. 9, no. 4, pp. 625–636, Dec. 2002, doi: 10.3758/BF03196322.

[8] N. W. Schlesinger and S. Gray, "The impact of multisensory instruction on learning letter names and sounds, word reading, and spelling," *Annals of Dyslexia*, vol. 67, no. 3, pp. 219–258, Oct. 2017, doi: 10.1007/s11881-017-0140-z.

[9] R. Widyana, K. Astuti, M. F. Bahrussofa, and G. M. Githa, "The effectiveness of jolly phonics and multisensory learning methods in improving preschoolers pre-reading skills," *International Journal of Innovation, Creativity and Change*, vol. 11, no. 8, pp. 1–13, 2020.

[10] V. L. Biron *et al.*, "Teaching cricothyrotomy: a multisensory surgical education approach for final-year medical students," *Journal of Surgical Education*, vol. 70, no. 2, pp. 248–253, Mar. 2013, doi: 10.1016/j.jsurg.2012.11.004.

[11] D. C. B. Lee and G. A. Beggs, "Tactile models for the visualization, conceptualization, and review of intermolecular forces in the college chemistry classroom," *Journal of Chemical Education*, vol. 98, no. 4, pp. 1328–1334, Apr. 2021, doi: 10.1021/acs.jchemed.0c00460.

[12] C. J. Chen and P. L. Liu, "Combining immersive virtual reality with CLIL and TPR to enhance English as foreign language learners' language acquisition," *Educational Technology and Society*, vol. 28, no. 1, pp. 383–396, 2025, doi: 10.30191/ETS.202501_28(1).SP05.

[13] M. R. U. Saputra and K. A. Nugroho, "'Learn-to-read' application for remediation of dyslexic children based on multisensory approach," in *2015 4th International Conference on Instrumentation, Communications, Information Technology, and Biomedical Engineering (ICICI-BME)*, Nov. 2015, pp. 220–225, doi: 10.1109/ICICI-BME.2015.7401366.

[14] R. D. Agustia and I. N. Arifin, "Implementation of visual, auditory, kineshthetic, tactile model learning system to help mild retarded children in alphabetical and numeric learning," *IOP Conference Series: Materials Science and Engineering*, vol. 407, no. 1, p. 012009, 2018, doi: 10.1088/1757-899X/407/1/012009.

[15] A. G. Khalifa and M. A. E. Saad, "The effectiveness of touch math on improving early mathematics ability of kindergarten children with mild to borderline intellectual functioning in an inclusion classroom," *Journal of Intellectual Disability - Diagnosis and Treatment*, vol. 9, no. 2, pp. 189–194, Apr. 2021, doi: 10.6000/2292-2598.2021.09.02.5.

[16] L. Rauscher *et al.*, "Evaluation of a computer-based training program for enhancing arithmetic skills and spatial number representation in primary school children," *Frontiers in Psychology*, vol. 7, p. 913, Jun. 2016, doi: 10.3389/fpsyg.2016.00913.

[17] A. J. Magana, M. I. Serrano, and N. S. Rebello, "A sequenced multimodal learning approach to support students' development of conceptual learning," *Journal of Computer Assisted Learning*, vol. 35, no. 4, pp. 516–528, Aug. 2019, doi: 10.1111/jcal.12356.

[18] K. Alwashmi, G. Meyer, F. Rowe, and R. Ward, "Enhancing learning outcomes through multisensory integration: a fMRI study of audio-visual training in virtual reality," *NeuroImage*, vol. 285, p. 120483, Jan. 2024, doi: 10.1016/j.neuroimage.2023.120483.

[19] N. Kucirkova and M. Kamola, "The significance of children's olfactory experiences in a Norwegian kindergarten: an olfactory researcher-practitioner collaboration," *Educational Action Research*, vol. 32, no. 4, pp. 586–605, Aug. 2024, doi: 10.1080/09650792.2023.2240391.

[20] S. Ferrando, E. Volta, and G. Volpe, "Multisensory technologies to support teaching: an ongoing project," in *Proceedings of the 21st Annual ACM Interaction Design and Children Conference (IDC'22)*, 2022, pp. 557–563, doi: 10.1145/3501712.3535284.

[21] M. A. K. Alenizi, "Effectiveness of a program based on a multi-sensory strategy in developing visual perception of primary school learners with learning disabilities: a contextual study of Arabic learners," *International Journal of Educational Psychology*, vol. 8, no. 1, pp. 72–104, Feb. 2019, doi: 10.17583/ijep.2019.3346.

[22] A. Covaci, L. Zou, I. Tal, G.-M. Muntean, and G. Ghinea, "Is multimedia multisensorial? - A review of mulsemedia systems," *ACM Computing Surveys*, vol. 51, no. 5, pp. 1–35, Sep. 2019, doi: 10.1145/3233774.

[23] G. S. Agalyasri and Bhuvaneswari G., "Enhancing vocabulary instruction for children with speech and hearing impairments: the role of multiple sensory modalities," *Theory and Practice in Language Studies*, vol. 13, no. 10, pp. 2429–2438, Oct. 2023, doi: 10.17507/tpls.1310.01.

[24] M. T. D. Gonzalez, J. Phillips-Silver, N. G. Maurno, L. F. García, and P. Ruiz-Castañeda, "Improving phonological skills and reading comprehension in deaf children: a new multisensory approach," *Scientific Studies of Reading*, vol. 27, no. 2, pp. 119–135, Mar. 2023, doi: 10.1080/10888438.2022.2095280.

[25] A. Gnaedinger, H. Gurden, B. Gourévitch, and C. Martin, "Multisensory learning between odor and sound enhances beta oscillations," *Scientific Reports*, vol. 9, no. 1, p. 11236, Aug. 2019, doi: 10.1038/s41598-019-47503-y.

[26] N. Andersen and V. Swami, "Science mapping research on body image: a bibliometric review of publications in body image, 2004–2020," *Body Image*, vol. 38, pp. 106–119, Sep. 2021, doi: 10.1016/j.bodyim.2021.03.015.

[27] R. Kumar, "Bibliometric analysis: comprehensive insights into tools, techniques, applications, and solutions for research excellence," *Spectrum of Engineering and Management Sciences*, vol. 3, no. 1, pp. 45–62, Jan. 2025, doi: 10.31181/sems31202535k.

[28] D. Yu, Z. Xu, W. Pedrycz, and W. Wang, "Information sciences 1968–2016: a retrospective analysis with text mining and bibliometric," *Information Sciences*, vol. 418–419, pp. 619–634, Dec. 2017, doi: 10.1016/j.ins.2017.08.031.

[29] J. M. Merigó and J.-B. Yang, "A bibliometric analysis of operations research and management science," *Omega*, vol. 73, pp. 37–48, Dec. 2017, doi: 10.1016/j.omega.2016.12.004.

[30] M. Aria and C. Cuccurullo, "bibliometrix: an R-tool for comprehensive science mapping analysis," *Journal of Informetrics*, vol. 11, no. 4, pp. 959–975, Nov. 2017, doi: 10.1016/j.joi.2017.08.007.

[31] N. Donthu, S. Kumar, D. Mukherjee, N. Pandey, and W. M. Lim, "How to conduct a bibliometric analysis: an overview and guidelines," *Journal of Business Research*, vol. 133, pp. 285–296, Sep. 2021, doi: 10.1016/j.jbusres.2021.04.070.

[32] C. Andrä, B. Mathias, A. Schwager, M. Macedonia, and K. von Kriegstein, "Learning foreign language vocabulary with gestures and pictures enhances vocabulary memory for several months post-learning in eight-year-old school children," *Educational Psychology Review*, vol. 32, no. 3, pp. 815–850, Sep. 2020, doi: 10.1007/s10648-020-09527-z.

[33] A. K. M. Khazaleh, M. S. S. Alnasraween, H. O. M. Abzakh, and F. K. N. AL Shraah, "The level of applying evidence-based strategies in teaching students with learning disabilities and its relationship to their professional competence from their teachers' point of view," *Perspectives of Science and Education*, vol. 67, no. 1, pp. 726–742, Mar. 2024, doi: 10.32744/pse.2024.1.41.

[34] B. Mathias, C. Andrä, A. Schwager, M. Macedonia, and K. von Kriegstein, "Twelve- and fourteen-year-old school children differentially benefit from sensorimotor- and multisensory-enriched vocabulary training," *Educational Psychology Review*, vol. 34, no. 3, pp. 1739–1770, Sep. 2022, doi: 10.1007/s10648-021-09648-z.

[35] K. Nikielska-Sekuła, "Mapping multisensory migration research," *Ethnic and Racial Studies*, vol. 49, no. 7, pp. 1290–1311, May 2026, doi: 10.1080/01419870.2025.2562651.

[36] H. Broadbent, T. Osborne, D. Mareschal, and N. Kirkham, "Are two cues always better than one? The role of multiple intra-sensory cues compared to multi-cross-sensory cues in children's incidental category learning," *Cognition*, vol. 199, p. 104202, Jun. 2020, doi: 10.1016/j.cognition.2020.104202.

[37] H. Jajarmi and R. Pishghadam, "Emotioncy-based language instruction: a key to enhancing EFL learners' vocabulary retention," *Applied Research on English Language*, vol. 8, no. 2, pp. 207–226, 2019, doi: 10.22108/are.2019.114399.1388.

[38] M. J. Cobo, A. G. López-Herrera, E. Herrera-Viedma, and F. Herrera, "Science mapping software tools: review, analysis, and cooperative study among tools," *Journal of the American Society for Information Science and Technology*, vol. 62, no. 7, pp. 1382–1402, Jul. 2011, doi: 10.1002/asi.21525.
[39] R. M. Joshi, M. Dahlgren, and R. Boulware-Gooden, "Teaching reading in an inner city school through a multisensory teaching approach," *Annals of Dyslexia*, vol. 52, no. 1, pp. 229–242, Jan. 2002, doi: 10.1007/s11881-002-0014-9.
[40] M. Jang and Y. Chang, "The effects of multisensory memory strategies on Korean EFL students' vocabulary learning," *English Teaching*, vol. 78, no. 4, pp. 27–57, Dec. 2023, doi: 10.15858/engtea.78.4.202312.27.
[41] S. Z. Ahmad, N. N. A. A. N. Ludin, H. M. Ekhsan, A. F. Rosmani, and M. H. Ismail, "Bijak membaca — applying phonic reading technique and multisensory approach with interactive multimedia for dyslexia children," in *2012 IEEE Colloquium on Humanities, Science and Engineering (CHUSER)*, Dec. 2012, pp. 554–559, doi: 10.1109/CHUSER.2012.6504375.
[42] W. C. Chiang, Y. J. Hsu, and J. L. Shih, "The influence of digital storybooks to the learning attitudes of students with reading disabilities," in *Proceedings of the 19th International Conference on Computers in Education, ICCE 2011*, 2011, pp. 16–24.
[43] R. di Fuccio and S. Mastroberti, "Tangible user interfaces for multisensory storytelling at school: a study of acceptability," *Qwerty*, vol. 13, no. 1, pp. 62–75, 2018.
[44] G. A. Fernández, R. A. Ocampo, A. R. Costantino, and N. S. Dop, "Application of didactic strategies as multisensory teaching tools in organic chemistry practices for students with visual disabilities," *Journal of Chemical Education*, vol. 96, no. 4, pp. 691–696, Apr. 2019, doi: 10.1021/acs.jchemed.8b00816.
[45] M. A. Marino, F. Wisnewski, A. Alexis, and C. Reilly, "Multisensory learning in the undergraduate chemistry lab: the case for smell," *Journal of Chemical Education*, vol. 102, no. 7, pp. 2592–2599, Jul. 2025, doi: 10.1021/acs.jchemed.4c01545.
[46] E. Paraskevopoulos, N. Chalas, A. Anagnostopoulou, and P. D. Bamidis, "Interaction within and between cortical networks subserving multisensory learning and its reorganization due to musical expertise," *Scientific Reports*, vol. 12, no. 1, p. 7891, May 2022, doi: 10.1038/s41598-022-12158-9.
[47] D. Z. Melhem, A. M. Al Zoubi, M. M. Al-Shannaq, A. S. H. Raiyan, and H. Melhem, "Improving geometric thinking skills through a multisensory-based CRA framework in students with learning difficulties and various sensory preferences," *Educational Process International Journal*, vol. 16, no. 1, p. e2025255, 2025, doi: 10.22521/edupij.2025.16.255.
[48] Z. Katai and L. Toth, "Technologically and artistically enhanced multi-sensory computer-programming education," *Teaching and Teacher Education*, vol. 26, no. 2, pp. 244–251, Feb. 2010, doi: 10.1016/j.tate.2009.04.012.

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