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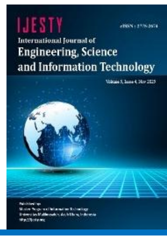

Digital Teaching and Learning Scaffolding in Education: A Systematic Review Using Bibliometric Analysis

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Abstract

This study aims to systematically analyze the evolution, research trends, and scientific impact of digital teaching and learning scaffolding through the application of bibliometric analysis. By employing the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 methodology, a total of 396 relevant journal articles published between 2013 and 2023 were identified from Google Scholar using Publish or Perish (PoP). The dataset was then analyzed using VOSviewer, with a specific focus on citation patterns, keyword co-occurrence, co-authorship networks, and thematic clusters. The bibliometric mapping revealed five dominant research clusters: (1) integration of digital technology in higher education, (2) learning strategies and their impact on students' outcomes, (3) digital games and scaffolding approaches in children's education, (4) teacher education development and practice, and (5) contextual influences in educational research. In addition, the study identifies prominent authors, highly influential publications, and major institutional as well as international collaborations, offering a comprehensive overview of the intellectual structure of the field. The findings highlight an increasing global interest in digital scaffolding in education, demonstrating its significant contributions to improving student engagement, cognitive development, problem-solving, and personalized learning experiences. Nevertheless, several challenges remain evident, particularly in terms of accessibility across diverse contexts, teacher readiness to adopt innovative pedagogies, and technological limitations within resource-constrained environments. This research contributes to the academic discourse by providing evidence-based insights and practical recommendations to optimize the implementation of digital scaffolding in contemporary educational settings. Moreover, it emphasizes the importance of continuous exploration of emerging technologies such as artificial intelligence (AI), virtual reality (VR), and adaptive learning systems to further strengthen the effectiveness and sustainability of digital scaffolding practices in the future.

Keywords: *Bibliometric Analysis, Digital Scaffolding, Digital Teaching, Educational Technology, Secondary Education.*

1. Introduction

In an era of rapid technological transformation, education is increasingly transitioning to digital platforms, necessitating innovative pedagogical strategies to enhance learning outcomes. One such approach, scaffolding, provides structured support to students as they navigate complex learning tasks, fostering independent inquiry, critical thinking, and problem-solving skills [1][2].

In digital learning environments, scaffolding is implemented through various tools, strategies, and technologies that guide learners, ensuring engaged exploration and self-regulation [3]. Recent research underscores its substantial impact on cognitive development, academic performance, and metacognitive skills [4][5], making it an essential component of digital education.

However, despite its proven benefits, significant gaps remain in understanding how digital scaffolding is applied in secondary education research, particularly through bibliometric analysis tools like VOSviewer [6]. Bibliometric analysis enables a systematic review of research output, trends, and collaboration patterns, providing valuable insights into the evolution of digital scaffolding in education [7].

This study aims to bridge these gaps by employing bibliometric techniques, including citation analysis, co-citation analysis, bibliographic coupling, and co-word analysis, to comprehensively evaluate digital teaching and learning scaffolding in secondary education [8]. Through this approach, the study offers a structured overview of existing research, identifies influential studies, and provides evidence-based recommendations to optimize digital scaffolding implementation in educational practice.

2. Methods

This study set out to examine research topics associated with digital teaching and learning scaffolding in education through a bibliometric approach. Bibliometrics, a term encompassing a variety of analytical techniques within scientometrics, was used. Specifically, citation network analysis and optimal clustering were the two bibliometric techniques employed. The analysis adhered to the PRISMA 2020 methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), which is instrumental in the identification, selection, evaluation, and synthesis of studies [9].

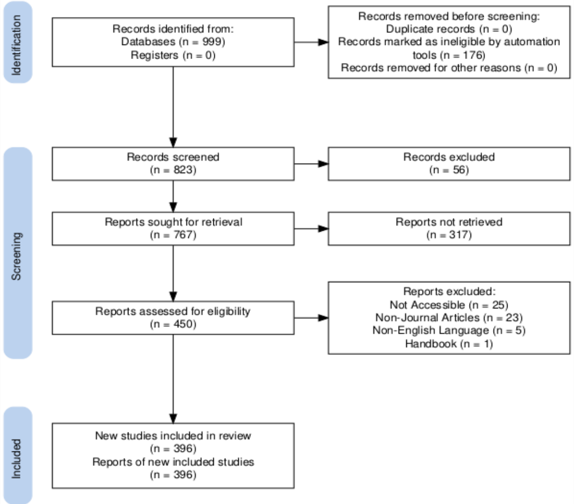

Fig 1. Systematic Literature Review Using PRISMA

The systematic literature review (SLR) process in this study followed the PRISMA guidelines [9]. The methodological steps encompassed identification and screening stages, which are outlined as follows:

2.1. Literature Identification

2.1.1. Data Sources

The articles for this study were sourced from publications indexed in Google Scholar, chosen for being the largest academic database available. Publish or Perish (PoP) was utilized as it is an effective tool for retrieving articles from Google Scholar [8][10]. Google Scholar was selected due to its open-source nature [11][12], indexing full texts or metadata from peer-reviewed journals, books, conference papers, theses, preprints, abstracts, technical reports, court opinions, and patents [13]. Article retrieval was facilitated using Harzing's PoP reference management software to survey the literature on the chosen topic [11][14]. The literature identification process included:

1. Collecting publication data using the Publish or Perish application.
2. Checking for duplicate articles retrieved via PoP using Mendeley Desktop, with data saved in BibTeX format beforehand.
3. Processing bibliometric data in Microsoft Excel to determine article types and publishers. Only research journal articles and publications from credible publishers such as Emerald, Elsevier, Taylor & Francis, Springer, ScienceDirect, MDPI, JSTOR, Wiley Online Library, and university publishers were included.
4. Conducting computational analyses and mapping using VOSviewer.

2.1.2. Search and Filtering Process

Articles were sourced using the specific keywords: "Digital" AND "Teach*" OR "Learning" AND "Scaffold*" AND "Education" on Google Scholar. To maintain focus on research journal articles [8], publications such as proceedings, newspapers, books, book reviews, and book chapters were excluded [12]. The study spanned a 10-year publication range, from 2013 to 2023. Initially, 999 related articles were identified. Articles meeting the study criteria were then exported in RIS, BibTeX, and CSV formats. RIS files were utilized for further analysis using VOSviewer.

2.1.3. Duplicate Removal and Initial Filtering

The initial step was to eliminate duplicates, though none were found. By utilizing Mendeley Desktop's automation filter, 176 irrelevant articles were removed. Automation tools greatly reduced the manual screening workload, particularly in bibliometric SLR studies [6], [9].

2.2. Screening Process

2.2.1. Title and Abstract Screening

From 823 remaining articles, titles and abstracts were screened for relevance to digital teaching and learning scaffolding in education, resulting in the exclusion of 56 articles.

2.2.2. Specific Relevance Criteria

Screening criteria focused on articles related to digital teaching and learning scaffolding, prioritizing those with appropriate methodologies and educational contexts. This ensured alignment with the study's objectives [15].

2.3. Eligibility Assessment

3.3.1. Content and Methodological Suitability

Out of the 767 articles screened, 317 were excluded following content analysis. Among the 450 remaining articles, 54 were excluded for the following reasons: 25 were inaccessible, 23 were non-research papers, five were in non-English languages, and one was a handbook. A stringent eligibility assessment was essential to ensure valid bibliometric analysis and maintain the quality of the selected articles [16]

2.4. Final Inclusion

2.4.1. Included Studies

After completing all stages, 396 studies were chosen for the bibliometric analysis of digital teaching and learning scaffolding in education. These articles underwent further scrutiny, including research trend mapping and author collaboration analysis using VOSviewer. This process followed PRISMA guidelines to ensure systematic and bibliometric rigor [9].

2.4.2. VOSviewer Implementation

VOSviewer software was used to create visual networks of frequently occurring terms in the field [15][16][17][18][19]. This software is highly effective and widely applied in bibliometric analyses [22][23]. It was employed to generate density maps of keyword linkages, where node color represents density levels (red = high density, blue = low density) influenced by neighboring nodes' quantity and weight [23]. High-density areas indicate strong correlations and research proximity, highlighting "hotter" or more popular topics. This density distribution provides insights into the evolution of major research themes over time [24].

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3. Result and Discussion

3.1. Analysis of Citation Trends

The citation trends related to digital teaching and learning scaffolding in education from 2013 to 2023 reveal significant fluctuations in both the number of publications and the academic impact as measured by citations. As illustrated in Figure 2, the volume of publications peaked in 2020 at 59 articles, aligning with the educational shift towards remote learning during the COVID-19 pandemic. However, this surge was followed by a marked decline in 2023, with only 16 publications.

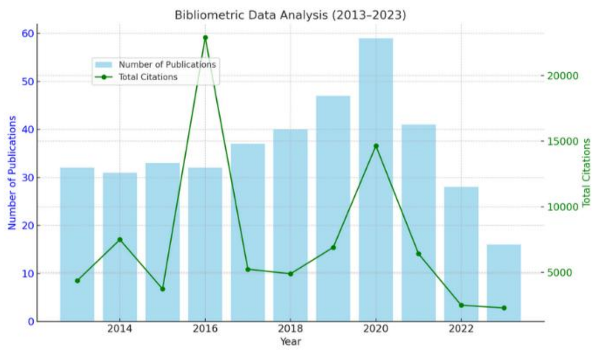

Fig 2. Citation Trends

Figure 2 shows the fluctuations in the number of publications, total citations, and average citations per article from 2013 to 2023. The highest spike in citations occurred in 2016 with 22,906 citations, while 2023 witnessed a sharp decline to only 2,296 citations. These patterns suggest that while the number of articles has increased, the citation impact does not always correlate directly with publication volume. The year 2016 stands out as a high point in academic influence.

Total citations mirrored this pattern, with significant peaks in 2016 (22,906 citations) and 2020 (14,651 citations). These years likely reflect landmark publications that significantly shaped the academic landscape. The article by John Gerard Scott Goldie (2016), "Connectivism: A Knowledge Learning," emerged as one of the most cited, with 12,715 citations, underlining the transformative influence of digital teaching theories. The steep decline in citations by 2023 (2,296 citations) may suggest a shift in research priorities or a saturation point in the discussion of digital scaffolding.

The average citations per article mirrored the trends in total citations, peaking in 2016 (715.81 citations/article) and again in 2020 (248.32 citations/article). This indicates that while the overall number of publications increased, the focus on high-quality, impactful studies remains a central theme in determining academic influence. The evidence supports the notion that citation count is not purely a function of publication volume but is more intricately tied to the depth, relevance, and innovation of the research [26].

In comparison with broader educational technology trends, this data aligns with shifts seen in other areas, such as AI in education, where peaks in citation tend to coincide with breakthroughs in technology and pedagogy [27]. The decline in citations in 2023 may reflect evolving educational priorities, particularly the rise of emerging technologies and methodologies such as AI-driven adaptive learning, which demand interdisciplinary collaboration for a more comprehensive understanding of educational scaffolding [28].

3.2. Analysis of the Top 10 Most Productive Authors

As depicted in Figure 3, the most productive authors in the field of digital scaffolding include Siu Cheung Kong, Zhihui Cai, and Davy Tsz Kit Ng, each with six publications. These authors, along with others such as Amy M. Kamarainen and Pi-Hsia Hung, contribute consistently to advancing research in digital scaffolding. This sustained productivity likely stems from both individual research dedication and the facilitative role of cross-disciplinary collaborations [29], which have proven instrumental in driving innovation in educational research.

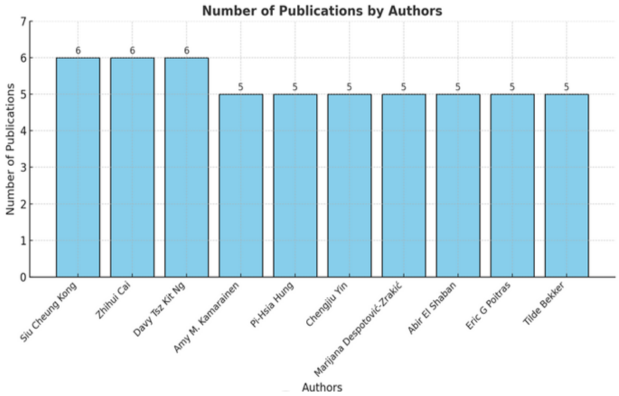

Fig 3. Number of Publications by Author

Figure 3 highlights the top 10 authors by publication count, underscoring the significant contributions made by these scholars to the body of work on digital scaffolding. The consistent productivity of Siu Cheung Kong and Zhihui Cai exemplifies the role of collaboration in increasing research output.

However, while publication volume is a key indicator of research activity, the impact of these authors in terms of citations varies, reflecting the broader trend that academic influence is not necessarily correlated with the sheer number of articles published [30]. The findings suggest that, although collaboration boosts productivity, high-quality contributions to the field are essential for ensuring long-term academic impact.

3.3. Analysis of the Top 10 Most Frequently Cited Articles

The top-cited articles from 2013 to 2023 offer crucial insights into the dominant themes and theoretical foundations in digital scaffolding. As shown in Figure 4, the most cited article, “Connectivism: A Knowledge Learning” [25], played a foundational role in shaping the discourse on digital scaffolding by emphasizing the integration of technology and constructivist learning theories. Another frequently cited article, “Implications for Educational Practice”, reflects the evolving role of digital scaffolding in contemporary educational settings, particularly in response to the shifting dynamics of online learning due to the pandemic.

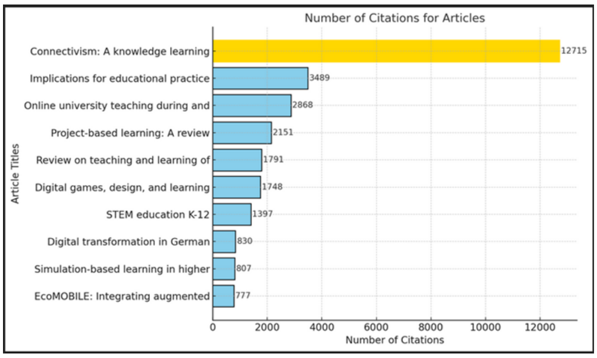

Fig 4. Top 10 Most Frequently Cited Articles

Figure 4 provides a list of the top 10 most frequently cited articles, detailing their citation counts, author names, and publication years. This visualization demonstrates the central role of influential articles in shaping the academic discourse on digital scaffolding.

The central themes of these articles revolve around technology-based education, student-centered learning, and pedagogical innovations such as project-based and STEM learning. This aligns with broader trends in educational technology, where digital tools, particularly those associated with gaming and immersive learning experiences, are becoming central in shaping modern pedagogies [31]. These studies highlight the role of digital scaffolding in enhancing critical thinking, problem-solving, and creativity among learners, which are essential skills for future educational success.

3.4. Author Keyword Analysis

An author keyword co-occurrence analysis was conducted to visualize the relationships between keywords [32] (Figure 3). Out of 2,295 keywords, 39 met the threshold, with a minimum occurrence of 10 set in VOSviewer. The analysis revealed that the term "Education" appeared 130 times, while "Student" and "Learning" occurred 114 times each. Similarly, the terms "Teacher" and "Scaffolding" appeared 112 times each. Other frequently occurring terms include "Teaching," "Study," "Scaffold," "Technology," "Use," "Practice," "Teacher Education," and "Digital Technology," reflecting the core focus areas in 396 documents.

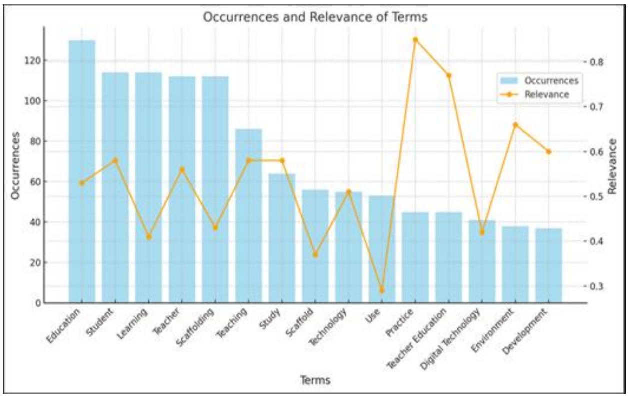

Fig 3. Author Keyword Analysis

The co-occurrence analysis of author keywords, as shown in Figure 4, emphasizes the importance of terms like "education," "student," and "learning," which reflect the core focus areas in digital scaffolding literature. The growing presence of terms such as "digital technology," "teacher education," and "scaffolding" underscores the increasing emphasis on how technology can be used to support both teaching and learning in contemporary educational environments [32].

Figure 4 illustrates the co-occurrence analysis of author keywords, highlighting significant themes in the literature related to digital scaffolding. Key terms such as "education," "learning," and "student" appear most frequently, reflecting the ongoing emphasis on foundational educational concepts in digital scaffolding research.

The emergence of "COVID" and "systematic review" as significant keywords indicates the shifting research landscape due to the pandemic, highlighting the urgency of adapting educational practices during times of crisis. The presence of these keywords also signals an increasing trend towards consolidating knowledge through systematic reviews to ensure best practices in digital scaffolding. The rise of these keywords underscores the need for adaptive learning frameworks that incorporate the dynamic interplay between technology and pedagogy in response to evolving educational needs.

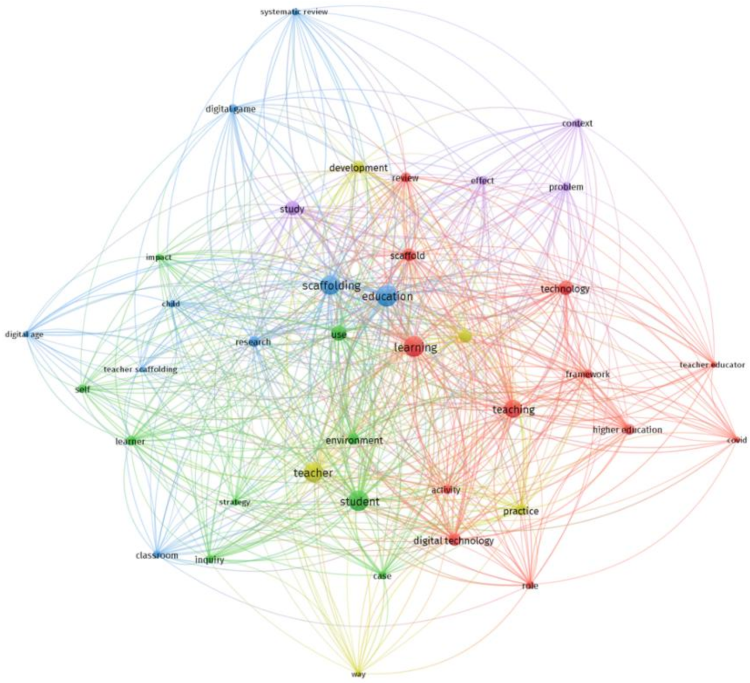

Fig 4. Co-occurrence Clusters

3.5. Author Co-Citation Network Visualization

The co-citation analysis in Figure 5 reveals the structure of collaborative networks in the field of digital scaffolding. Strong connections between authors such as Arnab and Barzilai (2019), and Belland (2017) and Elinich (2018), suggest that these scholars are key contributors to the development of scaffolding frameworks in education. The identified clusters indicate that while there is a robust collaborative environment, significant intellectual influences continue to emerge from authors deeply engaged in specific thematic areas such as cognitive development, AI, and technology-enhanced learning [35].

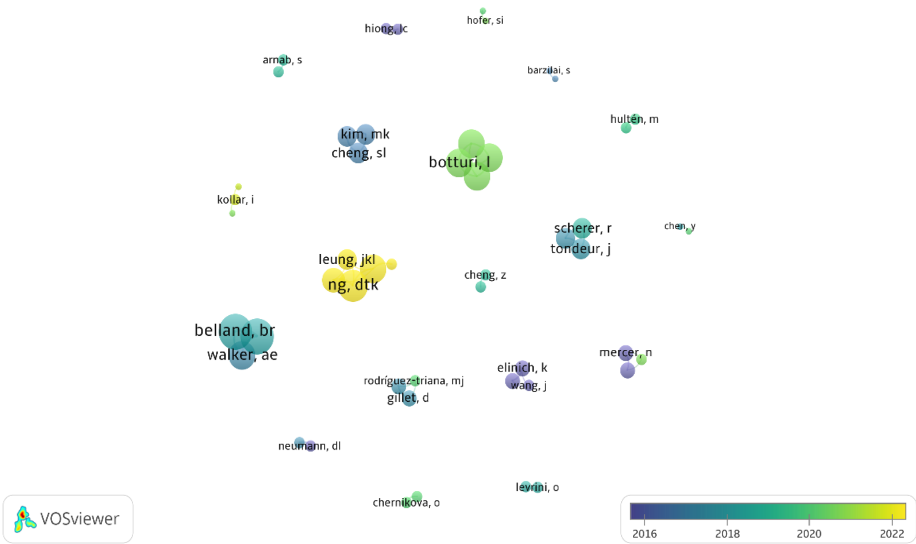

Fig 5. Author Co-Citation Network Visualization.

Figure 5 visualizes the co-citation network of authors in the field of digital scaffolding. This network illustrates how frequently authors are cited together, reflecting the strength of collaboration and knowledge sharing within the academic community.
These networks reflect the interdisciplinary nature of digital scaffolding research, where education, technology, and psychology intersect to create more effective scaffolding strategies. The link strength analysis further reinforces this point, showing that authors contributing to central themes such as digital game-based learning and teacher professional development hold critical positions in the co-citation network, acting as connectors across various research domains [36].

3.6. Analysis and Interpretation of Clusters

The cluster analysis of digital scaffolding research reveals five primary themes: integration of digital technology in education, learning strategies, digital games in children's education, teacher professional development, and contextual influences in educational research. Each of these clusters highlights key areas of educational transformation that have evolved significantly in response to technological advancements and societal shifts.
The integration of digital technology in higher education, for example, is examined in light of the COVID-19 pandemic's effect on remote learning and the increased need for scaffolding to support independent online learners [37]. Similarly, the focus on teacher education and development underscores the crucial role that ongoing professional development plays in ensuring effective integration of digital scaffolding practices in classrooms [38].

4. Conclusion

This study underscores the importance of digital scaffolding in education, particularly in secondary school learning. Utilizing bibliometric analysis with tools such as VOSviewer, the research successfully mapped trends, patterns, and key contributions in the field of digital scaffolding. The primary findings highlight that digital scaffolding not only enhances students' comprehension but also supports the development of critical thinking, problem-solving, and independent learning skills.
The study makes a significant contribution to the literature by mapping the collaboration networks among researchers and identifying key keywords such as education, student, and digital technology, which reflect the central focus of this field. Furthermore, the findings reveal that while the number of publications is increasing, academic impact is more influenced by the quality and relevance of research rather than sheer volume. The use of the PRISMA method and VOSviewer software facilitated a comprehensive analysis of relevant journal articles, providing a holistic view of the research landscape in this domain.
As an implication, the results of this study can assist educators and policymakers in optimizing the implementation of digital scaffolding. Future studies are encouraged to explore how emerging technologies and innovative methodologies can further enhance the effectiveness of digital scaffolding, particularly in the continually evolving post-pandemic educational context.

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