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Research Article

The Use of Multimodal Strategies to Develop Vocabulary and Reading Comprehension: A Bibliometric Analysis

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ABSTRACT

A bibliometric analysis was used to explore studies regarding the development of students' vocabulary and reading comprehension with the use of multimodal strategies. There are 1,290 Scopus- indexed articles from 2020 to 2024, with key authors, theories, and themes identified. The results show increased exploration and interest in gamification, augmented reality, and digital tools developed and analyzed using theories in cognition and motivation. This study identifies the trends and gaps in future research and practice. Specifically, this study highlights that more longitudinal studies are needed, as well as more research on how multimodal learning connects with digital and media literacy.

Keywords*: Multimedia, Multimodals, learning styles, Teaching and learning, Reading comprehension, Vocabulary*

Background

Lately, educators have become more worried about the students' declining vocabulary and reading comprehension skills despite the advancements in pedagogy and technology. The Programme for International Student Assessment (PISA), shows that lots of students can't read at the level they are expected to (OECD, 2019). This literacy gap can greatly affect students' achievement, ability to learn throughout life, and future employment.

Many things contribute to these literacy challenges. Some reasons include insufficient reading engagement, inadequate number of diverse and meaningful texts, and traditional instructional methods. Researchers and educators are now turning to multimodal learning– the use of multiple modes, such as text, audio, video, images, gestures, and interactive digital tools to present and engage with content to help students learn, addressing the problems in literacy.

While multimodal learning refers to multiple modes including sensory modes, it is essential to differentiate it from multimedia learning, digital formats combining words and pictures. This study mainly explores how digital applications or tools are used in multimodal learning which align closely with Mayer's (2009) Cognitive Theory of Multimedia Learning. This theory explains how students learn better when information is presented in both words (spoken

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and written) and pictures (images or videos). Dalton and Proctor (2008) found that using multimedia glossaries and digital texts helped students' vocabulary and reading performance. Similarly, Chun (2002) noted that using videos and pictures helped language learners guess the meaning of new words and remember them more easily.

Multimodal learning also helps students engage more deeply and fairly, especially students who may have different backgrounds, learning styles, or learning disabilities. By using multimodal resources, teachers can make lessons easier to understand for everyone (Jewitt, 2008). These tools help promote critical thinking and analytical skills to the students when combining information from different sources, which improves their understanding. Rowsell and Walsh (2011) demonstrated that students learn better when they use and create multimodal content.

Beyond vocabulary and reading comprehension, multimodal strategies can increase students' motivation, self-efficacy, and independence. For example, games and augmented reality can make fun experiences in learning, and encourage students to read and explore a language (Nouri, 2019). Tools that give feedback allow learners to track their progress and improve.

Despite growing interest and empirical support, there are still some gaps in the research. Most studies are focused only on specific tools. Also, a large portion of existing literature explains how effective multimodal works but little research on their long-term impact on literacy development. Additionally, the connections between multimodal literacy, digital literacy, media literacy, and traditional reading instruction remain underexplored, even as these domains increasingly intersect in today's classrooms. Furthermore, only a small number of studies have used bibliometric methods that rely on quantitative, data-driven methods to map research patterns, author networks, citation structures, and keyword trends. This kind of method is important for understanding how the field is growing and where more research is needed.

In light of these gaps, the current study uses bibliometric analysis to explore how multimodal strategies are being used to improve vocabulary and reading comprehension. It aims to systematically examine the structure and development of research in this domain by finding the key publications, authors, and topics in the fields; exploring recurring themes and research clusters; and analyzing co-citation and co-word networks.

Methods

This study utilized a bibliometric research design to examine scholarly literature on multimodal strategies for improving vocabulary and reading comprehension. Bibliometric analysis quantitatively identifies key patterns, influential publications, and research gaps within a field. VOSviewer, a software tool for visualizing bibliometric networks, was employed to analyze co-authorship, co-citation, and keyword co- occurrence, offering a detailed view of the intellectual and thematic structure of multimodal learning research.

Data were collected from the Scopus database using targeted keyword search terms such as "visual OR aural OR kinesthetic OR learning styles," "multimedia," "reading comprehension," and "vocabulary development." The use of Boolean operators guaranteed accurate outcomes. The search was limited to English-language, peer-reviewed documents published during the 2020–2024-time frame from the Social Sciences, and 1,290 related documents on education and psychology were retrieved.

To ensure rigor, inclusion thresholds were applied: only articles with at least 10 citations were considered for citation analysis, while references needed 12 or more citations for co- citation analysis. For keyword analysis, terms that occurred 18 times were taken into account, using a wider threshold of 80 to emphasize dominant research themes. These criteria ensured the analysis reflected important and influential scholarship.

Three main bibliometric techniques were conducted using VOSviewer. Co-citation analysis revealed core literature in multimodal learning; co-word analysis uncovered dominant themes and trends; and co-authorship patterns were briefly explored to determine key contributors. Visual maps showed citation and keyword frequency, with node size and

link thickness indicating strength of connections. Ethical concerns were minimal, as the study utilized publicly available data, with full citation of all tools and sources to maintain academic integrity.

2.1 Search Strategy and Data Collection

Table 1. Search string used for database search

Keyword	Justification
(*visual OR aural OR Kinesthetic OR "Learning styles*") AND (Multimedia) AND (Learning AND Teaching)	To identify literature on the role of multimodals / multimedia in learning and teaching vocabulary and reading comprehension

Result and Discussion

The main findings of this bibliometric study of 1,290 texts on multimedia and learning styles for learning and teaching students are detailed in this section. The results revealed publication growth trends, highlighted influential works shaping the field, and mapped the intellectual structure through co-citation and co-word analysis. These findings provided information on the role of multimedia and multimodal in enhancing the learning, vocabulary instruction, and reading comprehension of students

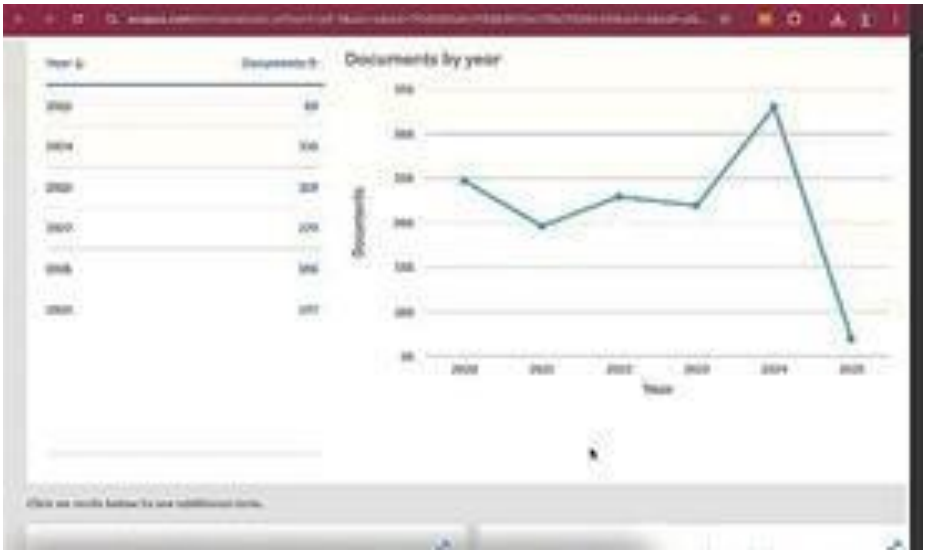

Figure 1. Number of publications and citations
(Source: Scopus)

The graph illustrates the annual publication output from 2020 to 2025, based on documents retrieved from the Scopus database. The six-year period saw **1,290 documents** reported, with increasing academic interest regarding multimodal strategies to vocabulary and reading comprehension.

In **2020**, 247 documents were published, indicating an already active engagement with multimodal learning strategies, likely driven by the onset of the COVID-19 pandemic that pushed digital modes of education practices forward. A gradual decline in **2021** (196 publications), potentially indicating a transitional period as educators adapted to the remote and hybrid learning environments.

By **2022**, publication number bounced back to **229**, followed by **219** in **2023**. These consistent outputs suggest that multimodal learning became a sustained area of inquiry, as schools embraced long-term strategies for online and blended learning. Notably, **2024 recorded the highest publication rate at 330**, a high point in research production. This surge reflects the culmination of post-pandemic pedagogical innovations and an ongoing focus on inclusive and engaging literacy instruction.

In contrast, **2025 saw a steep drop to 69 publications**, which may be due to the partial status of the year at the time of data collection or a change in research focus as the educational landscape stabilized.

Overall, the data showed a steady increase in interest toward multimodal learning throughout the pandemic and beyond, highlighting its relevance in supporting vocabulary and reading comprehension across various educational settings.

Citation analysis

Using document citation analysis, the most cited documents in the set are shown in Table 2. The most cited three pieces of work were by Dindar et al. (2021) at 55, Chen, C.-H. (2020), at 71, and Mou T.-Y. (2024) at 11. These citation counts indicate the influence and relevance of these studies in the academic community.

Table 2. Top 10 highest-cited documents

No	Authors	Title	Citations
1	Dindar M. et.al (2021)	An experimental study on the effects of gamified cooperation and competition on English vocabulary learning	55
2	Chen C. H. (2020b)	AR videos as scaffolding to foster students' learning achievements and motivation in EFL learning	71
3	Mou T. Y. (2024)	The practice of visual storytelling in STEM: Influence of creative thinking training on design students' creative self-efficacy and motivation	11
4	Zhang R. et. al (2024)	Self-regulated digital game-based vocabulary learning: motivation, application of self- regulated learning strategies, EFL vocabulary knowledge development, and their interplay	10
5	Lin X. F. et. al (2023)	Technological support to foster students' artificial intelligence ethics: An augmented reality-based contextualized dilemma discussion approach	26
6	Şimşek B. et. al (2023)	The effects of augmented reality storybooks on student's reading comprehension	13
7	Yu Z. (2023b)	Learning Outcomes, Motivation, and Satisfaction in Gamified English	13
8	Qiao S. et. al (2023)	Understanding how gamification of English morphological analysis in a blended learning environment influences students' engagement and reading comprehension	11
9	Chu S. T. et. al (2023)	Incorporating teacher intelligence into digital games: An expert system-guided self-regulated learning approach to promoting EFL students' performance in digital gaming contexts	21
10	Zatarain Cabada R. et. al (2023)	Experiences of web- based extended reality technologies for physics education	12

Trends and Emerging Themes in the Use Multimodal in Learning and Teaching in Developing Vocabulary and Reading Comprehension

The analysis of the top 10 most-cited documents reveals significant **trends and emerging themes** in the use of **multimodal approaches** to expand vocabulary and reading ability in educational settings, especially within English as a Foreign Language (EFL) contexts.One of the dominant trends is the incorporation of **gamification**, evident in Dindar et al. (2021), Yu (2023), Qiao et al. (2023), and Zhang et al. (2024). These studies highlight the cognitive and motivational benefits of game-based learning in reading engagement and vocabulary acquisition, with Dindar et al. (2021) focusing on the benefits of gamified cooperation and competition on vocabulary development.

Another dominant modality is **augmented reality (AR)**, as featured in studies from Chen (2020), Lin et al. (2023), and Şimşek et al. (2023). Chen (2020), with 71 citations, showed how AR videos function as powerful scaffolding tools to improve both achievement and motivation for EFL learners. Lin et al. (2023) and Şimşek et al. (2023) extended AR's use of AR to contextualized learning and story-based reading comprehension, respectively, showing AR's growing role of AR in immersive literacy learning.

Emerging themes include **self-regulated learning** (Chu et al., 2023; Zhang et al., 2024), **expert-system support**, and **visual storytelling** (Mou, 2024), in recognition of a move toward personalized, technology-rich learning. These studies collectively suggest that multimodal strategies, particularly gamification, AR, and narrative media, redefine language teaching in making learners more engaged, motivated, and understanding.

Citation Distribution and Implications for the Use Multimodal in Learning and Teaching in Developing Vocabulary and Reading Comprehension

The citation distribution across the top ten most- cited documents reveals key patterns and implications in the use of multimodal strategies for developing vocabulary and reading comprehension in educational contexts, particularly in EFL. **Chen (2020)** has been cited 71 times, showing strong interest in using **augmented reality (AR)** to support learning and boost student motivation. **Dindar et al. (2021)**, with 55 citations, shows that **gamified learning**—using games in education—is also popular, especially for helping students learn new words through teamwork and competition.

Mid-tier citation counts, such as Lin et al. (2023) with 26 and Chu et al. (2023) with 21, suggest growing interest in newer ideas, such as using **AR for teaching ethics** or using **AI-based games** to help students manage their own learning. The remaining studies, with 10 to 13 citations, – Şimşek et al. (2023), Yu (2023), and Qiao et al. (2023) - suggest an emerging interest in **AR storybooks**, **gamified engagement**, and **blended learning for reading comprehension**. Notably, newer publications– Zhang et al. (2024) and Mou (2024) - have lower citation counts (10–11), possibly due to recency rather than limited impact.

Overall, the studies suggest that **gamification and AR** remain dominant and well-cited modalities. At the same time, **new approaches** like storytelling and expert-guided learning are starting to grow in interest. The implication is a shifting landscape where multimodal learning is valued not only for its engagement potential but also for helping students learn in more **personalized and immersive** ways.

Co-citation analysis

The ten most frequently co-cited documents with **total link strength** reveals key theories and methods that form the foundation studies on vocabulary and reading comprehension skills with the use of multimodal. A core theory found in these studies is **Self-Determination Theory (SDT)** by **Ryan and Deci** (2000a, 2000b) (1985), which highlights the importance of **motivation, independence, and engagement** in learning. These texts, with total link strengths of 12, 10, and 7, respectively, are commonly linked through gamification and interactive learning technologies (Dindar et al., 2021; Yu, 2023).

Another important theoretical theory seen in these studies is **Bandura's (1997)** work on **self- efficacy**, which means believing in your

own ability to learn. This concept is frequently cited in studies integrating game-based and augmented reality tools to help learners to do better as cited by Chu et al., 2023; Zhang et al., 2024.

To ensure the rigour of their study, **Cohen's (1988)** guide on statistical power and **Fornell and Larcker's (1981)** work on statistics and model are also referred. For understanding students' experiences more deeply, **Braun and Clarke's (2006)** thematic analysis framework were often utilized.

Also, important theory is **Mayer's (2009)** theory of **Multimedia Learning** and **Kapp's (2012) gamification strategies** on how multimodal tools are designed as it helps how people learn using multimedia and games in education. these co- cited works collectively reveal a strong interdisciplinary foundation combining motivation, cognition, and methodology, creating effective ways to help students learn vocabulary and improve reading comprehension through multimodal learning.

Table 3. Top 10 documents with the highest co-citation and total link strength

Documents	Citation	Total link strength
Ryan R.M., Deci E.L., Intrinsic and Extrinsic Motivations: Classic Definition and New Directions, contemporary educational psychology, (2000)	17	12
Ryan R.M., Deci E.L., Self Determination Theory and the facilitation of intrinsic motivation, social development, and well- being, American Psychologist, (2000)	16	10
Cohen J., Statistical Power Analysis for the Behavioral Sciences, (1988)	35	9
Deci E.L., Ryan, R.M., Intrinsic Motivation and Self-Determination in human behavior, (1985)	14	7
Fredricks J.A., Blumenfield P.C., Paris A.H., School Engagement: potential of the concept, state of the evidence, review of educational research, (2004)	10	7
Braun V., Using thematic Analysis in Psychology, qualitative research in psychology, (2006)	35	6
Mayer R. E., Multimedia Learning, (2009)	11	6
Fornell C., Lacker D.F., Evaluating Structural Equation models with unobservable variables and measurement error, journal of marketing research, (1981)	11	5
Bandura A., Self-Efficacy: The Exercise of Control, (1197)	16	4
Kapp K. M., The Gamification of Learning and Instruction: game-based methods and strategies for training and education, (2012)	10	3

Source: Author interpretation based on VOSviewer analysis

Based on network visualization, co-citation analysis produced four distinct clusters. Figure 2 shows the network structure of the co-citation analysis. Each cluster was labelled and characterized based on representative publications according to the author's inductive interpretation and understanding of the four clusters.

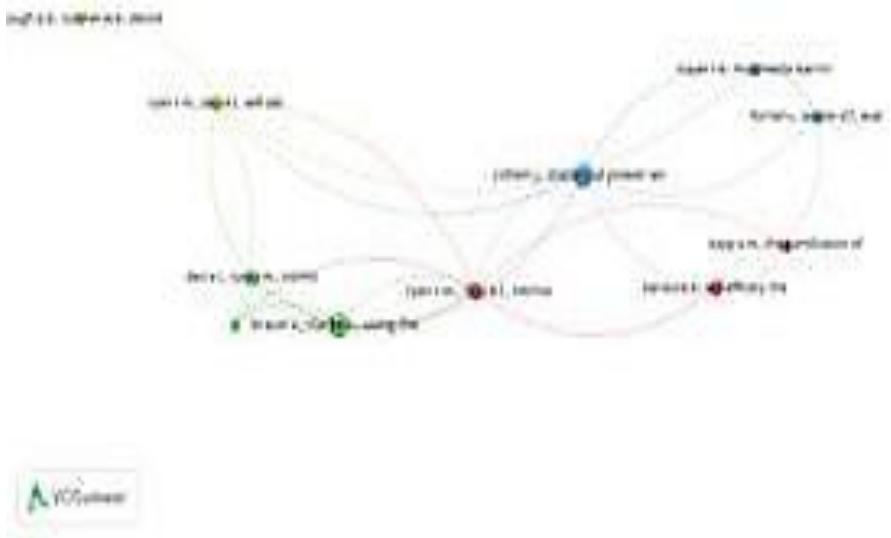

Figure 2. Co-citation analysis of the Use of Multimodal in Learning and Teaching in Developing Vocabulary and Reading Comprehension

The co-citation analysis of studies on multimodal approaches to vocabulary and reading comprehension identifies specific thematic clusters. The **green cluster** focuses on Deci and Ryan's **Self-Determination Theory**, with a focus on learner motivation and autonomy. Their frequent association with Braun and Clarke reflects the use of qualitative methods, like thematic analysis, to examine learners' experiences with multimodal instruction.

The **blue cluster** highlights methodological rigor and cognitive theory, with Cohen's **statistical power** and Mayer's **multimedia learning theory**. This suggests a strong foundation in both quantitative analysis and cognitive principles of how multimodal inputs support vocabulary and reading comprehension.

The **red cluster** focuses on learner engagement and technology, with frequent citations of Kapp, who is well-known for **gamification**, and Bandura, for **self-efficacy theory**. This reflects interest in how motivational strategies and learner confidence support multimodal approaches to literacy development.

Lastly, the **yellow cluster** highlights foundational reading research, citing Gough and Turner on **the roles of decoding and comprehension**. Together, these clusters show that the field integrates psychological theory, multimedia learning, technology, and traditional literacy frameworks.

Table 4 summarizes the co-citation analysis by presenting its clusters, cluster labels, number of articles, and representative publications.

Table 4. Co-citation clusters on the Use of Multimodal in Learning and Teaching in Developing Vocabulary and Reading Comprehension

Cluster	Cluster label	No. of articles	Representative publications
1 (red)	Motivation, Self-Efficacy, and Gamification in Multimodal Vocabulary and Reading Development	3	bandura a., self-efficacy: the exercise of control, (1997); kapp k. m., the gamification of learning and instruction: game-based methods and strategies for training and education, (2012); ryan r. m., deci e. l., intrinsic and extrinsic motivations: classic definitions and new directions, contemporary educational psychology, 25, 1, pp. 54-67, (2000)

Cluster	Cluster label	No. of articles	Representative publications
2 (Green)	Qualitative Inquiry into Motivation and Engagement in Multimodal Vocabulary and Reading Development	3	braun v., clarke v., using thematic analysis in psychology, qualitative research in psychology, 3, 2, pp. 77-101, (2006); deci e.l., ryan r.m., intrinsic motivation and self- determination in human behavior, (1985); fredricks j. a., blumenfeld p. c., paris a. h., school engagement: potential of the concept, state of the evidence, review of educational research, 74, 1, pp. 59-109, (2004)
3 (Blue)	Quantitative Methods and Multimedia Learning in Vocabulary and Reading Comprehensi on Research	3	cohen j., statistical power analysis for the behavioral sciences, (1988); fornell c., larcker d. f., evaluating structural equation models with unobservable variables and measurement error, journal of marketing research, 18, 1, pp. 39-50, (1981); mayer r. e., multimedia learning, (2009)
4 (Yellow)	Cognitive and Motivational Perspectives on Multimodal Vocabulary and Reading Comprehensi on	2	Gough p. b., tunmer w. e., decoding, reading, and reading disability, remedial and special education, 7, 1, pp. 6-10, (1986); ryan r. m., deci e. l., self-determination theory and the facilitation of intrinsic motivation, social development, and well-being, American psychologist, 55, 1, pp. 68-78, (2000)

Co-citation analysis identified four research clusters on multimodal learning in vocabulary and reading comprehension. The red cluster, labeled **"Motivation, Self-Efficacy, and Gamification in Multimodal Vocabulary and Reading Development,"** emphasizes the role of learner confidence and engagement. Bandura (1997) highlighted self-efficacy as critical to learning, considering that more confident students are more likely to tackle complex texts. Multimodal strategies—like visual and auditory aids—support self-efficacy by enriching the reading experiences.

Ryan and Deci's (2000) Self-Determination Theory added that motivation increases when students feel autonomy, competence, and connection. Multimodal methods such as interactive storytelling or digital annotation enhance intrinsic motivation, making learning more meaningful and engaging for students.

Kapp (2012) introduced gamification as a way to boost motivation and participation. Game-like features—challenges, rewards, and progress tracking—align with self-efficacy and intrinsic motivation by offering feedback and a sense of accomplishment. These tools can aid vocabulary and reading comprehension through interesting, goal-oriented activities.

The green cluster, labeled **"Qualitative Inquiry into Motivation and Engagement in Multimodal Vocabulary and Reading Development,"** discusses how motivation and engagement affect vocabulary and reading in multimodal environments. Braun and Clarke (2006) promote thematic analysis to identify patterns in student motivation and engagement across modalities like visual, auditory, and kinesthetic resources.

Deci and Ryan's (1985) Self-Determination Theory emphasizes that students are more motivated to read when they feel autonomy, competence, and relatedness. Multimodal environments with choice and interactive features can facilitate intrinsic motivation, making reading more meaningful and interesting.

Fredricks, Blumenfeld, and Paris (2004) categorized school engagement into behavioral, emotional, and cognitive dimensions, showing how multimodal strategies like digital storytelling and interactive activities improve

engagement by addressing the differences in learning style.

The blue cluster, labeled **"Quantitative Methods and Multimedia Learning in Vocabulary and Reading Comprehension Research,"** focuses on using quantitative methods and multimedia principles in vocabulary and reading studies. Central to this cluster is Mayer's (2009) Cognitive Theory of Multimedia Learning, which emphasizes that learning is most effective when information is presented visually and auditorily, consistent with the brain's natural processing. Mayer's principles, like multimedia, coherence, and modality, guide the design of instructional materials to enhance vocabulary and comprehension.

Cohen (1988) made these studies more rigorous using statistical power analysis based on effect size and power to ensure multimodal interventions are statistically significant and produce meaningful outcomes. His standards help researchers assess the effectiveness of multimedia tools in improving literacy.

Fornell and Larcker (1981) developed structural equation modeling (SEM), allowing researchers to explore complex interactions between multimedia elements and cognitive factors, providing insight into how multimodal instruction affects vocabulary and reading skills.

The yellow cluster, labeled **"Cognitive and Motivational Perspectives on Multimodal Vocabulary and Reading Comprehension,"** explores how cognitive and motivational theories inform multimodal strategies. At its core is Gough and Tunmer's (1986) Simple View of Reading, where comprehension is a product of decoding and language understanding. Multimodal materials—like pictures, sound, and interactive texts—support both elements by providing contextual cues and simplifying complex ideas.

Ryan and Deci's (2000) Self-Determination Theory complements this by emphasizing the role of intrinsic motivation, driven by autonomy, competence, and relatedness. Multimodal environments that offer varied, learner-centered formats help fulfill these needs, enhancing both engagement and comprehension.

Co-word analysis

Co-word analysis was applied to the same database. From the 1,620 keywords, 80 met the minimum of 18 occurrences, resulting in four clusters. Keywords with the highest co- occurrence were humans (348), students (674), and humans (295). Table 5 summarizes the top 15 co-occurring keywords with their number of occurrences and total link strengths.

Table 5. Top 15 keywords in the co-occurrence of keywords analysis

Ranking	Keyword	Occurrences	Total link strength
1	Human	348	3058
2	Students	674	2957
3	Humans	297	2647
4	Female	178	2010
5	Male	172	1963
6	Student	217	1919
7	Article	164	1709
8	Adult	118	1318
9	Motivation	344	1217
10	E-Learning	329	1029
11	Controlled Study	84	971
12	Child	87	923
13	Reading	86	880
14	Psychology	76	874
15	Learning	115	860

The co-occurrence analysis of keywords revealed important themes directing in multimodal approaches to learning and teaching vocabulary and reading comprehension. Out of the top 15 key words *"students"* (Occurrences = 674; Total Link Strength = 2957) and *"human"* (348; 3058) dominated the landscape, highlighting that most of the research is focused on real learners and different teaching methods responses. The presence of both *"human"* and *"humans"* (297; 2647) also suggests that many studies involve real-life experiments and observations, especially in areas like educational psychology. (Bandura, 1997; Deci & Ryan, 1985).

Keywords like *"female"* (178; 2010), *"male"* (172; 1963), *"child"* (87; 923), and *"adult"* (118; 1318) indicate that researchers are looking at how multimodal strategies work for different age groups and genders, testing variety of learners. The term *"motivation"* (344; 1217) is also common linking well to the idea of learning outcomes, supporting self-determination theory (Ryan & Deci, 2000) and the integration of gamified multimodal tools (Kapp, 2012) to enhance learner engagement.

The appearance of *"e-learning"* (329; 1029) points to the growing use of digital tools, especially in the post-pandemic. Additionally, keywords such as *"reading"* (86; 880) and *"learning"* (115; 860) confirmed the targeted focus on vocabulary acquisition and reading comprehension.

"Controlled study" (84; 971) and *"article"* (164; 1709) suggest that the research in this field is mostly data-based and published in academic journals, showing strong scientific implication.

Overall, these top keywords reveal an intersection of psychological theory, digital innovation, and empirical rigor, contributing to the development of multimodal strategies in literacy education.

Take note that VOSViewer treated case and plurality literally. It reads the raw keyword list from your dataset exactly as it appears since it comes from multiple journals or databases, where different authors use slightly different forms of the same word. So "human" and "humans," and "student" and "students" are not automatically recognized as the same concept.

Figure 3 presents a network map of the co-word analysis. The map produced four clusters that were classified and labeled based on the author's inductive interpretation of the occurring words. All clusters were closely related and partially integrated.

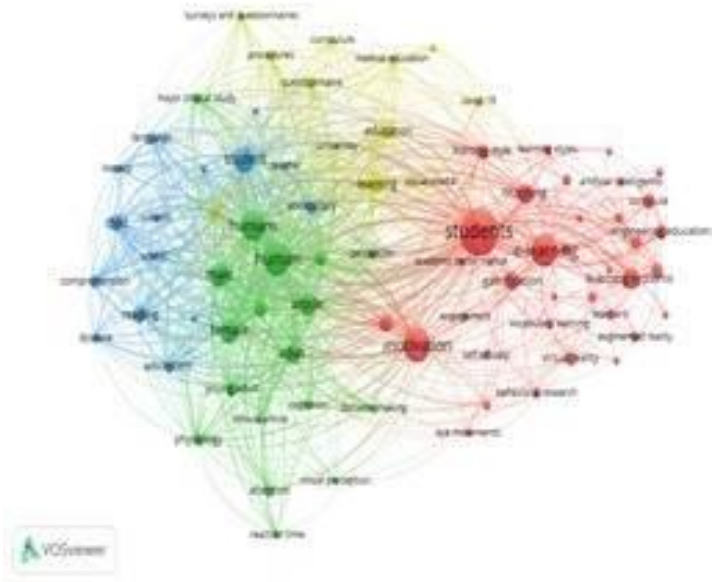

Figure 3. Co-word analysis on the Use Multimodal in Learning and Teaching in Developing Vocabulary and Reading Comprehension

- Cluster 1 (red): This cluster focuses on the integration of **digital tools and gamification** in the learning environment. It shows growing interest in how **online platforms** support student motivation and self-efficacy, which are important for effective **vocabulary acquisition and reading comprehension**. Kapp (2012) supported this by arguing that game-based strategies enhance learning engagement. Bandura (1997) and Ryan and Deci (2000) further explained how self- efficacy and intrinsic motivation boost learning outcomes in multimodal contexts.
- Cluster 2 (green): This cluster was rooted in the **cognitive and psychological processes** during reading and vocabulary learning. This suggests that when designing effective multimodal strategies, understanding learners' **mental processes** (e.g., attention, cognition, and vision) is important. Gough and Tunmer (1986) supported the role of **decoding skills** and cognitive load in reading development, which aligns with Mayer's (2009) theory of **multimedia learning**.
- Cluster 3 (blue): This cluster centers on **research approaches and educational settings**, especially in colleges, universities, and medical schools. The prominence of *questionnaires* and *surveys* indicates a reliance on **empirical methods** for studying how well multimodal tools work. The presence of *pandemic* and *covid-19* reflects an increase in online learning research, where multimodal tools have become essential (Cohen, 1988; Fornell & Larcker, 1981). This has prompted rapid curriculum adaptations using multimedia tools.
- Cluster 4 (yellow): This cluster represents the traditional themes in **language development and reading education**, particularly among children. Terms such as *dyslexia* and *literacy* emphasize on learners with **reading difficulties** and highlights the value of these methods in **early education** and for supporting **inclusive classrooms** (Mayer, 2009; Fredricks et al., 2004).

Table 6 summarizes the co-word analysis represented by the cluster label, number of keywords, and representative keywords.

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Table 6: Co-word analysis on the use of Multimodal in reading comprehension and Vocabulary

Cluster No and color	Cluster label	No of keywords	Representative Keywords
1 (red)	Technology-Enhanced Multimod al Learning for Vocabulary and Reading Comprehe nsion	38	academic performance, artificial intelligence, augmented reality, behavioral research, computer aided instruction, curricula, e- learning, education computing, engineering education, eye movements, eye tracking, feedback, gamification, higher education, human computer interaction, language learning, learning experiences, learning outcome, learning style, learning styles, learning systems, learningstyles, machine learning, motivation, online learning, reading comprehension, self-efficacy, student learning, students, surveys, teachers',teaching, teaching and learning, virtual reality, visual communication, visualization, vocabulary learning

Cluster No and color	Cluster label	No of keywords	Representative Keywords
2 (green)	Cognitive and Perceptual Foundatio ns of Multimodal Learning	19	adult, article, attention, clinical article, cognition, controlled study, decision making, female, goals, human, human experiment, humans, male, perception, physiology, reaction time, vision, vision perception, young adult
3 (blue)	Multimod al Pedagogy and Education al Adaptation in Medical and Higher Education during the COVID-19 Pandemic	17	covid-19, curriculum, education, learning, medical education, medical student, pandemic, pandemics, procedures, psychology, questionnaire, social media, students, medical, surveys and questionnaires, training, universities, university
4 (yellow)	Multimod al Interventi ons for Literacy, Vocabulary, and Reading Comprehe nsion in School- Aged Learners	16	adolescent, awareness, child, comprehension, dyslexia, knowledge, language, literacy, major clinical study, randomized controlled trial, reading, school, schools, student, teacher, vocabulary

Implications

This study's findings provide key insights that can guide both theory and practice in education. By analyzing current research on multimodal strategies, this study highlights how such approaches can enhance vocabulary and reading comprehension, providing valuable implications for educators, researchers, and policymakers.

Theoretical Implications

This bibliometric analysis reveals key theoretical implications for multimodal literacy, especially in vocabulary and reading comprehension. It highlights the interdisciplinary nature of multimodal learning, integrating cognitive theories such as Mayer's Cognitive Theory of Multimedia Learning and motivational theories such as Self-Determination Theory (Ryan & Deci) and Self-Efficacy Theory (Bandura), which emphasize the role of dual-channel processing, autonomy, and learner confidence.

The findings also highlight the growing influence of digital modalities—gamification, augmented reality, and visual storytelling—indicating a shift from traditional text-based instruction to more interactive learning. The frequent citation of Kapp's work on gamification illustrates how digital strategies are redefining literacy in terms of motivation and engagement.

Additionally, the analysis reinforces the importance of the motivation–engagement–learning connection. The co-citation of studies on intrinsic motivation, self-efficacy, and thematic analysis (e.g., Braun & Clarke) implies that effective multimodal settings not only encourage cognitive processing but also emotional and behavioral engagement.

Finally, bibliometric patterns indicate that multimodal learning is emerging as a distinct theoretical field. The clustering of relevant citations and consistent application of particular frameworks suggest the need for dedicated models to better understand and facilitate multimodal vocabulary and reading comprehension in changing educational contexts.

Practical Implications

The results of this bibliometric analysis provide practical insights for educators and leaders aiming to enhance vocabulary and reading comprehension through multimodal approaches. It identifies a growing trend in using digital tools such as educational games, augmented reality (AR), and interactive e-books.

These technologies increase engagement and offer personalized, immersive learning experiences, making reading and vocabulary instruction more effective and inclusive.

The study also emphasizes the importance of motivation and self-directed learning. Student- centered, hands-on activities—like AR storybooks and game-based vocabulary tasks— facilitate greater understanding and long-term retention. It also highlights the need to consider cognitive load and multimedia design when developing instructional materials. According to Mayer's multimedia learning principles, balancing text, visuals, and audio can reduce overload and enhance comprehension. Teacher training in effective content design is essential to ensure materials support rather than hinder learning.

Multimodal strategies are particularly useful in online and hybrid classrooms, which have become more prominent post-COVID-19. These approaches are especially beneficial for students with reading difficulties, language barriers, or diverse learning needs.

Finally, the study urges policymakers and administrators to invest in both technology and professional development. Supporting teachers in using multimodal tools can foster more engaging, inclusive, and future-ready literacy environments.

Conclusion

This bibliometric analysis mapped the scholarly landscape of multimodal strategies for enhancing vocabulary and reading comprehension, analyzing 1,290 Scopus-indexed documents (2020–2024). The findings highlight the increasing application of gamified learning, augmented reality, and multimedia instruction to boost student motivation and literacy outcomes. Co-citation and co-word analysis demonstrate that multimodal learning is rooted in cognitive, motivational, and instructional design theories, establishing it as an interdisciplinary and dynamic nature as a research area.

However, a number of limitations should be highlighted. The analysis was restricted to the Scopus database and recent English-language peer-reviewed articles, potentially excluding influential earlier works, non-English studies, and grey literature. Citation frequency was used to measure the impact, which may not always indicate the quality or applicability of a study. Furthermore, this study did not analyze the full content of individual publications, limiting insights into specific applications and results in educational contexts.

Future studies should broaden the research scope by utilizing multiple databases and a wider range of publications, while exploring the cognitive load effects of augmented reality compared to gamified applications for students with dyslexia—a theme highlighted in the co-word analysis. Complementary systematic reviews or meta-analyses are needed to assess the effectiveness of specific multimodal interventions within actual classrooms. Longitudinal studies could examine the long- term effectiveness of these strategies across learner groups and educational contexts. Further exploration is also recommended to determine how multimodal learning intersects with digital and media literacy, as well as inclusive education. With the ever-advancing nature of technology, continued evaluation of tools like AI platforms, virtual reality, and adaptive systems will be essential to maintain multimodal strategies as effective and appropriate for 21st-century literacy development.

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