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Mapping Research Trends on Metaverse-Based Multisensory Learning for Dyslexia: A Bibliometric Study

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Abstract

Background: Research on immersive and multisensory learning for dyslexia has expanded alongside the development of augmented reality (AR), virtual reality (VR), extended reality (XR), and metaverse-based learning environments. These technologies offer promising opportunities to enhance learner engagement, accessibility, and literacy development. However, existing studies remain largely technology-oriented and conceptually fragmented, with limited efforts to synthesize multisensory, embodied, and affective learning principles into coherent pedagogical frameworks specifically designed for learners with dyslexia.
Aims: This study maps research trends, thematic structures, and conceptual orientations in immersive and metaverse-based multisensory learning for dyslexia, and identifies research gaps that hinder the development of theory-driven instructional models.
Methods: A descriptive bibliometric analysis was conducted on Scopus-indexed publications from 2020–2025. After screening, 54 studies were analyzed using keyword frequency and co-occurrence mapping, using VOSviewer to visualize to visualize conceptual relationships and thematic patterns.
Results: The analysis reveals a gradual shift from technology-centered assistive tools toward increasing attention to learner engagement, inclusive design, the use of artificial intelligence, and pedagogical considerations. Nevertheless, key learning principles such as multisensory input, metaphor-based learning, embodied interaction, and affective support are mostly implemented as isolated design features rather than integrated instructional components.
Conclusion: The findings suggest that metaverse-based learning systems are still predominantly conceptualized primarily as technological infrastructures rather than holistic learning ecosystems. This fragmentation indicates a significant need for integrated pedagogical frameworks that systematically combine multisensory, embodied, cognitive, and affective learning dimensions within immersive educational environments for learners with dyslexia.

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INTRODUCTION

Dyslexia is a neurodevelopmental learning disorder characterized by persistent difficulties in accurate and fluent word reading, spelling, and phonological processing. These challenges are frequently accompanied by limitations in verbal memory and verbal processing speed, which collectively constrain learners' access to conventional text-based instructional practices (Carroll et al., 2025; Snowling et al., 2020). Beyond academic performance, dyslexia often affects learners' motivation, self-concept, and emotional well-being. Children with dyslexia report lower reading motivation, poorer psychological well-being, and higher levels of anxiety compared to peers without dyslexia, suggesting that affective and self-perception variables are integral to understanding dyslexic learning profiles (Donolato et al., 2024). These affective challenges highlight the need for learning environments that not only address cognitive difficulties but also support engagement, confidence, and emotional safety. In this context, educational technologies, particularly interactive

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and immersive learning environments, offer promising opportunities to create adaptive, multisensory, and motivating learning experiences that may help reduce these affective barriers.

In response to these challenges, educational research has increasingly explored multisensory and technology-enhanced learning approaches. Augmented reality (AR) and virtual reality (VR) have emerged as prominent instructional and assistive technologies capable of presenting learning content through combined visual, auditory, and kinesthetic modalities. Empirical studies consistently indicate that immersive technologies can enhance learner engagement, sustain attention, and support foundational literacy skills among learners with dyslexia, particularly when compared to traditional instructional approaches (Ahmad et al., 2021; Villaverde et al., 2023; Fei et al., 2022).

More recently, the conceptual expansion toward extended reality (XR) and metaverse-oriented learning environments has further broadened the scope of immersive learning research. Unlike standalone AR or VR applications, metaverse-based environments are characterized by persistence, interactivity, embodiment, and adaptability (De Witte et al., 2026). These features enable learners to engage in personalized, self-paced, and socially mediated learning experiences, which align closely with the documented learning profiles of students with dyslexia (Radianti et al., 2020).

Despite this growing body of work, existing research on immersive technologies for dyslexia remains conceptually fragmented. Studies are distributed across education, psychology, human–computer interaction, and engineering disciplines, often emphasizing technological feasibility, usability, or short-term learning outcomes. In many cases, instructional designs are weakly anchored or entirely unanchored in established cognitive, multisensory, or motivational learning theories. As a result, technological innovation has frequently outpaced pedagogical integration, limiting the development of coherent, theory-driven instructional models for dyslexic learners.

To clarify the research trajectory of this emerging field, a systematic mapping of research trends and thematic orientations is required. Bibliometric analysis provides a structured and transparent approach for examining publication growth, intellectual structure, and conceptual evolution within interdisciplinary research domains (Donthu et al., 2021; Passas, 2024). Accordingly, this study aims to map research trends on immersive and metaverse-based multisensory learning for dyslexia through a descriptive bibliometric analysis of Scopus-indexed publications from 2020 to 2025.

Beyond offering an overview of the field, this study also establishes a conceptual rationale for advancing integrated pedagogical frameworks. By identifying recurring themes and persistent gaps, particularly regarding multisensory integration, cognitive load management, embodied learning, and affective support, the bibliometric findings provide the empirical foundation for the Metaverse-based Multisensory Flexible Comprehension Method (MSFCM). In addition to experimental and design-oriented studies, prior research has also highlighted the broader potential of immersive and augmented reality technologies as inclusive educational tools for learners with dyslexia and other special educational needs. Studies report improvements in engagement, accessibility, and learner confidence when immersive technologies are applied as supportive learning media rather than as standalone interventions (Aborokbah, 2021; Pamungkas et al., 2025). These findings further support the relevance of examining immersive learning not only from a technological perspective but also from an inclusive pedagogical standpoint.

Accordingly, this study is guided by the following research questions: (1) What are the publication trends and document characteristics of research on immersive and multisensory learning for dyslexia between 2020 and 2025?; (2) What thematic clusters and dominant learning strategies emerge from the existing literature?; (3) How are multisensory, metaphor-based, embodied, and affective learning approaches conceptualized in immersive learning environments?; and (4) What conceptual gaps remain in the literature that limit the development of integrated pedagogical frameworks for dyslexia intervention?

Addressing these research questions enables this study to systematically map the intellectual structure of the field and identify conceptual gaps that inform the development of integrated pedagogical approaches such as the Metaverse-based Multisensory Flexible Comprehension Method (MSFCM).

METHODS

Research Design

This study employed a descriptive bibliometric research design to map publication trends, thematic structures, and conceptual orientations in research on metaverse-based multisensory learning for dyslexia. A bibliometric approach was selected due to the emerging, interdisciplinary, and conceptually fragmented nature of the field, where empirical findings are dispersed across education, psychology, and technology-related disciplines. The study focused on descriptive mapping rather than citation-based performance analysis to ensure interpretive coherence and transparency.

Participants

No human participants were involved in this study. The unit of analysis consisted of peer-reviewed scientific publications indexed in the Scopus database.

Population and Sampling Method

The population comprised Scopus-indexed publications addressing dyslexia, learning difficulties, multisensory learning, and immersive digital environments. A purposive sampling strategy was applied using predefined inclusion criteria. As this study did not involve human subjects or psychometric measurement, questionnaires, scoring procedures, validity, and reliability testing were not applicable.

Instrument

The primary instrument was a structured bibliographic dataset extracted from the Scopus database. Bibliographic metadata including publication year, document type, source title, author keywords, and abstracts, served as the analytical material. Manual thematic classification tables were used to support interpretive analysis.

Procedures

Data collection was conducted by applying a structured Boolean search strategy to the Scopus database. The search targeted publications published between 2020 and 2025 and written in English. After duplicate removal and relevance screening, a final dataset of 54 publications was retained. The procedure included dataset characterization, keyword extraction, thematic grouping, and trend analysis.

Although the final dataset consists of 54 publications, this reflects the specialized and emerging nature of research at the intersection of dyslexia, multisensory learning, and immersive technologies such as AR, VR, XR, and metaverse-based environments. The search strategy applied strict inclusion criteria to ensure conceptual relevance, focusing only on studies that explicitly address immersive or multisensory learning approaches related to dyslexia or learning difficulties. As a result, many technology-focused studies that did not directly examine dyslexia-related learning processes were excluded. In bibliometric research within niche or developing fields, a focused dataset is considered appropriate for identifying conceptual structures, thematic patterns, and emerging research directions. Therefore, the selected corpus provides a sufficiently coherent basis for mapping the intellectual landscape and identifying conceptual gaps that may inform the development of integrated pedagogical frameworks for dyslexia intervention in immersive learning environments.

Data analysis relied on descriptive statistical techniques, including frequency counts and distribution analyses of publication trends, document types, and keyword occurrences. Bibliometric mapping and network visualization were conducted using the VOSviewer software to examine keyword co-occurrence patterns and conceptual relationships within the dataset. Thematic clustering was further supported through qualitative content analysis of abstracts and author keywords to identify recurring research themes. No inferential statistical tests were applied due to the exploratory nature of the study and the characteristics of the dataset.

Limitations

This study is limited to publications indexed in the Scopus database and may not capture relevant studies published in non-indexed sources. The bibliometric analysis emphasizes conceptual mapping rather than impact measurement, and the findings should be interpreted as a snapshot of research trends rather than a comprehensive evaluation of effectiveness.

Given the bibliometric and non-interventional nature of this study, PRISMA guidelines were selectively adopted to guide transparency in dataset identification, screening, and inclusion procedures, without constituting a full systematic review.

This study employed a descriptive bibliometric research design to map publication trends, thematic structures, and conceptual orientations in research on immersive multisensory learning for dyslexia. Bibliometric analysis is particularly suited to emerging and interdisciplinary research areas, where conceptual boundaries remain fluid and empirical findings are dispersed across diverse publication venues (Passas, 2024). This bibliometric study employed the Scopus database as the primary source due to its comprehensive coverage of peer-reviewed literature across education, psychology, and technology-related disciplines. To ensure transparency and replicability, a structured Boolean search strategy was applied. The search string combined key concepts related to dyslexia, inclusive education, and immersive learning using Boolean operators **AND** and **OR** as follows:

("dyslexia" AND "inclusive education") OR ("learning difficulties" OR "specific learning disorder") AND ("multisensory learning" OR "augmented reality" OR "virtual reality" OR "metaverse").

The use of the asterisk allowed for the inclusion of word variants to capture a broader range of relevant studies. This strategy ensured that publications addressing dyslexia, either directly or indirectly, through inclusive education, multisensory instruction, or immersive digital environments, were systematically identified.

RESULTS AND DISCUSSION

Results

The results of this descriptive bibliometric analysis identified clear patterns in the development of research on immersive and metaverse-based multisensory learning for dyslexia between 2020 and 2025. The publications demonstrate a steady increase in scholarly attention, particularly after 2022, indicating growing interest in immersive technologies within inclusive and special education contexts.

The distribution of document types shows a predominance of journal articles and conference proceedings, reflecting the exploratory and interdisciplinary nature of the field. Thematic clustering based on abstracts and author keywords identified five dominant research themes: (1) AR-supported literacy learning, (2) motivation and engagement, (3) inclusive interaction design, (4) immersive assistive systems, and (5) AI- and metaverse-oriented learning environments.

Temporal analysis indicated an evolution from technology-centered assistive applications toward broader considerations of learner engagement, usability, accessibility, and early pedagogical reflection. Despite this progression, multisensory learning strategies, embodied interaction, metaphor-based learning, and affective support were most often presented as discrete design features rather than as integrated instructional systems.

Data Classification

The bibliometric dataset analyzed in this study consists of Scopus-indexed publications published between 2020 and 2025 that are conceptually relevant to dyslexia intervention. Rather than limiting the corpus to studies that explicitly label dyslexia as the primary research focus, the dataset also includes studies addressing learning difficulties, multisensory learning, metaphor-based learning, embodied learning, immersive environments, and assistive educational technologies that are pedagogically applicable to learners with dyslexia.

As shown in Table 1, the dataset can be classified into five conceptual categories:
(1) direct dyslexia studies,
(2) learning difficulties and specific learning disorders,
(3) multisensory learning approaches,
(4) metaphor- and narrative-based learning strategies, and
(5) immersive and assistive digital technologies.

This classification highlights that while explicit dyslexia-focused studies form an important subset, a substantial portion of the literature contributes indirectly by offering methods, strategies, or technological affordances relevant to dyslexia intervention. This inclusive dataset construction reflects the interdisciplinary and method-driven nature of the field, where pedagogical innovation for dyslexia often emerges from adjacent domains rather than from dyslexia-labeled research alone.

Table 1. Classification of Scopus-Indexed Publications by Conceptual Relevance to Dyslexia (2020–2025)

Category	Conceptual Focus	Relevance to Dyslexia Intervention	Representative Scopus Studies
Direct Dyslexia Studies	Explicit dyslexia focus	Primary intervention target	(Abdalla et al., 2024; Radianti et al., 2020; Ahmad et al., 2021; Ausín Villaverde et al., 2023)
Learning Difficulties / SLD	Dyslexia-related cognitive constraints	Closely aligned	(Lozano-Álvarez et al., 2025; Ridzwan & Mohammad, 2025)
Multisensory Learning	Visual–auditory–kinesthetic integration	Core dyslexia strategy	(Fei et al., 2022; Sparks et al., 1992)
Metaphor & Narrative Learning	Symbolic & narrative scaffolding	Cognitive access pathway	(Tiede et al., 2022)
Immersive & Assistive Technologies	AR / VR / XR systems	Delivery medium	(Abdalla et al., 2024; Radianti et al., 2020)

The temporal analysis presented in Table 2 reveals a clear evolution in research focus across the 2020–2025 period. Early publications (2020–2021) predominantly conceptualized immersive technologies, particularly augmented reality, as assistive tools aimed at improving literacy-related skills such as reading and spelling. This phase was characterized as technology-centric, with emphasis placed on feasibility and task-level outcomes.

In 2022, the literature began to emphasize learner engagement and gamification, reflecting a growing recognition of motivational and affective dimensions in learning interventions. By 2023, attention shifted toward inclusive design, usability, and interaction challenges, indicating increased sensitivity to learner variability and cognitive constraints.

More recent publications (2024–2025) demonstrated emerging interest in AI-enabled systems, extended reality environments, accessibility considerations, and early pedagogical reflection. This progression suggests that the field has gradually moved from tool adoption toward design awareness, yet has not fully transitioned into a consolidated pedagogical framework.

Table 2. Temporal Evolution of Research Focus in Scopus Publications (2020–2025)

Period	Dominant Research Focus	Interpretation
2020–2021	AR as an assistive literacy tool	Technology-centric phase
2022	Engagement & gamification	Motivation-driven phase
2023	Inclusive & usability design	Design-awareness phase
2024	AI, XR, accessibility	System-integration phase
2025	Cognitive load & immersive pedagogy	Early pedagogical reflection

To examine conceptual relationships within the literature, a keyword co-occurrence network was generated using bibliometric mapping techniques. The visualization presented in Figure 3 illustrates the interconnected structure of dominant research concepts within the dataset.

The network reveals several central nodes linking dyslexia research with multisensory learning, immersive technologies, assistive systems, and emerging metaverse-oriented learning environments. These connections indicate that immersive technologies are frequently associated with themes of engagement, accessibility, and assistive support.

The analytical strategy followed established methodological guidelines for bibliometric research in emerging domains, emphasizing transparency, replicability, and interpretive coherence rather than citation-based performance metrics (Donthu et al., 2021; Öztürk et al., 2024).

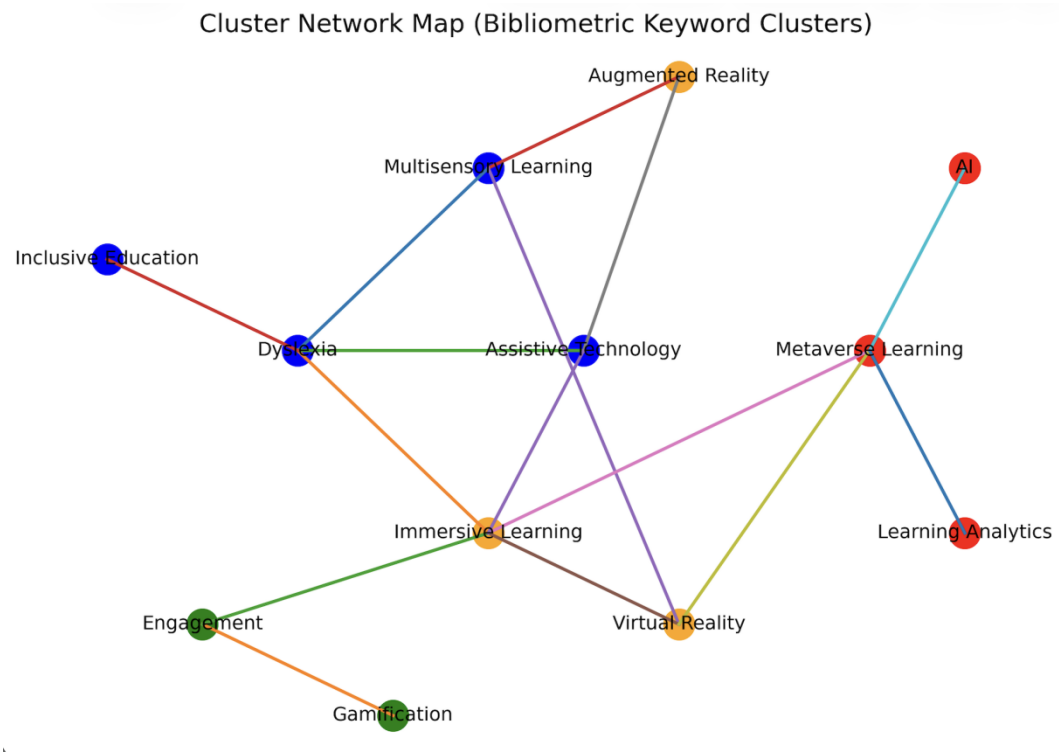

Figure 2. Keyword Co-occurrence Network of Immersive Learning Research for Dyslexia (2020–2025)

In the network visualization, each node represents an author keyword, and node size reflects its frequency of occurrence within the dataset. Larger nodes therefore indicate concepts that appear more frequently in the analyzed publications. The colors represent thematic clusters generated through keyword co-occurrence analysis, grouping together keywords that frequently appear within the same publications and reflecting underlying conceptual structures in the research field. The links between nodes represent co-occurrence relationships, while the distance between nodes reflects the relative strength of their association across the analyzed publications. This visualization therefore provides an overview of the conceptual landscape and thematic relationships within immersive learning research related to dyslexia.

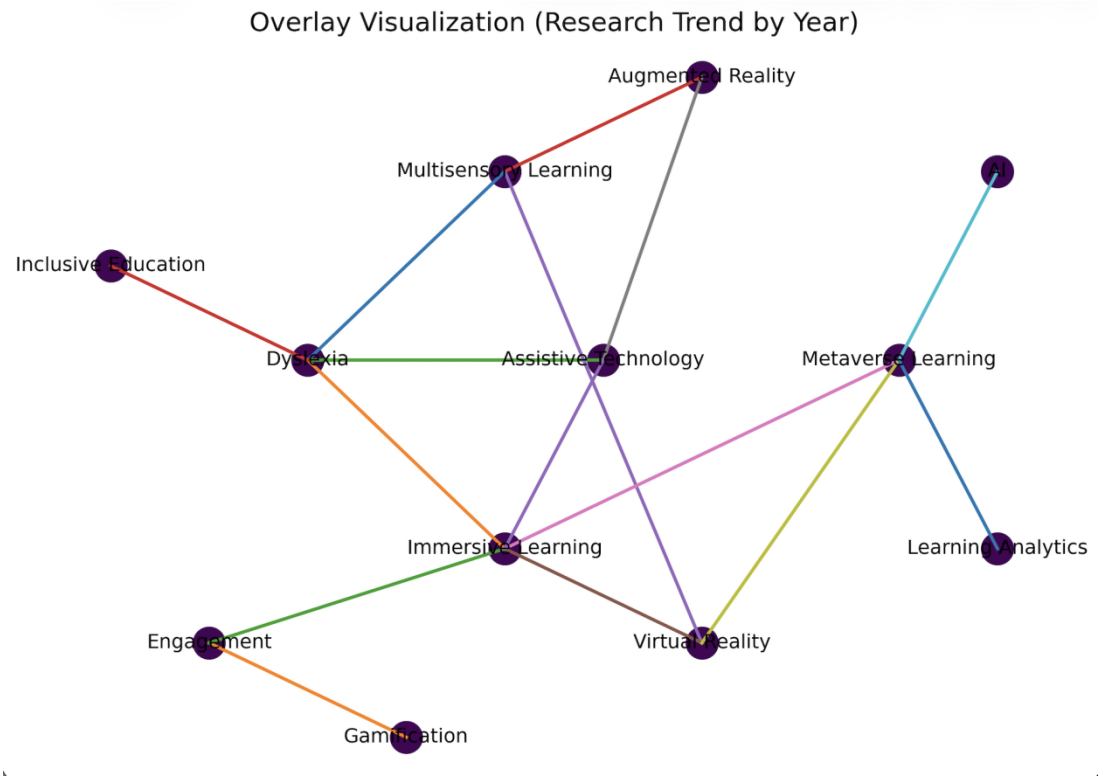

Figure 3. Overlay Visualization of Research Trends

In the overlay visualization, each node represents an author keyword, while the color of the node indicates the average publication year associated with that keyword within the dataset. Keywords shown in darker colors represent earlier research topics, whereas nodes with brighter colors indicate more recent themes emerging in the literature. The links between nodes represent co-occurrence relationships between keywords across the analyzed publications.

As illustrated in Figure 3, earlier studies tended to focus on themes such as augmented reality, assistive technology, and multisensory learning, reflecting the initial exploration of technological tools to support dyslexia intervention. In contrast, more recent research increasingly addresses metaverse learning, artificial intelligence, and learning analytics, indicating a shift toward more integrated and data-driven immersive learning environments. This pattern suggests an evolving research trajectory from technology-focused experimentation toward broader immersive learning ecosystems.

As shown in Figure 4, terms such as *dyslexia*, *multisensory learning*, *immersive learning*, and *assistive technology* appear in high-density areas, indicating that these concepts represent the core research focus of the field. In contrast, emerging themes such as *metaverse learning*, *learning analytics*, and *artificial intelligence* appear in lower-density zones, suggesting that these topics are still developing within the research landscape.

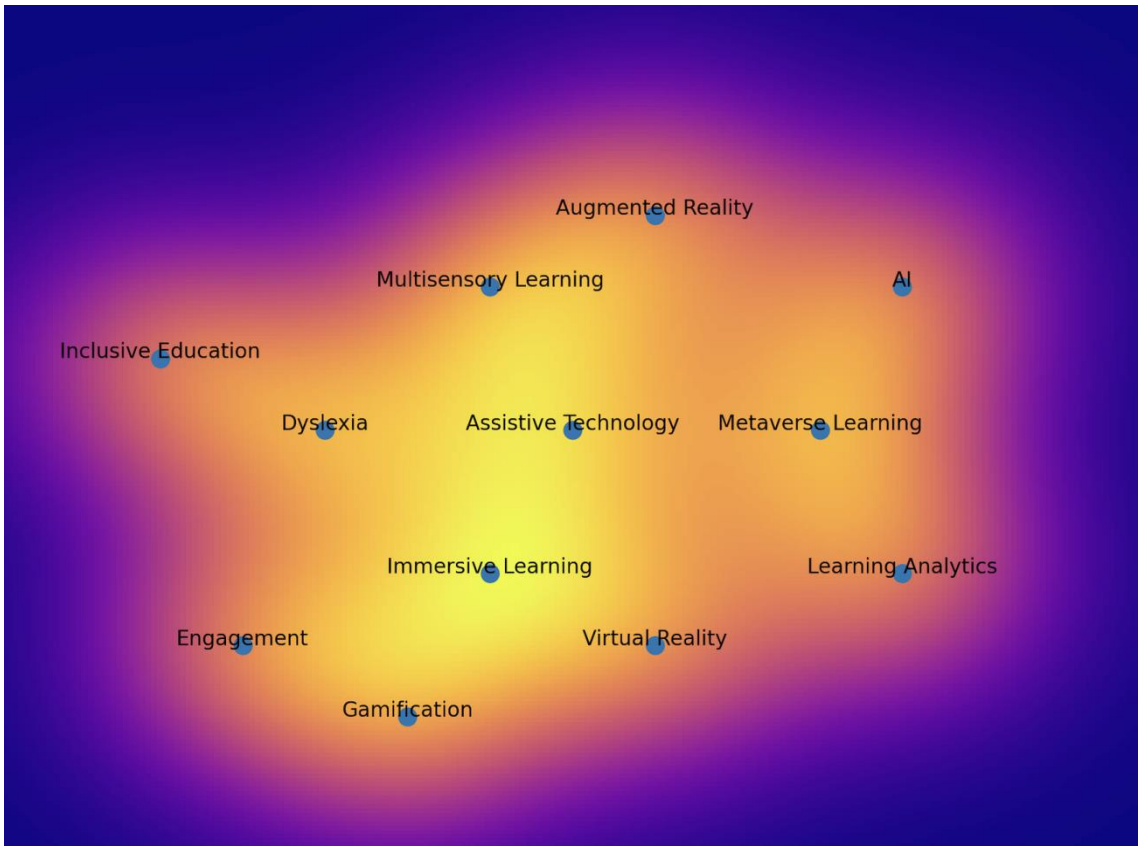

Figure 4. Keyword Density Map of Immersive Learning Research for Dyslexia (2020–2025)

The density visualization reinforces the interpretation that immersive and multisensory approaches constitute the conceptual core of the literature, while metaverse-based learning environments represent a more recent extension of the research domain.

Despite the growing volume of research, the bibliometric mapping reveals several persistent conceptual gaps in the literature. As summarized in Table 3, multisensory elements are frequently implemented but rarely conceptualized as part of an integrated pedagogical framework. Similarly, metaphor-based learning strategies often appear implicitly within game-based or narrative environments without being explicitly articulated as cognitive scaffolds.

Another major limitation concerns the framing of dyslexia interventions. Many studies conceptualize dyslexia as a technical problem addressed through digital tools, rather than as a complex cognitive–affective learning profile requiring integrated pedagogical responses. In addition, most interventions remain task-specific and fragmented, focusing on isolated literacy skills rather than on sustained learning journeys.

Table 3. Unaddressed Bibliometric Gaps Across Scopus Literature (2020–2025)

Identified Gap	Evidence Across Literature	What Has Not Been Addressed
No integrated multisensory framework.	Sensory elements fragmented	Unified instructional method
Metaphor treated implicitly.	Games & narratives exist	Metaphor as core pedagogy
Dyslexia framed as a technical issue.	Tool-based interventions	Cognitive–affective approach
Fragmented learning experiences.	Single-task focus	Learning journey continuity
Metaverse lacks pedagogy.	Platform-level discussion	Instructional model

The absence of an integrated pedagogical method constitutes the central contribution opportunity identified by this bibliometric study. Table 4 positions the Metaverse-based Multisensory Flexible Comprehension Method (MSFCM) as a conceptual response to the gaps identified across the literature.

Unlike existing studies that address multisensory input, metaphor, embodiment, or affective engagement in isolation, MSFCM synthesizes these elements into a unified instructional approach. The method conceptualizes learning as a flexible, metaphor-driven journey within an immersive environment, where sensory integration, embodied interaction, and emotional safety are treated as core design principles rather than secondary outcomes.

In this sense, MSFCM does not introduce a new technology but articulates a pedagogical synthesis that has been conceptually absent from the literature between 2020 and 2025. The bibliometric evidence presented in this study thus provides empirical justification for advancing MSFCM as a framework for future research and practice in dyslexia-focused immersive learning.

Table 4. Positioning MSFCM Against Identified Bibliometric Gaps

Dimension	Scopus Literature (2020–2025)	MSFCM Contribution
Multisensory Integration	Partial & implicit	Systematic
Metaphor-Based Learning	Incidental	Central
Embodied Interaction	Isolated	Integrated
Affective Safety	Outcome	Design principle
Metaverse Usage	Infrastructure	Learning ecology

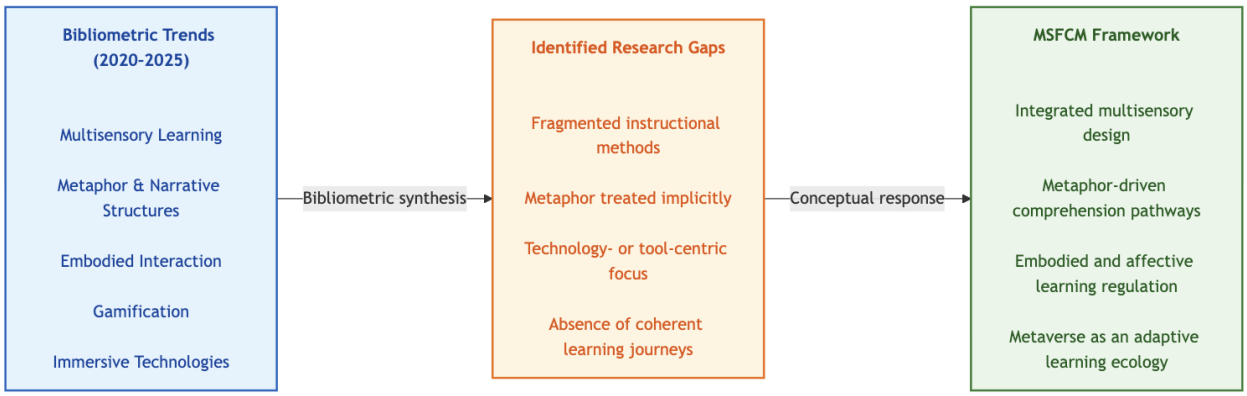

Figure 5. Synthesizing Bibliometric Trends into the Metaverse-based Multisensory Flexible Comprehension Method (MSFCM)

These findings imply a critical need to reposition immersive technologies from tool-based interventions toward pedagogically grounded learning environments. For educators and instructional designers, the results highlight the importance of integrating multisensory input, embodied interaction, and affective regulation as core design principles rather than optional enhancements.

For researchers, the identified fragmentation underscores the urgency of theory-driven approaches that align cognitive, sensory, and emotional dimensions within immersive learning contexts for learners with dyslexia. As noted in recent reviews of immersive learning environments, technological affordances have advanced rapidly, yet instructional coherence and long-term learning trajectories remain underexplored (Llanos-Ruiz et al., 2025).

Discussion

The bibliometric findings presented in this study primarily revealed patterns, thematic orientations, and conceptual gaps in the literature on immersive and multisensory learning for dyslexia. Importantly, the Metaverse-based Multisensory Flexible Comprehension Method (MSFCM) is not

presented as a direct empirical outcome of the bibliometric analysis. Rather, it is proposed as a conceptual response derived from the gaps identified through bibliometric mapping.

The findings indicate that research on immersive learning for dyslexia has advanced technologically but remains pedagogically fragmented. Multisensory interaction, engagement-oriented design, and assistive technologies frequently appear across studies; however, these elements are typically implemented as isolated features rather than as components of a coherent instructional model. As a result, technological innovation has progressed more rapidly than pedagogical integration has within the field. This observation is consistent with previous studies emphasizing that immersive technologies often prioritize technological capability over structured learning design (Paudel et al., 2025; Smith & Hattingh, 2020).

Within this context, the proposed MSFCM framework aims to address these limitations by conceptualizing immersive environments as structured learning ecologies that integrate multisensory, cognitive, and affective learning processes. One of the critical issues identified in the literature concerns the cognitive load experienced by learners with dyslexia, particularly due to constraints in phonological processing, working memory, and information integration. When learning materials rely heavily on textual processing alone, these constraints may increase extraneous cognitive load and hinder comprehension.

Drawing on Cognitive Load Theory, MSFCM seeks to reduce unnecessary cognitive processing demands by distributing learning information across multiple sensory channels. Instead of presenting information solely through written text, the framework organizes meaning through coordinated visual, auditory, and spatial representations within immersive environments. This approach is also supported by Dual Coding Theory, which suggests that learning becomes more effective when verbal and non-verbal information are processed simultaneously, enabling stronger conceptual encoding and memory retention.

In addition, MSFCM incorporates metaphor-based representations and embodied interaction as cognitive scaffolds for comprehension. Metaphorical learning structures allow abstract literacy concepts to be translated into concrete experiential forms, while embodied interaction enables learners to physically engage with symbolic elements in the environment. These mechanisms align with perspectives from embodied cognition, which emphasize that cognitive understanding can be strengthened through sensorimotor interaction with learning materials.

Within immersive environments such as metaverse-based platforms, these mechanisms may be implemented through interactive narrative spaces, gesture-based interaction, and multimodal feedback systems that guide learners through progressive comprehension pathways. In this sense, MSFCM functions not merely as a technological solution but as an instructional architecture that integrates multisensory input, metaphorical scaffolding, embodied interaction, and adaptive feedback into a continuous learning journey.

The bibliometric mapping further identified recurring learning strategies across the dataset. As summarized in Table 5, five dominant strategy types were identified: multisensory learning, metaphor-based learning, embodied interaction, gamified learning, and assistive digital learning. Each of these strategies addresses specific cognitive, emotional, or accessibility-related challenges commonly experienced by learners with dyslexia (Paudel et al., 2025; Smith & Hattingh, 2020). The integration of these strategies within a single instructional framework constitutes a key conceptual contribution of MSFCM.

Building on this strategy mapping, thematic clustering revealed five dominant research themes across the literature: AR-supported literacy learning, motivation and engagement, inclusive interaction design, immersive assistive systems, and AI- and metaverse-oriented learning environments. As shown in Table 6, each cluster is supported by multiple Scopus-indexed studies, indicating that these themes are empirically emergent rather than analytically imposed (Ji et al., 2025; Lozano-Álvarez et al., 2025). However, the absence of an integrated pedagogical model across these clusters further reinforces the need for a framework such as MSFCM that systematically connects immersive technologies with literacy-oriented instructional design.

By responding directly to the conceptual fragmentation identified through the bibliometric analysis, MSFCM provides a theoretical bridge between immersive technology development and pedagogically grounded dyslexia intervention. The framework therefore contributes to the field by proposing an integrated instructional model that aligns multisensory literacy support with immersive learning environments, offering a direction for future empirical research and design-based implementation. Beyond the structural mapping of research themes, a qualitative examination of abstracts and author keywords was conducted to identify recurring learning strategies underlying immersive learning interventions for dyslexia.

Table 5. Learning Strategy Types Identified in Scopus Abstracts (2020–2025)

Learning Strategy	Description	Dyslexia-Specific Contribution	Representative Studies
Multisensory Learning	Multi-channel sensory input	Supports phonological processing	(Bhatti et al., 2020; Fei et al., 2022; Lozano-Álvarez et al., 2025)
Metaphoric Learning	Symbols, narratives, spatial metaphors	Reduces abstraction barriers	(Tiede et al., 2022)
Embodied Learning	Movement and gesture-based interaction	Grounds language in action	VR-based studies
Gamified Learning	Game mechanics & feedback	Emotional safety & persistence	(Ausín Villaverde et al., 2023)
Assistive Digital Learning	AR, VR, and XR platforms	Access facilitation	(Bhatti et al., 2020; Fei et al., 2022; Lozano-Álvarez et al., 2025)

As summarized in Table 5, five dominant strategy types were identified: multisensory learning, metaphor-based learning, embodied interaction, gamified learning, and assistive digital learning.

Table 6. Thematic Clusters of Scopus Publications Relevant to Dyslexia Intervention

Thematic Cluster	Description	Supporting Studies (Scopus)
AR-Supported Literacy	Reading, spelling, vocabulary	(Ahmad et al., 2021; Bhatti et al., 2020; Fei et al., 2022)
Motivation & Engagement	Enjoyment, confidence, persistence	(Ausín Villaverde et al., 2023; Tiede et al., 2022)
Inclusive Interaction Design	Usability & cognitive constraints	(Ridzwan & Mohammad, 2025)
Immersive Assistive Systems	VR/AR learning environments	(Lozano-Álvarez et al., 2025)
AI & Metaverse Environments	Adaptive immersive systems	(Abdalla et al., 2024)

This study employs a descriptive bibliometric mapping approach rather than a citation-based performance analysis. This methodological choice is grounded in the emerging, interdisciplinary, and conceptually fragmented nature of research on immersive, multisensory, and metaphor-based learning approaches relevant to dyslexia intervention, where dominant authors, journals, and stable citation networks have not yet been firmly established. In such research domains, descriptive bibliometric mapping is considered more appropriate for identifying thematic patterns, conceptual orientations, and research gaps, as it emphasizes intellectual structure and conceptual development rather than evaluative metrics (Donthu et al., 2021; Gan et al., 2022; Passas, 2024).

Given the relatively small-to-medium size of the dataset and the diversity of publication types included, the primary objective of this bibliometric analysis is to map research trends and intellectual directions rather than to assess research impact or productivity. This methodological orientation aligns with established bibliometric guidelines for exploratory and emerging research fields, which

recommend science mapping approaches when the primary aim is conceptual synthesis instead of performance comparison (Donthu et al., 2021; Gan et al., 2022; Passas, 2024).

Research Contribution

This study contributes to the literature by providing a structured bibliometric mapping of an emerging and interdisciplinary research domain. Unlike prior studies that focus on effectiveness or technological feasibility, this research clarifies thematic orientations, temporal trends, and conceptual gaps across recent publications.

By synthesizing these findings, the study establishes a conceptual rationale for integrated pedagogical approaches, such as the Metaverse-based Multisensory Flexible Comprehension Method (MSFCM), positioning it as a response to gaps identified across the literature. To support the bibliometric mapping process, this study drew upon established bibliometric analysis tools and methodological references that emphasize transparency and replicability in science mapping research. Bibliometric data structuring and thematic exploration were informed by prior methodological work on bibliometric software and analytical frameworks (Aria & Cuccurullo, 2017), ensuring systematic handling of publication metadata and keyword-based thematic clustering.

Limitations

This study is limited to Scopus-indexed publications and may exclude relevant studies published in non-indexed journals or alternative databases. Additionally, the bibliometric approach emphasizes descriptive mapping rather than empirical evaluation of learning outcomes. As a result, the findings should be interpreted as indicative of research trends rather than instructional effectiveness.

Suggestions

Future research should move beyond fragmented, tool-centered approaches toward the development and empirical validation of integrated instructional frameworks within immersive environments. Longitudinal and design-based research is recommended to examine how multisensory, metaphor-driven, embodied, and affective learning components can be combined into sustained learning journeys for learners with dyslexia. Further studies may also explore how metaverse-based learning ecologies can support personalization, continuity, and learner well-being within inclusive education settings.

CONCLUSION

This bibliometric study mapped research trends on immersive and metaverse-based multisensory learning for dyslexia from 2020 to 2025. The findings indicate a growing scholarly interest in augmented reality, virtual reality, and emerging immersive environments; however, the field remains conceptually fragmented and predominantly technology-driven. While multisensory engagement, motivation, and inclusivity are frequently addressed, these elements are rarely integrated into coherent instructional frameworks or continuous learning journeys. The analysis reveals a persistent gap in the systematic integration of cognitive, multisensory, embodied, and affective learning dimensions across the examined period. By clarifying this gap, the study provides a conceptual rationale for the development of integrated pedagogical approaches within immersive environments. Future research should move beyond tool-centered designs toward theory-driven instructional models that support learning continuity and learner well-being in dyslexia-focused education.

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AUTHOR CONTRIBUTION STATEMENT

The authors solely conceptualized the study, designed the research framework, conducted the bibliometric analysis, interpreted the findings, and drafted the manuscript. The authors also developed the theoretical synthesis and approved the final version of the manuscript.

AI DISCLOSURE STATEMENT

Artificial intelligence tools were used to support language refinement and improve clarity during the manuscript preparation process. The use of AI was limited to editorial assistance and did not influence the research design, data collection, data analysis, result interpretation, or the generation of scientific conclusions. The authors take full responsibility for the content of this manuscript.

CONFLICTS OF INTEREST

The authors confirm the presence or absence of any potential conflicts of interest, financial, institutional, or personal that could influence the conduct of this study, the analysis of data, the preparation of the manuscript, or its publication.

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