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A Bibliometric Analysis of Metaverse-Integrated Learning in Language Acquisition

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Abstract. Metaverse-integrated learning (MIL) has garnered increasing attention in educational fields in recent years. While prior research has predominantly focused on scientific fields, only a few scholars have delved into its application in language acquisition. This study aimed to delineate the intellectual landscape of MIL in language acquisition, identifying key regions/countries, authors and journals, and to scrutinize the roles of self-efficacy, collaborative learning, and multi-modality within this context. Based on a bibliometric analysis, this study utilized both quantitative and qualitative methods to examine 248 articles from the Web of Science, spanning from 2010 to 2025, with the aid of VOSviewer and CitNetExplorer. The findings indicate that the primary research hubs are located in Taiwan, the United States and China. Among the authors, Lan Yuju is the most influential, while *Computer Assisted Language Learning* emerges as the most frequently cited journal in the field. With a significant upward trend in the academic domain, the findings further reveal that self-efficacy, collaborative learning, and multi-modality are not only crucial but also interdependent factors in MIL in language acquisition. These findings may provide implications for relevant educators and policymakers to enhance the MIL in language acquisition within the educational world.

Keywords: Metaverse-integrated Learning; Self-efficacy; Collaborative Learning; Multi-modality; Bibliometric Analysis

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1. Introduction

With the rapid evolution of technology, the integration of the metaverse into education has made significant strides. The concept of the metaverse was first introduced in the 1992 novel *Snow Crash*. At the 2021 Connect! conference, Mark Zuckerberg announced that Facebook would rebrand as Meta, signaling a strategic pivot towards the development and integration of virtual reality (VR) technologies (Lucia et al., 2025). As the latest generation of Web 3.0, governments around the world have increasingly sought to support its development.

In Asia, South Korea has launched a metaverse strategy to foster innovation across various sectors, including public services, culture and tourism (Shukla et al., 2024). This conceptual framework is brought to life through the integration of emerging technologies, such as augmented reality (AR), VR, extended reality (XR), blockchain, cloud computing, and digital twin technology (Fan et al., 2024).

In the education sector, research into the potential of metaverse technologies is thriving. Emerging spaces and roles for language learning, such as artificial intelligence bots, ambient intelligence and the metaverse, are becoming increasingly integral to our daily lives (Godwin-Jones, 2023). Metaverse-based language teaching (MBLT) has notably enhanced vocabulary acquisition, students' engagement and overall feelings of presence and community among learners (Çelik & Baturay, 2024).

While the high level of learner engagement in the metaverse can significantly boost academic success, it is also constrained by the digital literacy levels of both students and instructors (Li & Yu, 2023). Understanding how the metaverse transforms language learning is crucial for elucidating the relationship between humans, language and the world.

In this context, it is imperative to identify the key factors influencing MIL in language acquisition. The application of multi-modality can broaden learners' opportunities for language production, enabling them to interact with partners through visual, auditory and kinesthetic channels (Wu et al., 2023; Wang & Li, 2025). Collaborative learning among learners is fostered through interactivity and knowledge sharing, while also reducing emotional stress (Qureshi et al., 2023).

Furthermore, self-efficacy can directly or indirectly influence students' behaviors, enhancing their learning motivation and autonomy (Rodríguez-Ruiz et al., 2025). Thus, it is essential to systematically analyze the roles and relationships of self-efficacy, collaborative learning and multi-modality in MIL in language

acquisition, in order to provide a reference for optimizing the learning experience.

From the aforementioned references, a substantial number of scholarly review studies have focused on MIL. Table 1 provides a comparative analysis of previous and current research, highlighting differences in study type, time frame, key features, and the number of publications included. For instance, a scope review concentrated on virtual-agent-based language learning, analyzing 15 works (Gu et al., 2023). A scientometric analysis examined 4631 publications (Mohsen et al., 2024), while a meta-analysis on the effects of the metaverse on quality education analyzed 34 publications (Diao & Su, 2025).

However, a bibliometric analysis using both VOSviewer and CitNetExplorer to analyze MIL in language acquisition has yet to be conducted. Moreover, as an innovative learning platform, the metaverse specializes in providing learners with immersive, interactive and personalized experiences (Lucia et al., 2025). The challenge remains to effectively apply these advantages to language learning and enhance the efficiency of language acquisition through effective multi-model design. Thus, there is an urgent need for further research on the application of MIL in language acquisition.

Table 1: The Comparison of Prior Research on MIL with the Current Study

Study	Type	Time Period	Highlight	Number of Publications
Gu et al. (2023)	A scoping review	2012-2022	Virtual-agent-based language learning	15
Mohsen et al. (2024)	A scientometric review	1980-2021	Research trends in computer-assisted language learning	4631
Diao & Su (2025)	A meta-analysis	Before Oct. 2024	The effects of the metaverse on quality education	34
This study	A bibliometric study	2010-Oct. 10, 2025	The role of three elements in MIL	248

In light of the identified research gaps, the application of bibliometric analysis is both necessary and highly valuable. This method utilizes quantitative approaches to systematically examine bibliographic data within a specific academic field. Tools such as VOSviewer, Citespace, and CitNetExplorer are integral to this approach, enabling the visualization of intricate relationships,

including co-authorship patterns, keyword co-occurrences, and citation networks, through data sourced from databases like Web of Science. These visualization tools help identify key research topics and emerging trends, offering practitioners valuable insights to design more effective teaching strategies.

1.1 Research Questions

MIL plays a pivotal role in language acquisition, enabling learners to engage and interact with each other in various scenarios. Despite the promising opportunities metaverse platforms offer for enhancing language acquisition, there remains a significant gap in comprehensive studies that systematically explore emerging trends and thematic hotspots of MIL in language acquisition, particularly through the simultaneous use of VOSviewer and CitNetExplorer.

Moreover, while self-efficacy, collaborative learning and multi-modality have been recognized as beneficial in traditional language classrooms, their association with MIL remains unknown. The three constructs have never been investigated synchronously within the MIL context. Addressing these gaps, this study aims to investigate the development of MIL in language acquisition and explore the roles of self-efficacy, collaborative learning and multi-modality within MIL. The following research questions guide this inquiry:

RQ1: What is the annual trend of the publications and citations included?

RQ2: What are the top ten authors, sources, organizations and countries among the studies on the MIL in language acquisition over fifteen years?

RQ3: What are the prominent topics associated with the MIL in language acquisition?

RQ4: What is the role of self-efficacy in the MIL in language acquisition?

RQ5: What is the role of collaborative learning in the MIL in language acquisition?

RQ6: What is the role of multi-modality in the MIL in language acquisition?

By exploring these research questions, the findings are expected to optimize the MIL design and enhance the overall effectiveness of foreign language learning. Moreover, the findings may provide valuable insights for policymakers to develop effective teaching strategies and resource allocation plans.

2. Literature Review

2.1 Bibliometric Analysis in Educational Research

Bibliometric analysis has become increasingly popular among researchers as a systematic method for reviewing academic research to identify patterns, trends, and influences in a given field (Cobo et al, 2011; Passas, 2024). Bibliometric approaches have been adopted to give published works quantitative analysis (Ellegaard & Wallin, 2015). For scientific mapping, VOSviewer is employed to visualize the most cited sources, authors, institutions and countries, while CitNetExplorer is used to construct clustering methods (Min & Yu, 2023; Yu & Li, 2022). Citespace, another application, aims to visualize emerging phenomena and significant shifts in scientific areas over time, integrating knowledge graphs with visual thinking to reshape how we perceive the world (Chen, 2006). These studies not only showcase the achievements of prior studies but also outline emerging trends for future exploration.

2.2 Metaverse in Language Learning

Recently, the metaverse has emerged as a focal point in educational research. Defined as a 3D immersive space constructed by VR/AR, AI and virtual world platforms (Huynh-The et al., 2023; Çelik, 2025), the metaverse is characterized by immersion, interactivity and multi-user social experience (Onu et al., 2024). It provides an authentic and immersive learning environment, enabling learners to engage and collaborate through avatars (Nagao, 2023).

The application of the metaverse in language learning encompasses three main aspects. Firstly, it promotes learner output through role plays and scenario-based dialogues. XR technologies, including VR and 360° video technology, are particularly prevalent in language learning due to their specific advantages (Wu et al., 2023). 360° video technology, which combines elements of traditional video and VR, offers a more immersive and authentic presentation of learning content, especially when used with head-mounted displays (Rosendahl & Wagner, 2024).

Secondly, immersion significantly impacts learners' motivation, supporting individualized learning and reflective teaching practices (Wang & Li, 2025). Thirdly, the metaverse facilitates social and collaborative learning, which is beneficial for improving their learning performance. Learners supported by an external (out-of-video) pedagogical agent exhibited superior learning performance, reduced visual attention to instructional content, and engaged in more frequent behavioral interactions (Li et al., 2025).

Despite its advantages in promoting learner output through authentic and immersive contexts for language acquisition, the metaverse still faces a number

of challenges. For instance, there is a lack of metaverse apps or platforms specifically designed for language learning (Wu et al., 2024). The experience with metaverse technology and the duration of utility should be taken into consideration (Rosendahl & Wagner, 2024). Therefore, empirical studies are needed to promote its application in educational settings.

2.3 Self-efficacy in Language Learning

Self-efficacy refers to an individual's belief in their ability to accomplish a task in a specific context. Bandura (1982) defined it as the belief in one's capacity to initiate and persist in a behavior despite obstacles, encompassing both the necessary skills and the motivation to use them effectively. Research on self-efficacy in foreign language learning typically focuses on two main areas: learners and teachers (Waddington, 2023).

The personal traits of English foreign language teachers, including emotional intelligence and their ability to adapt instructional approaches, significantly influence their self-efficacy beliefs (Zhi et al., 2024). Instructors' confidence and self-efficacy can be enhanced by assisting them in applying a variety of teaching strategies (Orakçı et al., 2023). Students with higher self-efficacy were more eager to engage with artificial intelligence tools to satisfy their need for social interaction (Rodríguez-Ruiz et al., 2025) and promote positive learning experiences (Getenet et al., 2024).

2.4 Collaborative Learning in Language Learning

Collaborative learning refers to an educational context where learners participate in shared tasks, drawing on resources and skills from their peers to enhance overall learning achievement (Qureshi et al., 2023). According to Vygotskij's sociocultural theory, schools serve as cultural laboratories where learners gradually engage in the intellectual culture of their social settings, modifying their thinking and developing linguistic competence through active involvement in shared social practices (Vygotskij, 2012). Collaboration provides a way for individuals to increase their mobility (Beaver & Rosen, 1979).

Computer-Supported Collaborative Learning introduces new software aimed at bringing learners together to explore how they learn with the assistance of computers (Suthers, 2012). XR-supported collaborative learning refers to distributed collaboration situations where immersive technologies are utilized as a medium for collaborative learning (Makransky & Petersen, 2023). In language learning, students' academic writing skills and collaborative learning competence improved when provided with immersive and authentic learning materials (Adhami & Taghizadeh, 2024). Interaction with partners, student-instructor interactions, and social media were found to significantly and

positively impact collaborative learning (Qureshi et al., 2023).

2.5 Multi-modality in Language Learning

Multi-modality in language learning has garnered increased attention in recent years. It is defined as the application of different modes by a user to convey an idea, encompassing linguistic, visual, aural, gestural, or spatial modes. The concept, initially borrowed from Halliday's (1978) theoretical framework, argues that researchers should consider the utilization of multiple modes by users across varying contexts to achieve specific goals. Researchers have studied the effects of multi-modal strategies on second language acquisition, body movement-related and facial expression-related models (Jabeen et al., 2023), and the application of multi-modal strategies for TESOL (Early et al., 2015).

Experts have also examined the influence of multi-modal corrective feedback on learners' writing skills, and they provided recommendations for implementing multi-modal literacy in high-level English language acquisition (Camiciottoli & Campoy-Cubillo, 2018; Guo, 2023; Shu & Gu, 2023). Furthermore, a study showed that French learners' comprehension abilities were enhanced by utilizing BBC audiovisual materials that included textual, visual, and auditory components (Guichon & McLornan, 2008).

Drawing on the aforementioned information, multi-modal learning is highly beneficial in educational environments as it engages multiple sensory channels, thus stimulating an array of cognitive processes and promoting learning performance. Self-efficacy plays a pivotal role in shaping learners' motivation, persistence and confidence in successfully acquiring a new language. Collaborative learning in language acquisition enhances communication skills, fosters peer support, and promotes deeper understanding through shared knowledge and interaction. Given the benefits of these three elements for language learners, it is necessary to explore their roles and associations within the MIL context. To address the research gaps, the bibliometric analysis methodology is presented in the following section.

3. Methodology

3.1 Technique Selection

This study employed VOSviewer and CitNetExplorer to achieve the objectives proposed above. CitNetExplorer was used to analyze the development of time-series citation networks, while VOSviewer facilitated subject mining, document coupling and other bibliometric analysis (Yu & Li, 2022). The study followed a four-step approach. Firstly, the annual pattern of MIL in language acquisition was displayed.

Secondly, VOSviewer was used to identify the most frequently cited contributors, sources, organizations and countries/regions that were associated with MIL in language acquisition. Thirdly, VOSviewer was further applied to highlight hot topics in the field. Lastly, CitNetExplorer was applied to analyze the citation relationships among individual documents, using clustering analysis to group publications based on citation-based connections. Citation impact studies concentrate on involvement in current discussion and lasting visibility (Leydesdorff et al., 2016), while cluster analysis is a statistical method that categorizes observations into similar sets or groups (Ketchen & Shook, 1996).

3.2 Data Collection

The authors conducted a search on the Web of Science database on October 10, 2025, focusing on the Web of Science Core Collection, which includes the Social Science Citation Index (SSCI), Science Citation Index Expanded (SCIE), Emerging Science Citation Index (ESCI), and Arts & Humanities Citation Index (A&HCI).

Boolean operations were applied in the Web of Science to acquire a satisfactory result. The authors entered specific search queries into the database: TS = (MIL OR metaverse-based learning OR immersive learning OR virtual-world learning OR XR education) AND TS = (foreign language learn OR language learn OR EFL OR ESL). A total of 824 publications were retrieved, spanning from 2010 to 2025. The collected literature encompassed various article types: articles (n=738), review articles (n=69), early access (n=48), book reviews (n=9), editorials (n=5), retracted publications (n=3), meeting papers (n=2), proceeding papers (n=2), book chapters (n=1), and letters (n=1).

With regard to document type, only "Article" and "Review Article" were included, aligning with the focus on educational technology applications. The research covered a wide range of educational research levels, including elementary, secondary, and post-secondary education. To avoid potential technical issues in CitNetExplorer, such as upload errors caused by the absence of "publication year" information in early access files, these documents were excluded from the dataset. The study adhered to the guidelines of the PRISMA statement (Sarkis-Onofre et al., 2021) to ensure the process's efficacy and accuracy (as illustrated in Figure 1).

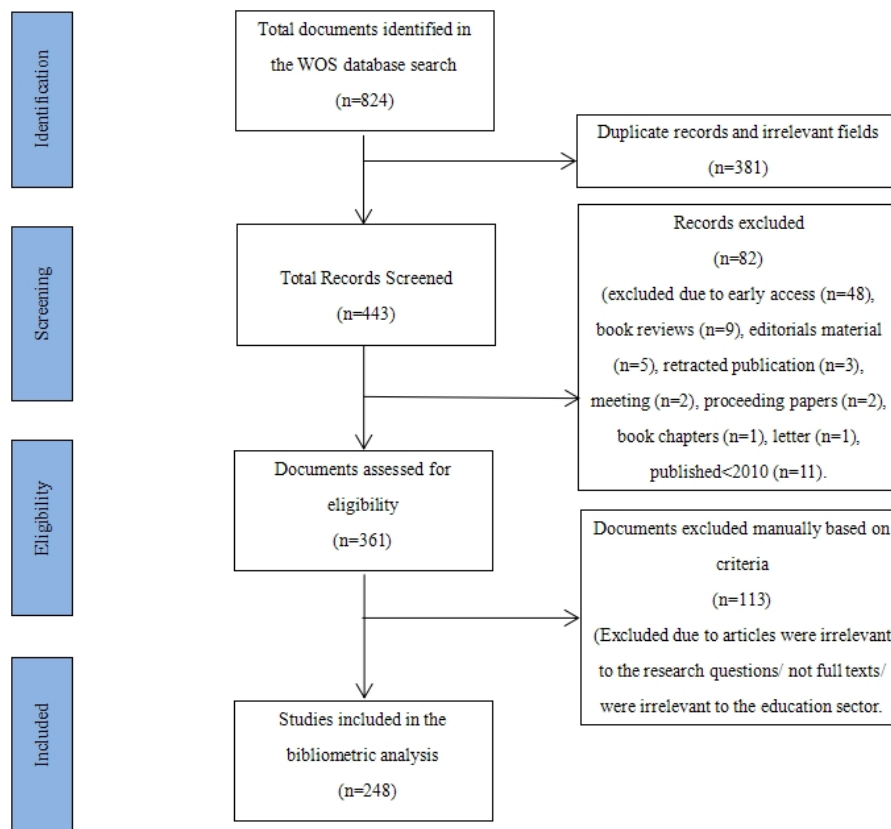


Figure 1: PRISMA Flow Diagram

The selected publications were written in several languages: English (n=364), French (n=7), Spanish (n=7), Chinese (n=2), German (n=1), and Portuguese (n=1). Consequently, 361 articles were collected. To ensure data reliability, we conducted a thorough review of titles and abstracts to verify alignment between the stated research aims and the actual content, excluding irrelevant studies. Articles were included if they: (1) focused on MIL; (2) provided sufficient details; and (3) presented significant findings. Conversely, articles were excluded if they: (1) were irrelevant to the research questions; (2) were duplicates, (3) not full texts, or (3) did not fall within educational disciplines. Through this process, 248 articles were manually selected from the initial 361 in the WOSCC databases.

Consequently, the relevant records were downloaded, and VOSviewer was used to identify the most productive authors, sources, organizations, and countries. A detailed explanation of the bibliometric analysis process and the presentation of the resulting data are provided in the results section.

4. Results

4.1 Temporal Distribution of Publications

The survey results presented the annual publication counts that were analyzed to identify trends among the selected studies. The dataset included 26 review articles and 357 regular articles, covering the period from January 2010 to October 2025, excluding November and December, as the search was concluded before the end of the year. Figure 2 illustrates the growing interest in MIL in language education since 2010. The number of related publications fluctuated up and down from 2010 to 2019.

However, a significant academic upturn in metaverse-related research emerged in 2020. From 2020 to 2024, there was a consistent and substantial increase in the volume of research, reaching a peak in 2024. Over the same period, citation counts also trended upward, with notable surges in 2023 and 2024, though there was a slight decline in 2025. Based on these publication patterns, it is evident that metaverse-integrated language learning has become an increasingly prominent academic field and is likely to remain a key focus of future research.

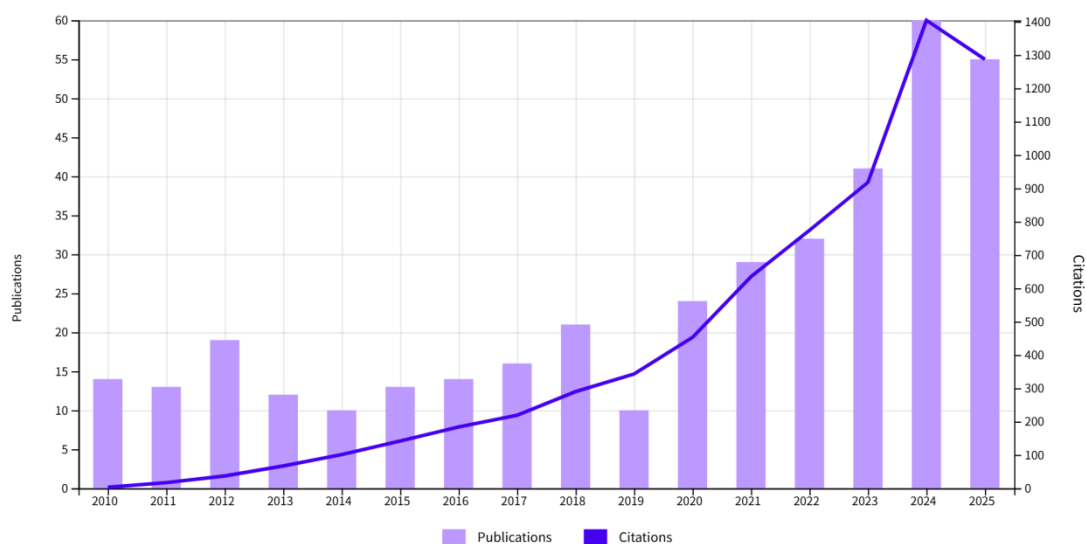


Figure 2: Annual Publications and Citations on MIL (Jan. 2010-Oct. 2025)

4.2 The Prolific Authors, Sources, Organizations and Countries within MIL in Language Acquisition

Working with high citation is the one that has been found to be useful by a large number of people (Garfield, 1979). VOSviewer was employed to pinpoint the most frequently cited authors, sources, institutions, and countries in this research area. Table 2 lists the top ten authors: Lan Yuju, Hsiu-Ting Hung, Parmaxi Antigoni, Julian ChengChiang Chen, Tzu-Yu Tai, Hao Jan howard Chen, Indy Y. T. Hsiao, Andrew Graeme Todd, Chen Nianshing, and Lee

Sangmin Michelle. The top ten cited sources include Computer Assisted Language Learning, Interactive Learning Environments, Education Technology & Society, Recall, Language Learning & Technology, Education and Information Technology, Calico Journal, IEEE Transactions on Learning Technology, International Journal of Computer-Assisted Language Learning and Teaching, and Journal of Educational Computing Research.

The top ten cited organizations are National Taiwan Normal University, National Taiwan University of Science and Technology, National Kaohsiung University of Science & Technology, National Cent University, Curtin University, National Yunlin University of Science & Technology, Purdue University, Education University of Hong Kong, Kyung Hee University and Jeonbuk National University. The top ten cited countries/regions are Taiwan, the USA, the People's Republic of China, South Korea, Japan, Australia, Spain, Canada, England, and France.

Table 2: Top Ten Cited Authors, Sources, Organizations, and Countries

N	Cited Author	Citation	Link	Cited Source	Citation	Link
1	Lan Yuju	473	69	Computer Assisted Language Learning	491	54
2	Hsiu-Ting Hung	247	66	Interactive Learning Environments	318	46
3	Parmaxi Antigoni	179	65	Education Technology & Society	290	29
4	Julian ChengChiang Chen	177	77	Recall	289	27
5	Tzu-Yu Tai	164	76	Language learning & Technology	220	33
6	Hao Jan howard Chen	155	74	Education and Information Technology	213	31
7	Indy Y. T. Hsiao	129	66	Calico Journal	122	21
8	Andrew Graeme Todd	115	60	IEEE Transactions on Learning Technology	106	16
9	Chen Nianshing	79	60	International Journal of Computer-Assisted Language Learning and Teaching	94	16

N	Organization	Citation	Link	Country/Region	Citation	Link
10	Lee Sangmin Michelle	42	56	Journal of Educational Computing Research	89	17
1	National Taiwan Normal University	781	77	Taiwan	1376	157
2	National Taiwan University of Science and Technology	281	32	USA	823	102
3	National Kaohsiung University Science & Technology	260	19	People's Republic of China	532	106
4	National Cent University	255	20	South Korea	254	54
5	Curtin University	196	20	Japan	241	17
6	National Yunlin University Science & Technology	121	20	Australia	222	39
7	Purdue University	101	16	Spain	149	11
8	Education University of Hongkong	76	21	Canada	118	34
9	Kyung Hee University	72	24	England	55	28
10	Jeonbuk National University	3	19	France	24	12

4.3 The Prominent Topics Within MIL in Language Acquisition

VOSviewer was employed to create a visual representation of the most frequently occurring keywords from the selected Web of Science studies (van Eck & Waltman, 2010). The bibliographic data were imported into VOSviewer to generate a visualization map, and a keyword co-occurrence network was constructed with a minimum threshold of four occurrences. Out of a total of 1064 identified keywords, 108 met this threshold, resulting in the creation of Figure 3. In the visualization, keywords with greater prominence are displayed in larger font sizes, while thicker connecting lines indicate stronger relationships between them.

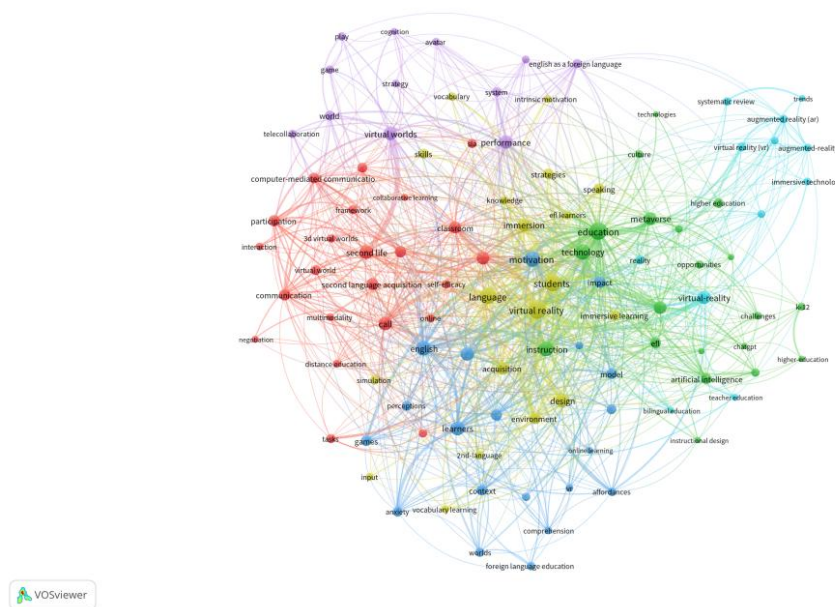


Figure 3: A Co-occurrence Map from Bibliographic Records

The 108 keywords were grouped into six clusters, with the top five keywords from each cluster selected based on frequency and total link strength, presented in Table 3. Cluster 1 contains 28 items, with notable terms such as VR (Total link strength = 204, Occurrence = 46), instruction (Total link strength = 99, Occurrence = 17), and technology (Total link strength = 91, Occurrence = 18). Cluster 2 includes 27 items, including CALL (Total link strength = 70, Occurrence = 14), participation (Total link strength = 62, Occurrence = 10), and computer-mediated communication (Total link strength = 43, Occurrence = 7). Cluster 3 comprises 18 items, such as design (Total link strength = 71, Occurrence = 14), experience (Total link strength = 47, Occurrence = 8), and games (Total link strength = 40, Occurrence = 7).

Cluster 4 encompasses 16 items, including immersion (Total link strength = 62, Occurrence = 15), environment (Total link strength = 61, Occurrence = 11), and acquisition (Total link strength = 61, Occurrence = 11). Cluster 5 contains 10 items, with motivation (Total link strength = 104, Occurrence = 19), AR (Total link strength = 24, Occurrence = 4), and cognitive load (Total link strength = 17, Occurrence = 4) among them. Cluster 6 is made up of 9 items, including performance (Total link strength = 61, Occurrence = 10), classroom (Total link strength = 58, Occurrence = 10), and impact (Total link strength = 40, Occurrence = 10).

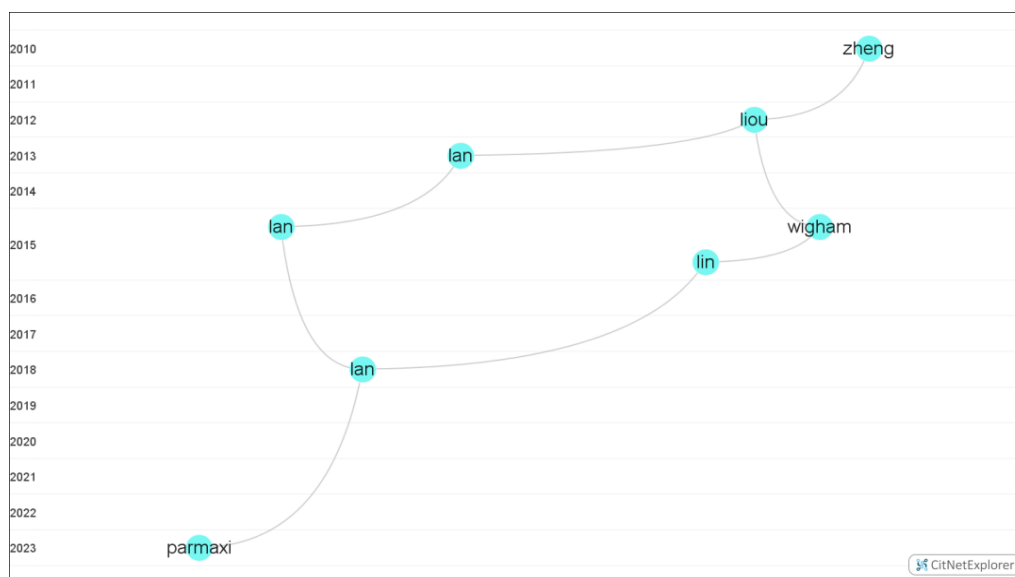
Table 4: Three Clusters and the Clustering Network

Color	Number of Publications	Number of citation link	Number of publications ≥ 5 citations	The highest citation score
Blue	92	299	23	16
Green	15	15	2	5
Purple	10	11	1	7

4.4 Self-efficacy in MIL in Language Acquisition

Self-efficacy influences cognitive processes, actions, and emotional responses, with higher levels being linked to better performance and reduced emotional stress (Bandura, 1982). The authors utilized CitNetExplorer to analyze citation relationships for specific topics by drilling down the longest paths separately (see Figure 5). CitNetExplorer is effective for exploring citation paths through scientific literature, and most publications on the longest path deal with the topic of author co-citation analysis (van Eck & Waltman, 2014).

By selecting Parmaxi (2023) and Zheng et al. (2010) in CitNetExplorer, eight publications and twelve citation links were identified. After drilling down the longest path, the authors visualized the relationships among these eight publications, revealing self-efficacy as a significant factor in MIL. The following publications highlighted the impact of self-efficacy on learning motivation and persistence in language acquisition through VR technology, highlighting its important role in MIL in language acquisition.

**Figure 5: Graphical Visualization of the First Longest Path**

Self-efficacy refers to learners' confidence in their ability to achieve success in their studies and learning objectives through diverse learning activities (Yu & Li, 2022). Its significance in MIL in language acquisition can be understood from the following dimensions.

Zheng et al. (2010) explored the impact of affective factors, particularly self-efficacy, on learning language within a three-dimensional game-oriented virtual environment. They discovered that while achievement scores reflected past behavior, students in the virtual environment developed higher self-efficacy and became more actively engaged in learning English. Their research suggested that self-efficacy is a powerful factor shaping learners' willpower and determination, with virtual worlds fostering sustained engagement in learning.

Furthermore, Liou (2012) addressed the aspect that students' immersive exploration and cooperative learning were facilitated by Second Life with an appropriate learning environment. Their study found that exposure to the Second Life virtual world strengthened learners' self-efficacy and sustained motivation, contributing to long-term language learning success.

4.5 Collaborative Learning in MIL in Language Acquisition

The researchers investigated the second longest citation path related to self-efficacy, spanning from an earlier publication (Wehner et al., 2011) to a recent one (Lee et al., 2024). A total of eight publications with twelve citation associations were recognized. Figure 6 provides a graphical visualization of the second longest path.

The second longest path revealed that collaborative learning played an important role in metaverse-integrated language learning. According to Qureshi et al. (2023), collaborative learning is influenced by several elements, such as learners' engagement, mutual cooperation, and the use of social media. Wehner et al. (2011) pointed out that a MIL environment can reduce learners' emotional stress when they encounter difficulties and enhance their participation in language learning activities, thereby creating a more enjoyable learning environment.

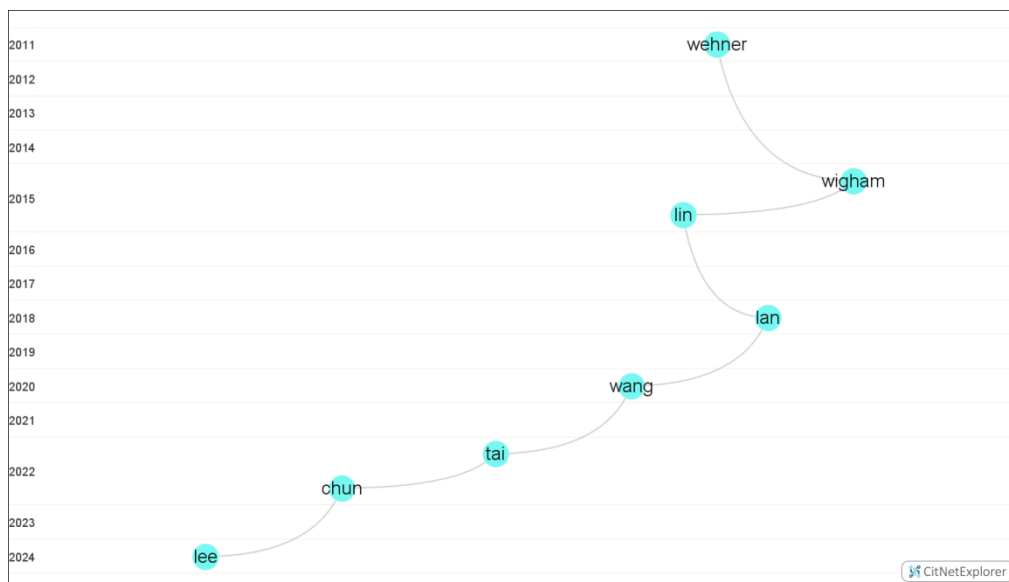


Figure 6: Graphical Visualization of the Second Longest Path

The authors identified the research papers to further explore the roles of collaborative learning within the domain. Wang et al. (2020) carried out a meta-analysis focusing on language learning in 3D virtual worlds. Drawing on the theory of situated learning, the authors found that 3D virtual worlds could provide learners with collaborative opportunities and facilitate knowledge acquisition through group tasks. Their work indicated that 3D virtual worlds positively influenced learners' attitudes, as they were more inclined to participate in interactive learning activities that incorporated modern technology compared to traditional learning methods.

Wu et al. (2023) further argued that collaborative learning played a great role in group learning, as learners are supposed to communicate with each other, solve problems together, and make progress together. They discovered that feedback and suggestions from peers could lead to practical improvements in metaverse-integrated learning approaches for both instructors and learners. Their findings revealed that collaborative learning positively influenced learners' attitudes and fostered meaningful peer interactions.

4.6 Multi-modality in MIL in Language Acquisition

Multi-modality caters to diverse types of learners (e.g., visual, auditory, kinesthetic) by offering multiple ways to understand and interact with learning materials (Kessler, 2022). The authors drilled down the third longest path, identifying the visualization in Figure 7, which included seven publications and eight citation links spanning from 2010 to 2025. After analyzing their citation relationships and key contributions, the authors identified seven publications centered on the theme of multi-modality. These articles primarily focused on the

functions and dimensions of multi-modality in language acquisition.

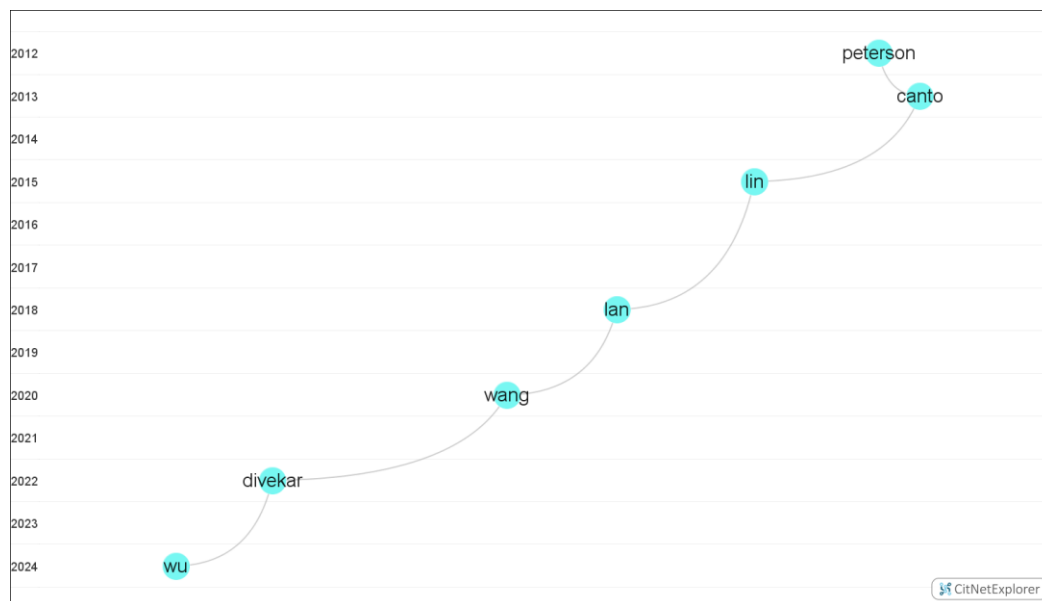


Figure 7: Graphical Visualization of the Third Longest Path

Wu et al. (2023) identified that metaverse-integrated language learning allows learners to interact with peers or partners in situated learning settings without the need for physical relocation. This creates more opportunities for language output, boosts students' intrinsic or extrinsic motivation, and enhances language learning proficiency.

Further study outlined three interconnected dimensions: (1) Reality + Mentality, which encompasses traditional classroom and textbook-based learning approaches; (2) Mentality + Virtuality, which highlights the necessity of mental engagement within virtual environments; and (3) Mentality + Virtuality + Reality, which illustrates the benefits of integrating real-world, virtual and cognitive elements. Their findings indicated that the integration of multiple modes caters to diverse learning styles, deepens immersion in the learning experience, and fosters greater learner autonomy throughout the language learning process.

In addition to the above dimensions, Divekar* et al. (2022) developed a Collaborative Immersive Language Learning Environment (CILLE), which combined multiple AI agents with immersive XR technology to enhance multi-modal and collaborative learning for students of Chinese as a foreign language. Their study demonstrated that interactions within CILLE functioned as intended, leading to significant improvements in vocabulary, listening comprehension, and speaking performance. However, they also identified two

primary challenges in the nascent field of multi-modal conversational AI research. First, instructors relied on technical specialists for designing teaching content. Second, they argued that multi-modal, multi-party interactions with AI agents need further refinement to fully realize their teaching and learning potential.

Based on the above information, self-efficacy, collaborative learning, and multi-modality in MIL are closely interrelated. Together, these three concepts can enhance learners' motivation, engagement and proficiency. In a MIL environment, multi-modality enables learners to interact virtually with their partners and instructors (Roy et al., 2023). Moreover, learners' collaborative learning can strengthen their self-efficacy (Lampropoulos & Evangelidis, 2025).

By working together towards a common goal and providing positive encouragement and feedback, students can bolster each other's self-efficacy. Multi-modality further supports self-efficacy by allowing learners to engage in ways that they find comfortable and effective (Huang et al., 2024). As a result, collaborative learning and multi-modality approaches can create a supportive and varied learning environment that, in turn, enhances learners' self-efficacy. A model illustrating the relationship between three factors in MIL is presented in Figure 8.

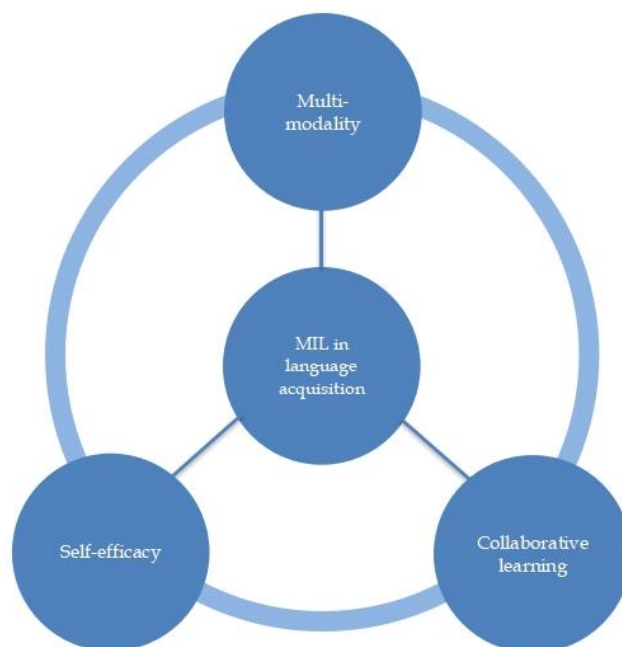


Figure 8: A Model of the Relationship Between Three Factors in MIL

Consequently, the results indicate that self-efficacy, collaborative learning, and multimodality play important roles in MIL language acquisition and together

constitute an interrelated framework. The following section further discusses these findings.

5. Discussion

The study examined the current state and emerging trends in the field of MIL in language acquisition. Several visual network maps were generated to identify key data patterns: an annual publications and citations network to reveal temporal trends; a citation network highlighting the most prolific contributors, institutions and countries/regions in the field; a keyword co-occurrence map to uncover hot topics; and three longest-path citation networks to explore the roles of self-efficacy, collaborative learning and multi-modality in the MIL.

RQ1 presented a network on the trend of MIL, indicating its growing influence in language acquisition. The finding aligns with the observations of Villalonga-Gómez et al. (2023), who observed a significant increase in educational metaverse publications in 2021, likely due to the COVID-19 pandemic's impact on education and the increased demand for immersive and interactive virtual learning spaces (Ratten, 2023). From the dimension of government policies, the United Arab Emirates and South Korea have led in formulating comprehensive metaverse strategies and integrating related technologies into public services, aligning with the global metaverse market projected to reach US\$5 trillion by 2030 (Shukla et al., 2024).

RQ2 listed the top ten most cited authors, sources, organizations and countries/regions, revealing that research on MIL in language acquisition is thriving in Taiwan, the United States, and China. This differs from the findings of Villalonga-Gómez et al. (2023), who identified the United States, the United Kingdom and Korea as the most productive countries. The reason may be attributed to several aspects. Firstly, the data sources and the time spans are different. Their study collected data from WoS and Scopus between the years 2007 and 2021, while this study used data exclusively from WoS between 2010 and 2025.

Secondly, the data coverage is different. Their work focused on higher education, whereas this study covered elementary, secondary and post-secondary levels, which may explain the country-level differences in publications. At the journal level, *Computer Assisted Language Learning* emerged as a key contributor, aligning with the findings of Mohsen et al. (2024). This suggests that MIL is experiencing rapid growth, and scholars in this field may benefit from examining publications in the aforementioned journals to identify future research directions and address existing gaps.

RQ3 identified the most frequently discussed keywords associated with MIL in language acquisition, including metaverse, VR, AR, technology, etc. The findings align with the observations of Villalonga-Gómez et al. (2023). Based on these results, this study explored the relationships between self-efficacy, collaborative learning and multi-modality in MIL and constructed a model, offering a fresh perspective. The model aims to improve learners' foreign language acquisition by promoting autonomy, facilitating interaction, and enriching the learning experience.

It functions as a tool to provide personalized learning strategies in an interactive context, integrating multi-modality resources to enhance the learning experience. According to Vygotsky (1978), humans' knowledge is obtained through the interaction between their perceptions and experiences, with individuals responsible for creating and acquiring knowledge. Thus, the uniqueness of the MIL model lies in its combination of personal cognition and social interaction. It could help learners acquire language skills through deep engagement and constructive learning processes.

RQ4 attempted to explore the role of self-efficacy in MIL. We found that the role of self-efficacy was highlighted in the language learning process (Liou, 2012; Zheng et al., 2010). In the MIL environment, learners' attitudes, motivation and persistence are greatly enhanced (Zheng et al., 2010). An interesting thing is that these findings align with the observations of Yu & Li (2022), who noted that self-efficacy may have an impact on online learning outcomes while fostering learners' self-regulation and persistence. Additionally, the findings also provide evidence for Bandura's self-efficacy theory, which posits that different modes of influence alter coping behavior partly by creating and strengthening self-perceptions of efficacy (Bandura, 1982).

RQ5 focused on the significance of collaborative learning in MIL in language acquisition. Three-dimensional virtual worlds further enrich such collaborative learning by enabling meaningful interaction and knowledge co-construction through shared tasks (Wang et al., 2020). Collaboration also extends to learner communities, where peer communication and cooperation facilitate task completion, and learner feedback informs educators and developers in optimizing metaverse technology and improving MIL products (Wu et al., 2023). This finding can be explained through the lens of sociocultural theory (Vygotskij, 2012), which suggests that learners progressively integrate into the intellectual life of their community and develop linguistic competence through active participation in shared social practice.

RQ6 examined multi-modality in MIL in language acquisition. By drilling down the third longest path, we found that multi-modality enables learners to interact with others without physical relocation, while integrating text-based, classroom-based instruction with virtual environments. This combination deepens learner immersion, fosters higher engagement and promotes learner autonomy in the language acquisition process, as reflected in the three dimensions proposed by Wu et al. (2023). However, Divekar* et al. (2022) also highlighted educators' reliance on technical experts, suggesting that the pedagogical potential of multi-modality in foreign language learning still requires further refinement.

As a subset of language learning, foreign language learning focuses on cultivating students' language skills, primarily listening, speaking, reading and writing. Teaching objectives, task design and course evaluation should be more specific and targeted. In contrast, the broader concept of language learning includes research on multilingual and cognitive skills, emphasizing the overall development of learners' cognitive strategies and language transfer (Koch et al., 2024).

6. Conclusion

This study delved into the research trends and the development of MIL in language acquisition, employing both qualitative and quantitative research methods. It also explored the interrelationships among learners' self-efficacy, collaborative learning, and the utility of multi-modality resources in the foreign language learning process. The analysis of annual publications revealed a growing interest in MIL within the field of language acquisition. The study identified the most influential authors, sources, institutions and countries/regions in the field.

It also underscored the significant roles of self-efficacy, collaborative learning and multi-modality, and constructed a MIL model for language acquisition. The research made both theoretical and practical contributions. Theoretically, it established a MIL model that incorporated three key factors, providing guidance for optimizing learning design. Practically, the bibliometric analysis that combined metaverse technology with language acquisition helped to improve the efficiency of language acquisition, which in turn could offer a reference for instructors to enrich their language classrooms.

A primary limitation of this research was the exclusive use of data from the Web of Science because the software tool CitNetExplorer only processes data from the Web of Science, potentially leading to the incompleteness of the research. Additionally, the reliability of the model relied on the bibliometric data, lacking

empirical data. Therefore, further validation through experiments or long-term research is necessary.

Future studies could examine the validation of the model through empirical analysis, particularly delving deeper into the roles of self-efficacy, collaborative learning, and multi-modality in MIL in language acquisition. For instance, surveys could be employed to gather students' feedback on feasibility, case studies to observe the application of the model, or controlled experiments to validate the model's key predictions. Incorporating additional databases, such as Scopus and Science Direct, could provide a more comprehensive analysis.

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