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Bibliometric Analysis of Research Trends on Graphic Design Software in Construction Learning

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ABSTRACT

This study aims to analyze publication trends related to the use of graphic design software in construction learning through a bibliometric approach using the Scopus database. Data were processed with the Biblioshiny application in RStudio to enable interactive visualization and in-depth exploration. The analysis covered various indicators such as publication growth, citation patterns, geographical distribution, international collaboration, and dominant research keywords. The findings reveal a significant rise in research activity after 2022, with China, the United States, and Malaysia emerging as major contributors, while Indonesia's participation remains limited. The most frequently studied software includes AutoCAD, Revit, and BIM, often combined with emerging technologies such as machine learning and virtual learning environments. These results indicate a strong global interest in integrating digital visualization tools into construction engineering education. Unlike previous bibliometric studies that broadly examined software engineering or e-learning, this research specifically focuses on graphic design software in construction learning contexts, offering a novel contribution to educational technology studies. The study highlights that such software not only enhances visualization and practical skills but also promotes innovation in curriculum design and teaching practices. Therefore, the integration of graphic design tools has become an essential element in improving the quality and digital readiness of construction education in the modern era.

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1. INTRODUCTION

The rapid advancement of digital technology has transformed various sectors, including education and construction. In construction learning, the use of graphic design software such as AutoCAD, Revit, and BIM has become essential for developing students' spatial visualization and technical drawing competencies. These tools allow learners to understand complex structural concepts through interactive, visual, and simulation-based approaches. Previous studies have confirmed that technology-based visualization enhances comprehension and motivation in construction-related subjects (Tuyet et al, 2022). Recent evidence also demonstrates that BIM-based digital modules can improve students' conceptual understanding and support independent learning in road-planning courses (Heryadi et al., 2023), while visual learning media significantly enhance vocational students' achievement in construction subjects (Adam et al., 2021).

Technology-supported learning media also play a crucial role in bridging theoretical knowledge and practical application. Similarly, augmented reality–based media have been shown to strengthen students' spatial and conceptual understanding through interactive three-dimensional visualization (Peterson et al., 2020). Studies in vocational construction education have shown that animation-based learning media can enhance students' understanding of structural and utility concepts, supporting more interactive and visualized learning processes (Triaghosa et al., 2022). Studies in vocational education have emphasized that digital platforms and multimedia-based learning tools can support contextual learning, self-paced skill development, and student engagement in technical subjects. Similar findings were reported in vocational construction programs, where the use of digital visualization and BIM-supported media effectively enhanced students' construction competencies (Heryadi et al., 2023; Adam et al., 2021). In addition, research in Indonesian vocational settings highlighted that the integration of AutoCAD-based learning media enhances students' understanding of construction drawing and spatial design (Lestari, 2025). In addition, the use of SketchUp and BIM applications in construction design has been proven to enhance students' spatial reasoning and modeling capabilities, especially in large-span building projects (Wisdianti et al., 2024). In recent years, artificial intelligence–driven visualization approaches have enhanced the application of design software in engineering education, supporting creative and data-driven learning processes (Guo et al., 2025).

Bibliometric analysis offers a systematic method to evaluate the development of scientific knowledge by identifying research trends, collaboration networks, and influential publications. Previous bibliometric studies in educational technology have primarily focused on e-learning platforms or software engineering (Wong et al., 2021; Ariffin et al., 2024), but limited attention has been given to the application of graphic design software in construction-related education.

Therefore, this study aims to fill that research gap by analyzing publication trends, thematic developments, and international collaboration patterns concerning the use of graphic design software in construction learning. The novelty of this research lies in its focus

on mapping global research dynamics within the intersection of construction engineering education and digital visualization technologies, providing insights for educators, researchers, and policymakers in improving curriculum design and technological readiness in the construction field.

2. METHOD

This study employed a descriptive quantitative approach using bibliometric analysis to examine publication patterns and research development in the field of construction learning that involves graphic design software. Bibliometric analysis was chosen because it allows the systematic evaluation of scientific production and provides an overview of trends, collaboration networks, and influential research themes within a specific topic area. This methodological framework aligns with previous comparative analyses on BIM implementation and digital construction education, which emphasized systematic evaluation of teaching and learning contexts (Correa et al., 2025).

2.1 Data Collection and Source

The research data consisted of all scientific articles addressing the use of design or visualization software in construction education published between 2016 and 2025. Data collection was conducted through the Scopus database, as it offers comprehensive coverage of high-quality international journals. Recent studies have emphasized the importance of ethical and privacy-aware data handling in large-scale digital analyses, a concern that aligns with current bibliometric research practices (Ribeiro-Navarrete et al., 2021). A purposive sampling technique was applied to ensure the inclusion of relevant and high-impact studies. The search query applied in Scopus was: TITLE-ABS-KEY (software AND design AND (learning OR education) AND construction) AND PUBYEAR > 2015 AND PUBYEAR < 2026 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English")).

2.2 Inclusion and Exclusion Ctiteria

Only peer-reviewed journal articles written in English and directly related to construction learning or engineering education were included. Excluded materials consisted of conference proceedings, review papers, book chapters, and articles unrelated to the educational context of construction design software. This step ensured that the data accurately represented publications focusing on teaching and learning aspects rather than industrial or purely technical applications. The data filtering process, including keyword refinement and the exclusion of unrelated publications, was conducted systematically and is illustrated in **Figure 1.**

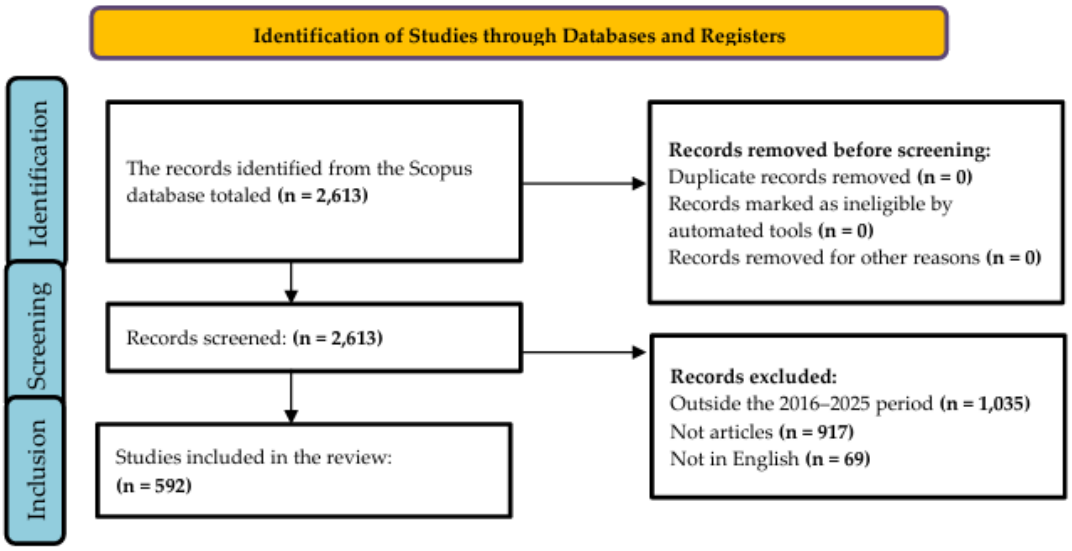

Figure 1. Data filtering process for bibliometric analysis using Scopus database and Biblioshiny in RStudio.

2.3 Data Validation and Analysis

To ensure construct validity, the selection of keywords (graphic design software, construction learning, engineering education) was carefully aligned with the research objectives. The metadata were retrieved and recorded on October 11, 2024, and updated on January 18, 2025, to include the most recent publications. The analysis was performed using the Biblioshiny package in RStudio, which enables visualization of co-authorship, keyword co-occurrence, citation patterns, and collaboration networks. A comparable bibliometric approach has been adopted in prior studies that utilized VOSviewer to map the evolution of e-learning research and its visualization patterns (Habibiet al., 2022). The overall bibliometric workflow—including data retrieval, mapping, and network visualization—was conducted through the Bibliometrix framework and is summarized in **Figure 2.**

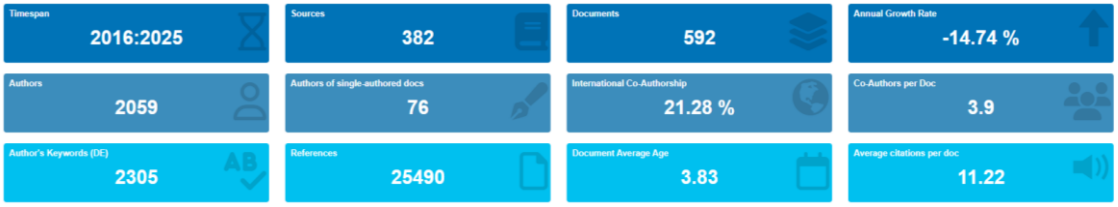

Figure 2. Bibliometric Analysis (2016-2025)

To address database limitation bias, the study acknowledges that Scopus—while extensive—may not include all regional publications, particularly from developing countries. Therefore, findings are interpreted as a representative yet partial overview of global research activity. The results are complemented by descriptive statistics, visual maps, and network analyses that collectively reveal the development of graphic design software studies within construction learning.

3. RESULT AND DISCUSSION

This study analyzed research trends on the use of graphic design software in construction learning by examining 592 Scopus-indexed articles published between 2016 and 2025. The findings provide insights into the evolution of digital visualization tools within the field of construction education. The most frequently mentioned software in the analyzed publications is summarized in **Table 1.**

Table 1. Summary of Software Used

Country	Frequently Used / Associated Software
China (1418 publications)	*Revit*, *AutoCAD*, *Python*, *MATLAB*, *BIM*, *SketchUp*
USA (651 publications)	*Unity*, *ANSYS*, *Visual Studio*, *MATLAB*, *Photoshop*
Malaysia (431 publications)	*Revit*, *BIM*, *SketchUp*, *AutoCAD*
Australia (317 publications)	*Grasshopper*, *Rhinoceros*, *Unity*, *Revit*
Germany (249 publications)	*SolidWorks*, *MATLAB*, *Python*, *OpenGL*
India (172 publications)	*MATLAB*, *AutoCAD*, *Python*, *ETABS*
United Kingdom (168 publications)	*ArchiCAD*, *Revit*, *Blender*, *Unity*
Greece, Turkey, Iran	Generally: *ETABS*, *AutoCAD*, *SAP2000*
Japan & Korea	*MATLAB*, *Simulink*, *Revit*, *Unity*

The table shows that AutoCAD, Revit, and Building Information Modeling (BIM) are the most dominant tools studied, often combined with SketchUp, Photoshop, and other visualization software. The popularity of these programs indicates a global emphasis on three-dimensional visualization and modeling skills in construction education. These findings are consistent with previous studies highlighting that 3D modeling and visualization technologies play a crucial role in enhancing students conceptual understanding and engagement in construction learning (John et al., 2025; Ka et al., 2025).

3.1 Publication and Citation Trends

The annual number of publications related to graphic design software in construction learning shows a consistent upward trajectory, with a notable surge after 2022. This indicates a growing academic and professional interest in digital-based learning environments. The increase in both publication and citation rates reflects the expanding influence of visualization and modeling technologies in construction education. The trend also parallels the global movement toward BIM integration and digital transformation in engineering curricula. Similarly, advanced BIM research has incorporated visual programming and optimization techniques to enhance structural efficiency and environmental performance in construction design (Yavan et al., 2024). Furthermore, the integration of neural network learning into BIM applications has been recognized as a promising approach to enhance efficiency and sustainability in design education (Zhang, 2024). Recent technological developments such as the metaverse have introduced immersive and interconnected

learning environments that expand the potential of digital visualization tools in engineering education. These environments enable students to experience realistic, interactive, and collaborative simulations in construction learning (Jamshidi et al., 2023).

3.2 Geographical Distribution and Collaboration Patterns

The bibliometric mapping reveals that China (1,418 publications) leads global research output, followed by the United States (651) and Malaysia (431). Several factors may explain this dominance. China's strong governmental investment in digital construction, national innovation programs, and integration of BIM and CAD tools into higher education curricula have accelerated research output. Similarly, the United States and Malaysia benefit from established research infrastructures and cross-institutional collaboration networks.

In contrast, Indonesia's research contribution remains limited, with only two publications identified. This gap suggests that the adoption of graphic design software in educational research and curriculum development is still at an early stage. Limited access to advanced software, insufficient institutional collaboration, and a lack of targeted funding in educational technology research may contribute to this situation. Strengthening university–industry partnerships and promoting training for lecturers in digital design software could help Indonesia expand its research visibility and pedagogical innovation in construction learning.

3.3 Thematic and Keyword Analysis

Keyword co-occurrence analysis identified three main research clusters, namely the Technical and Programming Cluster, the Educational Application Cluster, and the Human–Technology Interaction Cluster. The Technical and Programming Cluster includes terms such as software design, algorithm, and engineering, indicating a focus on computational tools and model optimization. The Educational Application Cluster encompasses students, architectural design, virtual reality (VR), and BIM, reflecting developments in pedagogical innovation and immersive learning environments. Meanwhile, the Human–Technology Interaction Cluster covers aspects such as usability, user experience, and interaction, emphasizing the importance of interface design and learner engagement. The relationships among frequently occurring keywords and their thematic clusters are illustrated in **Figure 3.**

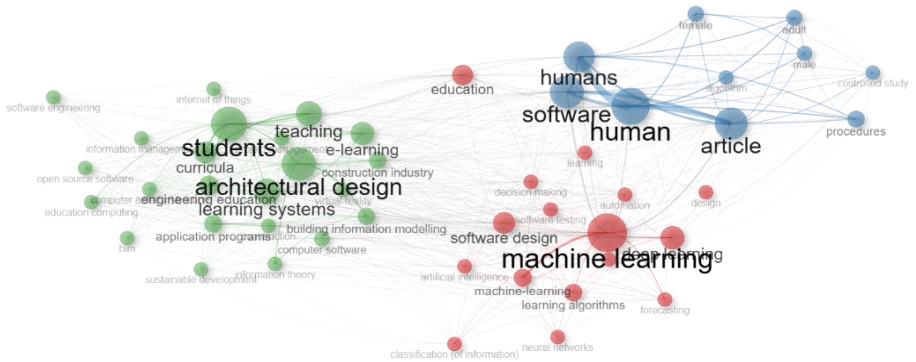

Figure 3. Network Visualization

3.4 Top-Cited Studies and Research Implications

The five most influential studies in this domain are presented in **Table 2**, highlighting the works that have shaped the integration of graphic design software in construction learning.

Table 2. Top 5 Most Cited Articles

No	Author(s)	Research Article Title	Citations	Year
1	SMITH KW, 2020, PUBL ASTRON SOC PAC	Design and operation of the ATLAS transient science server	207	2020
2	NAJI S, 2016, ENERGY	Estimating building energy consumption using extreme learning machine method	174	2016
3	CHEN Z, 2021, NUCLEIC ACIDS RES	ILearnPlus: A comprehensive and automated machine-learning platform for nucleic acid and protein sequence analysis, prediction and visualization	163	2021
4	DAS S, 2016, IEEE TRANS INF FORENSICS SECUR	Semantics-based online malware detection: Towards efficient real-time protection against malware	158	2016
5	EL-DIRABY T, 2017, AUTOM CONSTR	BIM-based collaborative design and socio-technical analytics of green buildings	129	2017

The top-cited articles—such as Smith et al. (2020) and El-Diraby (2017)—focus on integrating intelligent systems, BIM-based collaboration, and data-driven construction design. These studies illustrate how machine learning, visualization, and automation are redefining teaching and professional practices in the construction domain. Similarly, recent studies have highlighted the importance of integrating data analytics and systematic evaluation tools to improve teaching quality and learning outcomes in technical education (Li, 2022). For curriculum design, these findings imply that the ability to use digital design software is no longer optional but fundamental. Educational institutions should embed training in AutoCAD, Revit, and BIM into the learning framework for vocational and higher-education programs. Furthermore, collaboration with international research networks can help developing countries access knowledge resources and increase global visibility.

3.5 Summary Findings

Overall, the bibliometric results reveal an expanding and increasingly collaborative research landscape. Developed countries lead in research quantity and innovation, while developing countries—particularly in Southeast Asia—are emerging participants with significant potential for growth. The results also show a convergence between technological proficiency and pedagogical adaptation, suggesting that the effective use of graphic design software can bridge skill gaps and modernize construction education practices (Nguyen & Adhikari, 2025).

4. CONCLUSION

This bibliometric study provides an overview of research trends related to graphic design software in construction learning from 2016 to 2025. The analysis of 592 Scopus-indexed publications reveals a steady growth of scholarly interest in the use of digital design tools—particularly AutoCAD, Revit, and Building Information Modeling (BIM)—as essential components of modern construction education. Developed countries such as China, the United States, and Malaysia lead the research landscape due to stronger academic infrastructures and innovation policies that support digital transformation in engineering education. The findings demonstrate that the integration of visualization and modeling technologies is not limited to technical skills but also serves as a pedagogical innovation promoting experiential and project-based learning. However, research from developing countries, including Indonesia, remains limited. This highlights the need for greater institutional support, curriculum modernization, and university–industry collaboration to enhance the capacity for digital construction education.

Practically, this study implies that educators should embed graphic design software training into teaching strategies and curricula to align with Industry 5.0 and Education 4.0 principles. Policymakers and higher education institutions can use these findings to strengthen digital literacy frameworks and encourage cross-country collaborations. Future research could expand the dataset beyond Scopus by integrating Web of Science or regional databases to capture a broader perspective. Further studies might also employ mixed-method approaches to explore how digital visualization tools influence students' learning performance, creativity, and problem-solving skills.

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