The Eastasouth Journal of Learning and Educations
Vol. 3, No. 02, July 2025, pp. 152-162
ISSN: 3025-2504, DOI: 10.58812/esle.v3i02

Bibliometric Insights into Metacognitive Scaffolding: A Review of Research in Educational Psychology

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Article Info

Article history:

Received Jul, 2025
Revised Jul, 2025
Accepted Jul, 2025

Keywords:

Computer-Aided;
Educational Psychology;
Instruction;
Metacognition;
Scaffolding;
Self-Regulated Learning

ABSTRACT

This study presents a comprehensive bibliometric analysis of research on metacognitive scaffolding within the domain of educational psychology, aiming to uncover the intellectual structure, thematic patterns, and emerging trends in the field. Drawing data from the Scopus database covering publications from 2000 to 2025, the study analyzed 453 documents using VOSviewer software to perform co-citation, co-authorship, keyword co-occurrence, and temporal trend analyses. The results highlight the dominance of foundational theorists such as Flavell, Vygotsky, and Zimmerman, alongside contemporary scholars like Azevedo who have advanced the integration of metacognitive scaffolding into digital learning environments. Keyword analysis reveals core themes related to metacognition, scaffolding, and computer-aided instruction, as well as emerging areas such as inquiry learning, cognitive load, game-based learning, and learning analytics. The United States emerged as the most influential country in collaborative research networks, while regions like Indonesia remain underrepresented. These findings indicate a mature yet dynamically evolving research field that is increasingly shaped by technological innovation and interdisciplinary approaches. The study offers valuable insights for scholars, educators, and policymakers aiming to design effective, context-sensitive, and ethically grounded metacognitive scaffolding interventions in both traditional and digital learning settings.

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1. INTRODUCTION

The concept of metacognition, defined as "thinking about thinking" has gained considerable traction in the field of educational psychology, particularly for its role in enhancing learners' autonomy, strategic thinking, and problem-solving skills. Since [1] foundational work on metacognitive knowledge and regulation, researchers have explored various instructional interventions aimed at nurturing students' ability to monitor, plan, and evaluate their cognitive processes. Among these interventions, *metacognitive scaffolding* has emerged as a crucial pedagogical tool. This refers to instructional strategies designed to guide learners in applying metacognitive strategies

effectively, particularly in complex and open-ended learning tasks [2]. Scaffolding serves not only as temporary support but also as a developmental bridge towards learner independence.

As digital technologies have transformed educational environments, the practice of metacognitive scaffolding has extended into technology-enhanced learning settings. These include intelligent tutoring systems, adaptive learning platforms, and collaborative online environments that embed prompts, feedback, and reflective questioning techniques aimed at activating learners' metacognitive skills [3]. Such environments often utilize dynamic scaffolding mechanisms that respond in real time to learners' behaviors and misconceptions. Research in this area has highlighted the effectiveness of metacognitive scaffolding in improving learners' comprehension, self-regulated learning, and academic achievement, especially in disciplines requiring higher-order thinking, such as science and mathematics [4].

Furthermore, the theoretical underpinnings of metacognitive scaffolding have been enriched by frameworks such as Zimmerman's model of self-regulated learning [5], Vygotsky's zone of proximal development [6], and Winne and Hadwin's information processing model [7]. These models emphasize the temporal and contextual nature of scaffolding, urging educators to match the type and intensity of support with learners' current cognitive and metacognitive levels. As a result, researchers have focused not only on *what* types of scaffolding are effective but also on *when* and *how* they should be delivered to optimize learning outcomes.

Given its interdisciplinary relevance, the study of metacognitive scaffolding spans across multiple educational domains from early childhood education to higher education, from literacy development to STEM instruction. However, the field's rapid expansion has also resulted in a fragmented knowledge base, where studies vary significantly in terms of theoretical orientation, methodological approach, and application contexts. The diversity of research has produced a wealth of data but has also made it challenging for scholars to gain a coherent overview of trends, collaborations, and emerging themes in the field. In light of this complexity, bibliometric analysis offers a powerful method for synthesizing and visualizing the structure of the metacognitive scaffolding research landscape. By quantitatively analyzing large volumes of scientific publications, bibliometrics enables researchers to uncover influential authors, key institutions, core journals, thematic clusters, and intellectual linkages over time [8]. Tool like VOSviewer facilitates co-citation analysis, keyword mapping, and temporal trend analysis, thereby providing insights not only into what has been studied but also into where the field is heading.

Despite the growing body of literature on metacognitive scaffolding, there remains a lack of systematic efforts to map the intellectual structure and development of this research area using bibliometric techniques. Most reviews to date have been narrative or meta-analytic in nature, focusing narrowly on effectiveness or design principles without providing a holistic view of the field's evolution. Consequently, it is unclear how research on metacognitive scaffolding is distributed across time, disciplines, and regions, or which authors and topics have driven the field's development. This lack of bibliometric synthesis hinders strategic knowledge accumulation and limits the ability of educators, policymakers, and researchers to identify critical gaps and future directions. This study aims to conduct a comprehensive bibliometric analysis of research on metacognitive scaffolding within the domain of educational psychology.

2. METHOD

This study employed a **bibliometric analysis** approach to quantitatively examine the structure, development, and trends of research on metacognitive scaffolding in educational psychology. Bibliometric

methods offer a systematic way to evaluate large bodies of academic literature by applying statistical and network analysis techniques. This approach enables the identification of prolific authors, influential journals, collaborative patterns, and evolving thematic areas in the literature [8]. The analysis was designed to answer questions related to publication trends, authorial and institutional impact, co-authorship networks, and keyword co-occurrence, thereby providing a comprehensive overview of the intellectual landscape of metacognitive scaffolding research.

Data were retrieved from the **Scopus database**, one of the largest and most comprehensive bibliographic databases covering peer-reviewed academic literature. The search was conducted in June 2025 using a combination of keywords such as *"metacognitive scaffolding"*, *"metacognition AND scaffolding"*, and *"metacognitive support"*, limited to the subject area of educational psychology and related educational fields. The search strategy also included filters to limit document types to articles, reviews, and conference papers written in English. A total of 453 documents published between 2000 and 2025 were identified and downloaded in RIS format for further processing. The dataset was cleaned to remove duplicates, irrelevant records, and non-peer-reviewed materials before analysis.

The cleaned data were imported into **VOSviewer** for visualization and analysis. VOSviewer was used to generate bibliometric maps of co-authorship networks (authors and countries), co-citation analysis (references), and keyword co-occurrence. Co-authorship maps helped reveal collaboration patterns among researchers and institutions, while co-citation analysis provided insights into the foundational literature that shaped the field. Keyword co-occurrence analysis was used to identify thematic clusters and research hotspots.

3. RESULT AND DISCUSSION

3.1 Co-Authorship Analysis

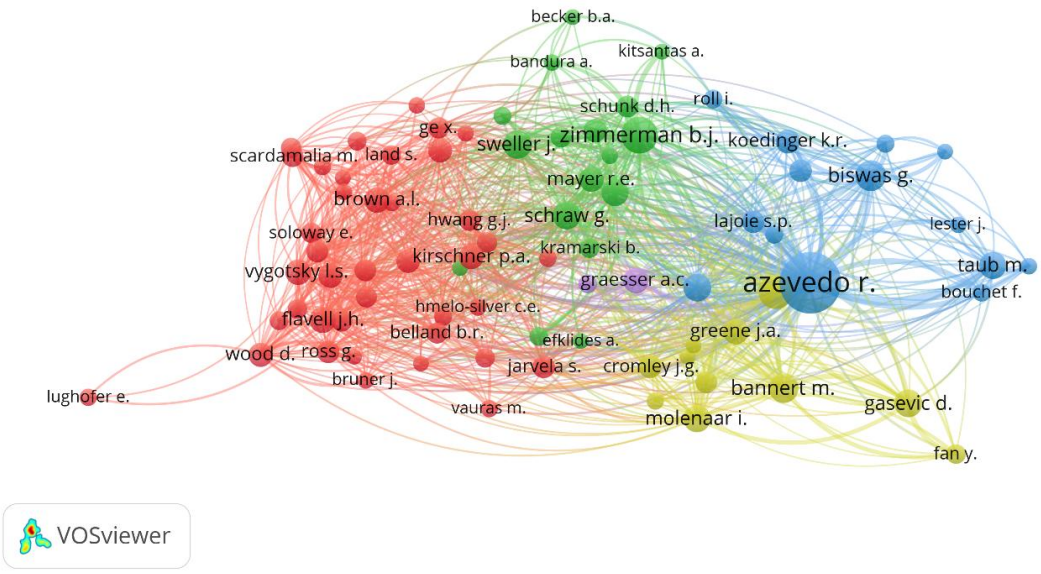

Figure 1. Author Visualization
Source: Data Analysis

Figure 1 presented in the image reveals four major clusters of influential authors in the domain of metacognitive scaffolding research within educational psychology. The **red cluster**, centered around foundational figures like Flavell,

Vygotsky, and Bruner, represents the theoretical and developmental psychology base, emphasizing core constructs such as metacognition, constructivism, and the zone of proximal development. The **green cluster**, featuring Zimmerman, Schunk, and Bandura, reflects a strong focus on self-regulated learning and social cognitive theory. The **blue cluster**, led by Azevedo, Lajoie, and Biswas, captures contemporary research emphasizing technology-enhanced metacognitive scaffolding and learning analytics. Finally, the **yellow cluster**, which includes Bannert, Greene, and Molenaar, appears to concentrate on empirical studies involving computer-based learning environments and real-time adaptive scaffolding.

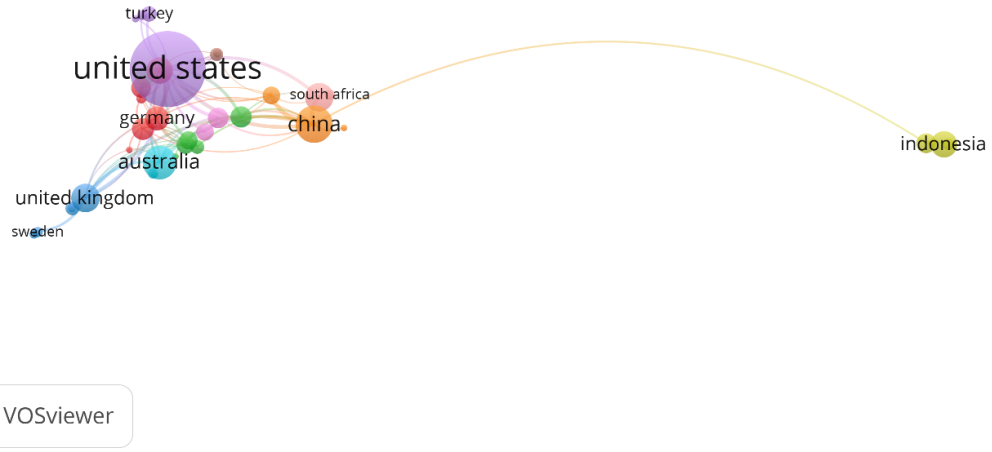

Figure 2. Country Visualization
Source: Data Analysis

Figure 2 illustrates the global collaboration patterns in metacognitive scaffolding research. The United States dominates the network as the central hub, with strong co-authorship linkages to countries such as Germany, Australia, the United Kingdom, and China, indicating its leadership role in producing and disseminating scholarly output. A dense cluster in the Western hemisphere shows significant interconnectedness among European countries and Anglophone nations, reflecting mature academic networks in educational psychology. Notably, Indonesia appears as an outlier, positioned far from the main cluster with minimal linkages—highlighting limited international collaboration or a relatively recent entry into the global discourse on metacognitive scaffolding.

3.2 Citation Analysis

Table 1. Most Cited Article

Citations	Author and Year	Title
644	[9]	Augmented reality for STEM learning: A systematic review
476	[10]	Augmented reality teaching and learning
360	[11]	Learning in science: A comparison of deep and surface approaches
360	[12]	Does adaptive scaffolding facilitate students' ability to regulate their learning with hypermedia?

Citations	Author and Year	Title
344	[13]	Scaffolding students' problem-solving processes in an Ill-structured task using question prompts and peer interactions
337	[14]	A case study of computer gaming for math: Engaged learning from gameplay?
322	[15]	A conceptual framework for scaffolding III-structured problem-solving processes using question prompts and peer interactions
215	[16]	A design framework for enhancing engagement in student-centered learning: own it, learn it, and share it
198	[17]	Analyzing Multimodal Multichannel Data about Self-Regulated Learning with Advanced Learning Technologies: Issues and Challenges
196	[18]	A framework for supporting metacognitive aspects of online inquiry through software-based scaffolding

Source: Scopus, 2025

3.3 Keyword Co-Occurrence Analysis

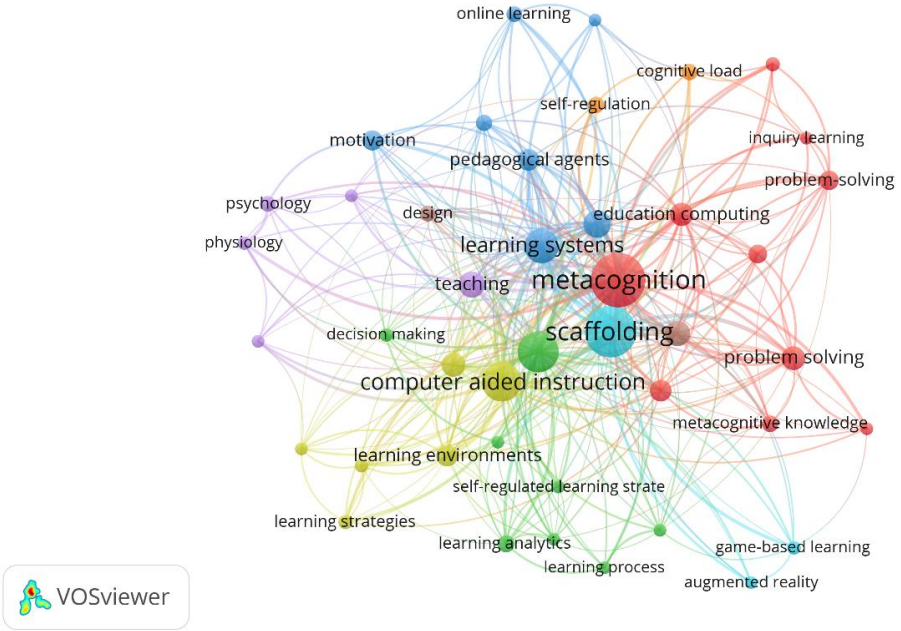

Figure 3. Network Visualization
Source: Data Analysis

The VOSviewer keyword co-occurrence visualization highlights the conceptual structure and thematic clusters within the research field of metacognitive scaffolding. The central nodes "metacognition" and "scaffolding" are prominently positioned and tightly connected, indicating their foundational role and frequent joint appearance in scholarly discussions. The close proximity of these terms to others such as "computer-aided instruction," "learning systems," and "learning environments" suggests that much of the literature situates metacognitive scaffolding within digital or technology-supported educational contexts. These keywords act as thematic anchors around which various subtopics and emerging research directions are organized.

The **green cluster**, centered on terms like **"computer-aided instruction"**, **"learning environments"**, **"learning strategies"**, and **"self-regulated learning"**, represents a strong

focus on how metacognitive scaffolding is operationalized in digital learning systems. It reflects a body of research exploring how technology can facilitate learners' ability to plan, monitor, and regulate their learning. This cluster includes concepts such as "learning analytics" and "learning process," indicating the growing role of data-driven systems in shaping metacognitive feedback and adaptivity. The presence of "learning analytics" also points to the integration of educational data mining into scaffolding design.

The **red cluster** is dominated by keywords such as **"problem-solving"**, **"inquiry learning"**, **"cognitive load"**, and **"metacognitive knowledge"**, which are associated with higher-order thinking processes. This cluster represents a research stream concerned with the cognitive demands of learning and how scaffolding strategies can reduce extraneous load and enhance deep understanding. It suggests that metacognitive scaffolding is often applied in contexts that require critical thinking and problem resolution such as STEM education where learners must manage complex and open-ended tasks. The link to "inquiry learning" further underscores the pedagogical alignment between scaffolding and constructivist or exploratory learning models.

The **blue cluster**, which includes **"online learning"**, **"pedagogical agents"**, and **"self-regulation"**, reflects a modern educational shift toward virtual environments. Here, research emphasizes how intelligent tutoring systems, conversational agents, or AI-based tools can scaffold learners' metacognitive processes, especially in remote or asynchronous learning contexts. The inclusion of "teaching" and "education computing" within this cluster also illustrates how metacognitive scaffolding is not limited to learner behaviors but extends to instructional design and delivery. This aligns with broader trends in educational technology that prioritize personalization, adaptivity, and learner autonomy.

The smaller **yellow and purple clusters** reveal emerging and interdisciplinary connections. The yellow cluster connects "game-based learning," "augmented reality," and "learning process," indicating experimental approaches to embedding scaffolding in immersive and interactive settings. These approaches suggest a future direction where metacognitive support is not just cognitive but also experiential. The purple cluster, which includes "motivation," "psychology," and "decision making," highlights the affective and psychological dimensions of metacognitive scaffolding, such as learner engagement and behavioral choices.

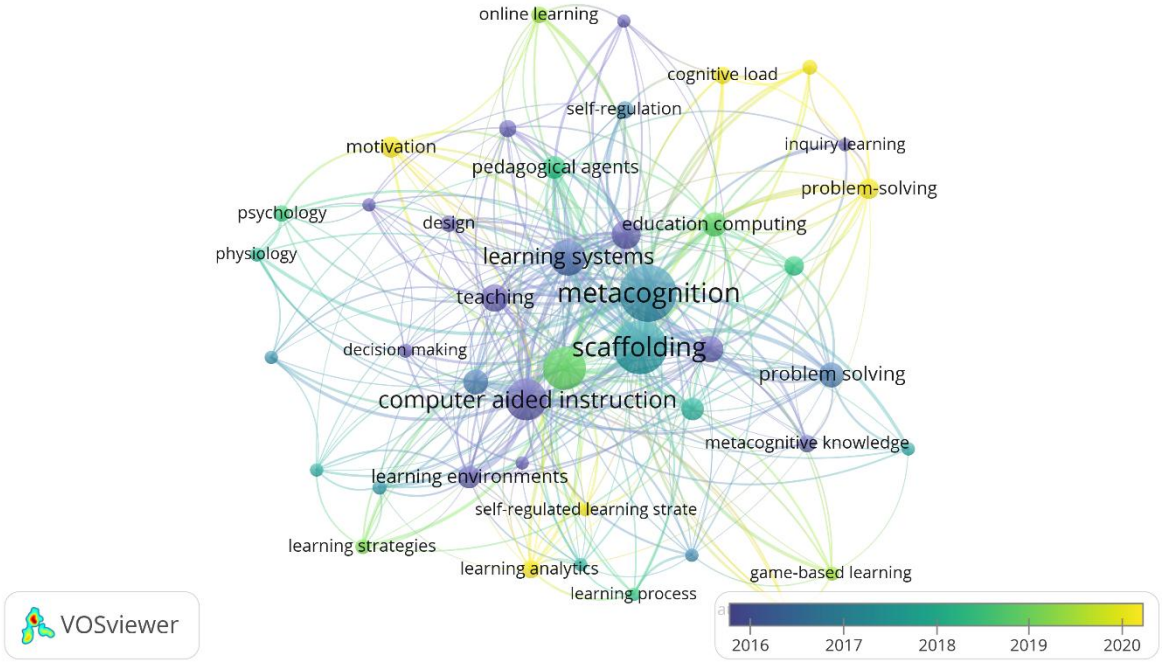

Figure 4. Overlay Visualization
Source: Data Analysis

The overlay visualization reveals the temporal evolution of research themes related to metacognitive scaffolding between 2016 and 2020. Core concepts such as "metacognition," "scaffolding," and "computer-aided instruction" are depicted in blue to green hues, indicating their sustained importance and early emergence in the field. These terms represent foundational constructs that have underpinned the literature since the initial development of theoretical and technological frameworks. Their central location and dense linkages highlight their continued relevance and integration across different research strands over the years. Moving towards the yellow spectrum, we observe newer and more recently emphasized keywords such as "inquiry learning," "problem-solving," "cognitive load," and "online learning." These themes represent contemporary research interests, often tied to recent educational challenges such as remote learning and the demand for high-level thinking skills in digital environments. Their more peripheral positions in the network suggest that these areas are emergent frontiers within the domain of metacognitive scaffolding, offering fresh avenues for exploration and innovation in both theory and practice. Notably, the visualization also captures the growing incorporation of **innovative educational technologies**, such as **"game-based learning," "learning analytics,"** and **"augmented reality,"** which are clustered around mid-to-late publication years (green tones). These keywords signify a **shift toward experiential, data-driven, and adaptive learning systems**, aligned with broader movements in educational technology.

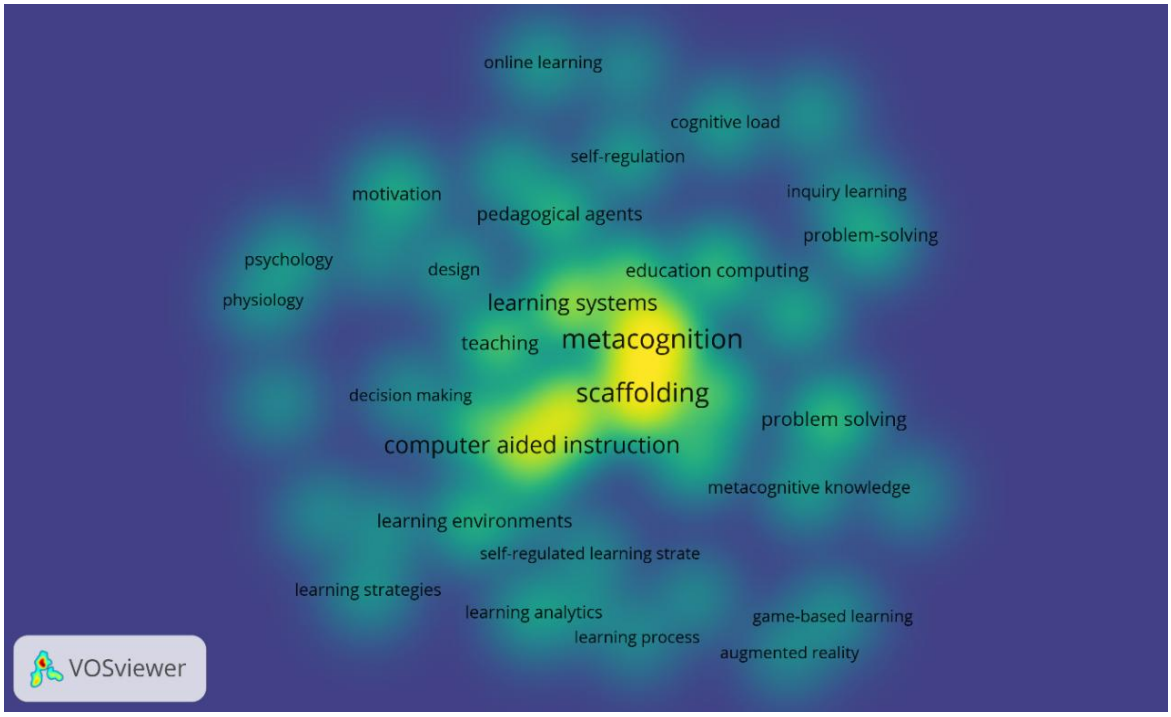

Figure 5. Density Visualization
Source: Data Analysis

The heatmap visualization illustrates the density and frequency of keyword usage in the research field of metacognitive scaffolding. The bright yellow areas, specifically around the terms "metacognition," "scaffolding," and "computer-aided instruction" indicate these are the most frequently occurring and highly central concepts within the literature. These keywords form the conceptual core of the domain, suggesting that the majority of scholarly discourse revolves around understanding and implementing scaffolding techniques to enhance learners' metacognitive processes, particularly within digitally supported or instructional environments. Moving outward from the center, the green to blue areas represent moderately to infrequently used terms such as "game-based learning," "learning analytics," "self-regulated learning," "augmented reality," and "inquiry learning." While these topics are less central, their presence on the map highlights emerging research directions and niche subfields. These peripheral terms often reflect innovative approaches or interdisciplinary intersections, indicating ongoing exploration in how newer pedagogical models and technological advancements can integrate with metacognitive scaffolding.

3.4 Discussion

The findings of this bibliometric study on metacognitive scaffolding in educational psychology reveal a multidimensional and evolving research landscape characterized by strong theoretical foundations, increasing interdisciplinarity, and growing technological integration. Through the analysis of co-citations, country collaborations, keyword co-occurrence, temporal trends, and density visualizations, this study uncovers both the intellectual structure and the dynamic development of the field over the past two decades.

One of the most striking observations from the co-citation analysis is the prominent role of foundational theorists such as Flavell, Vygotsky, Zimmerman, and Azevedo. The red and green clusters in the co-citation map

represent the convergence of classical cognitive-developmental theories with self-regulated learning frameworks. Flavell's concept of metacognitive knowledge and regulation [1], Vygotsky's sociocultural theory and zone of proximal development [6], and Zimmerman's model of self-regulated learning [5] continue to serve as theoretical anchors. Their frequent co-citation suggests that research on metacognitive scaffolding has remained theoretically grounded, emphasizing the interplay between learners' internal cognitive strategies and external instructional support. This theoretical consistency is crucial for maintaining conceptual clarity in a field that spans diverse educational levels and contexts.

On the other hand, the blue and yellow clusters, dominated by Azevedo, Biswas, and other contemporary scholars, indicate a shift toward empirical and technology-driven studies. These scholars emphasize real-time scaffolding in computer-based learning environments, adaptive learning systems, and intelligent tutoring. The central role of Azevedo, both visually and analytically, points to his influence in bridging traditional metacognitive theory with modern applications in learning analytics and educational technology. The field's evolution from theoretical discourse to applied, data-driven research reflects a maturation process in which metacognitive scaffolding is no longer merely a pedagogical ideal but an implementable component in scalable learning systems.

The country co-authorship map highlights the global distribution of research efforts and reveals the United States as the dominant hub of scholarly collaboration. Countries such as Germany, Australia, the United Kingdom, and China are well-integrated into international networks, signifying strong participation in the global research community. However, the map also reveals a notable geographic imbalance, particularly the isolated positioning of Indonesia, which appears on the periphery with minimal international collaboration. This suggests untapped potential for knowledge exchange and global partnerships in regions outside the established Western-centric research circles. Encouraging collaborative networks that include underrepresented countries can diversify perspectives and support the contextual adaptation of metacognitive scaffolding in non-Western educational systems.

The keyword co-occurrence analysis further enriches the understanding of thematic orientations within the field. The centrality of terms like "metacognition," "scaffolding," "learning systems," and "computer-aided instruction" confirms the core focus of the field, which lies at the intersection of cognitive support and educational technology. The green cluster, which includes terms such as "learning environments," "learning strategies," and "self-regulated learning," represents a robust research stream focused on how learners engage with instructional scaffolds in complex learning settings. These themes align with prior literature emphasizing the importance of learner autonomy and strategy development as key outcomes of metacognitive interventions [19].

Emerging keywords in the red and yellow clusters—such as "problem-solving," "inquiry learning," "cognitive load," and "metacognitive knowledge"—point to expanding interest in higher-order thinking and cognitive complexity. These studies explore how scaffolding can facilitate deeper learning processes, especially in open-ended or ill-structured problem contexts. This is consistent with research showing that well-designed scaffolds can help learners manage cognitive load, make informed decisions, and apply reflective practices in real time [20]. The overlap between "cognitive

load" and "scaffolding" also highlights an ongoing concern with instructional efficiency—balancing support without creating dependency or overload.

Another significant theme is the growing attention to online learning and pedagogical agents, clustered primarily in the blue segment of the keyword map. These keywords underscore the shift toward technology-mediated learning, accelerated by both innovation and necessity—such as during the COVID-19 pandemic. Online learning environments, powered by pedagogical agents and intelligent systems, increasingly serve as testbeds for implementing metacognitive scaffolds. These systems can dynamically assess learners' progress and provide tailored feedback, questions, or prompts, fostering greater metacognitive engagement. This represents a promising avenue for future research, particularly in exploring how AI and machine learning can enhance the personalization and adaptivity of scaffolding interventions.

Temporal keyword analysis provides further insights into the trajectory of research development. Early research themes, appearing in darker blue (2016–2017), revolved around general metacognitive and instructional constructs. In contrast, more recent keywords, highlighted in yellow (2019–2020), such as "inquiry learning," "problem-solving," "game-based learning," and "augmented reality," suggest a diversification of contexts and instructional formats. The incorporation of game-based environments and augmented reality tools into metacognitive scaffolding frameworks reflects an expansion into immersive and experiential learning. These environments allow for situated learning experiences where scaffolding can be embedded contextually and triggered dynamically, offering a rich space for enhancing learner reflection and control.

The density visualization adds yet another layer of interpretation by showcasing areas of high research intensity. The most densely populated zones, around "metacognition," "scaffolding," and "computer-aided instruction", confirm the dominance of these core concepts. However, lighter green and blue zones scattered across the map (e.g., "learning analytics," "decision-making," "game-based learning") indicate that while these topics are currently less central, they are growing in interest and could represent emerging frontiers of the field. This supports the idea of a maturing domain that is both consolidating its core and branching into innovative, interdisciplinary territories.

4. CONCLUSION

This bibliometric study provides a comprehensive overview of the intellectual structure, thematic evolution, and emerging trends in metacognitive scaffolding research within the field of educational psychology. The analysis reveals that the field is deeply rooted in foundational theories of metacognition and self-regulated learning while progressively expanding into technology-enhanced and data-driven educational environments. Core concepts such as "metacognition," "scaffolding," and "computer-aided instruction" remain central, whereas recent developments highlight increasing interest in problem-solving, inquiry learning, learning analytics, and immersive technologies like game-based learning. The dominance of contributions from countries like the United States, along with underrepresented participation from regions such as Indonesia, underscores the need for broader international collaboration. Ultimately, this study not only maps the past and present contours of metacognitive scaffolding research but also points toward future directions involving interdisciplinary integration, adaptive learning systems, and ethical considerations in digital pedagogy.

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