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OVERVIEW OF BIM CONTRIBUTIONS IN THE CONSTRUCTION PHASE: REVIEW AND BIBLIOMETRIC ANALYSIS

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SUMMARY: *Building Information Modelling (BIM) is a revolutionary invention within the construction industry that essentially aids the design, construction and management of construction projects throughout their lifespan. Globally, the Architecture, Engineering, and Construction (AEC) industry has for decades progressively adopted and implemented BIM. While there are several papers in this context, none have tried to extensively document BIM's comprehensive contributions and uses in the construction phase. Therefore, this paper aims to identify BIM's various contributions and uses in the construction phase and analyze publication trends, co-occurring keywords, contributing authors and countries. A systematic overview approach was used to review published articles on state-of-the-art of BIM in construction, supported by bibliometric network mapping analysis. A total of 409 documents were extracted and analyzed. The study's findings document BIM's various uses and contributions to the AEC industry, such as simulation of each stage of the construction process, virtual presentation of the building and site, visualization of progress, management of construction work, enhancement of safety, communication and collaboration, quick generation of reliable and accurate cost estimates, assistance in the fast realization of return on investment (ROI), and serving as a platform that hosts and documents various technological tools used during the construction phase. The bibliometric analysis reveals the most contributing scholars, countries, document sources, trend network mapping of co-occurring keywords, and publication trends. The primary practical implications of this study's discoveries can be exploited as a basis for further research and to influence the future direction of BIM in the AEC industry. The findings will enhance the wider spread, application and understanding of BIM in the AEC industry, thereby increasing BIM awareness and knowledge globally.*

KEYWORDS*: AEC industry, bibliometric, BIM, construction, design*

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1. INTRODUCTION

Over the past decades, the Architecture, Engineering, and Construction (AEC) industry has experienced an influx of technologies that promise to improve the construction process. Building Information Modelling (BIM) is one of the most concentrated and researched technologies in this framework (Ghanem 2022). Miettinen and Paavola (2014: 1) defined BIM as a "combination or a set of technologies and organizational solutions that are expected to increase inter-organizational and disciplinary collaboration in the construction industry and improve the productivity and quality of the design, construction and maintenance of buildings". Azhar *et al.* (2011) envisaged that BIM is the way for the construction industry's future. Olatunji (2019: 1240) opined that the future has begun; BIM is no longer a question of when but rather how the revolutionary potential of BIM (the future) shapes today's knowledge. The AEC industry and built environment researchers have now taken BIM acceptance seriously. Smith and Tardif's (2009: 60) views are still prevalent. The authors presume that the future construction industry must either "adopt (or adapt to) BIM now or die". Recently, there has been a rapid improvement in BIM adoption globally. Hasan and Rasheed (2019) and Toyin and Mewomo (2022a) traced the increase in the adoption of BIM to the positive impact BIM has had on the construction industry.

Nevertheless, developing countries still find it difficult to implement BIM in the construction phase of their projects (Ahmed 2018). The comprehensive barriers behind these difficulties were documented by (Awwad, Shibani and Ghostin 2020; Bouhmoud and Loudyi 2021; Toyin and Mewomo 2021) as insufficient knowledge about BIM contribution in the construction phase and a low understanding of the factors influencing BIM implementation, among others. Many studies have focused on implementing BIM in the construction phase; however, a few have extensively documented the comprehensive contributions and uses of BIM implementation in the construction phase. Moreover, scholars such as Shanbari, Blinn and Issa (2016); Ahmed (2018) and Hatem, Abd and Abbas (2018) have indicated the need for comprehensive documentation of BIM contributions and its uses in the construction phase. The authors submit that it may increase the interest of those willing to adopt or implement BIM. Thus, this study attempted to answer the following questions:

1. What are the contribution and uses of BIM in the construction phase?
2. What are the publication trends, co-occurring keywords, contributing authors, and countries?

The first question was investigated through a systematic overview of published (open-access) manuscripts related to the study area. At the same time, the second question was answered by examining and analyzing the bibliometric data to determine the publication trends, keywords, contributing authors and countries with data sourced from the Scopus database. Therefore, this paper aims to identify BIM's various contributions and uses in the construction phase and check publication trends, co-occurring keywords, contributing authors and countries. Subsequently, following the introduction to the topic, the methodology section describes the research workflow methods and details of the analysis, including the explanation of the systematic overview and the analysis process. The overview discussion section shows the findings of the systematic overview. The bibliometric analysis result section presents the statistical information and conclusions of the bibliometric analysis. To fully answer this study's first question, the result of the systematic overview was extensively checked. The gaps were drawn to discuss the voids in the present state-of-the-art BIM in the construction phase and propose future research works. Finally, the conclusion section sums up the study.

2. METHODOLOGY

Ma, Ma and Li (2017) and Toyin and Mewomo (2022a) agreed that it is essential to conduct a literature review to have proper scientific research. Therefore, this study adopted a systematic overview of published articles within the context of this study between 2008 and 2022. From a systematic overview, one can identify, for example, research trends and research foci based on what has previously been documented scientifically. However, this study involves four simplified processes to answer the research questions.

Step 1 - data collection: a collection of relevant published academic articles in this study context area between 2008 and 2022 using the search keywords "BIM" or "BIM in construction" and "construction phase." These search keywords were repeated in Google Scholar, the Scopus index, and the Web of Sciences (WOS). As Google Scholar has the links to the domain or repository of most papers, it is primarily used to download the full article indices in Scopus and WOS. However, Scopus and WOS abstracts were used to conduct the database search of the relevant articles. The two academic databases were used because they are considered two of the largest databases (Begić

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and Galić 2021). They provide online access to more than a million records in over 21,000 peer-reviewed journals and input citations (Amirkhani, Martek and Luther 2021). The first search generated 1,060, 508, and 145 documents, respectively.

Step 2 - screening: exclusion and inclusion criteria limited the data to 409 documents. Although using several databases for bibliometric analysis was not feasible due to overlapping results and the complexity in comparatively analyzing bibliometric networks (Xiang, Wang and Liu 2017), subsequently, Scopus was selected as the optimal database to draw a representative and adequate set of relevant papers for bibliometric analysis. Hence, this study focused on using Scopus documents for the bibliometric analysis. Exclusion criteria such as papers in-press, papers not related to the study context, papers not written in English, and papers lacking full details. After the inclusion and exclusion criteria, the documents were then filtered down to 409, based on the Scopus index.

Note: the last search was on the 15 May, 2022. However, 95% of WOS documents were contained therein, and all were included in Google Scholar. Therefore n=409.

Step 3 - data analysis: Relevant open access papers were selected for review, and the 409 bibliometric data were analyzed using VOSviewer software. A similar process was adopted by Xiang, Wang and Liu (2017); Amirkhani, Martek and Luther (2021) and Begić and Galić (2021).

Step 4 - findings: The review and bibliometric analysis findings were drawn and discussed. After that, conclusions and recommendations were drafted. Figure 1 shows the systematic overview flowchart adopted for this study.

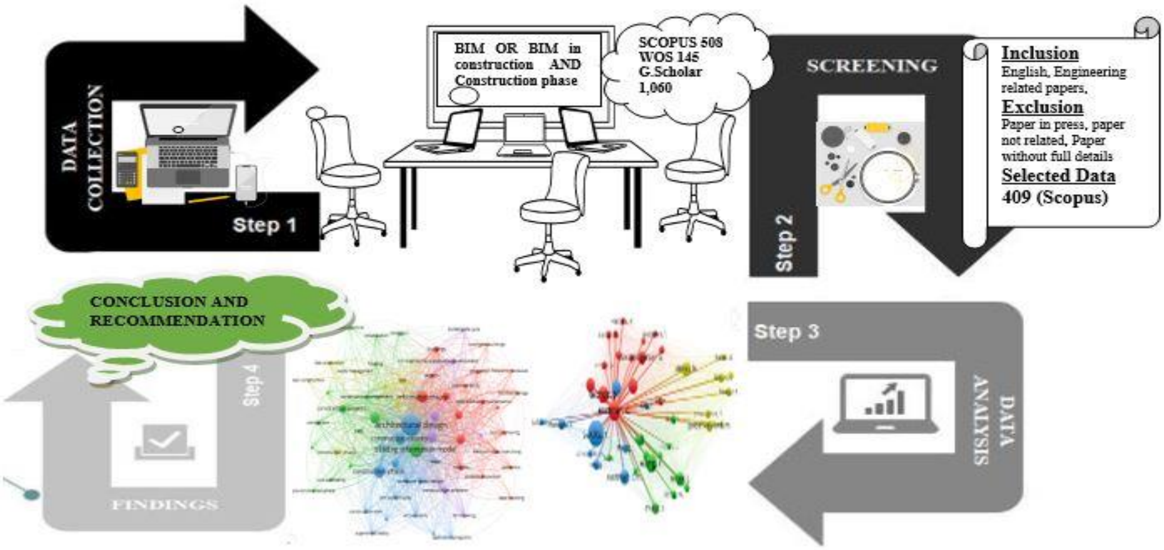

FIG. 1: Systematic overview workflow

3. BIM CONTRIBUTION AND USE IN CONSTRUCTION PHASE OVERVIEW

BIM comprises three essential characteristics. The first characteristic is that the model's data and information can be saved in the BIM databases to make collaboration easier (Rodrigues and Lindhard 2021; Sinaga and Husin 2021). The second characteristic enables control of the database updates, such that a database change impacts fundamental aspects of the model (Duarte-Vidal *et al.* 2021; Habte and Guyo 2021). The third characteristic is that by including industry-specific applications, model information may be recorded and upheld for future use (Vanlande, Nicolle and Cruz 2008; Bouhmoud and Loudyi 2021).

3.1 Possible uses of BIM in the construction phase

BIM has recently attracted widespread attention in the AEC industries (Cao *et al.* 2021; Toyin and Mewomo 2021). It can coordinate a project's design, analysis and construction processes, thus improving project reliability (Lahdou and Zetterman 2011; Carvalho, Villaschi and Bragança 2021). BIM design and construction plans may be linked by connecting the building model to the project schedule; AEC professionals could use BIM to simulate each stage of the construction process and display a virtual representation of the building and site (Cao *et al.* 2021).

Furthermore, it allows them to track, keep and quickly update the digital records of completed tasks during the construction phase (Habte and Guyo 2021). Subsequently, quantity surveyors can promptly generate accurate and reliable cost estimates through programmed quantity takeoffs from the building model (Mirarchi *et al.* 2020). These enable fast cost feedback on design changes (Fan, Wu and Hun 2015). It is also used as an efficient instrument to visualize progress and manage construction works (Lin 2014). The AEC's communication and discussion can be improved through visualization during the construction phase (Hajdasz 2008). Nevertheless, AEC can create additional management units, such as experience and knowledge management, which could be accommodated within the BIM platform.

3.2 Contribution of BIM in the construction phase

Fan, Skibniewski and Hung (2014) conducted an extensive survey among contractors who used BIM for their projects. It was reported that over 90% of the contractors claimed they were not willing to perform another project without BIM. This eagerness could be attributed to the real-life positive contributions and benefits realized with the help of BIM compared to the traditional construction method. The progress of BIM is still ongoing, and it has yet to realize its full potential. BIM's evolution from a construction tool to a project management culture may be viewed as the steady development of a new collaborative team approach. The contribution of BIM during on-site construction is simply one sign of the BIM cultural revolution. Di Giuda *et al.* (2020) revealed that with the help of BIM integration on the study project at the school of Melzo, BIM enables adequate quantitative and geometric control. Thus, by verifying the installed elements' positioning, dimensional correspondence and fixing methods on-site (Fig. 2), these checks guarantee quality output in conformity to the architectural and structural design and geographical layout, reducing rework or possible variations to a minimum.

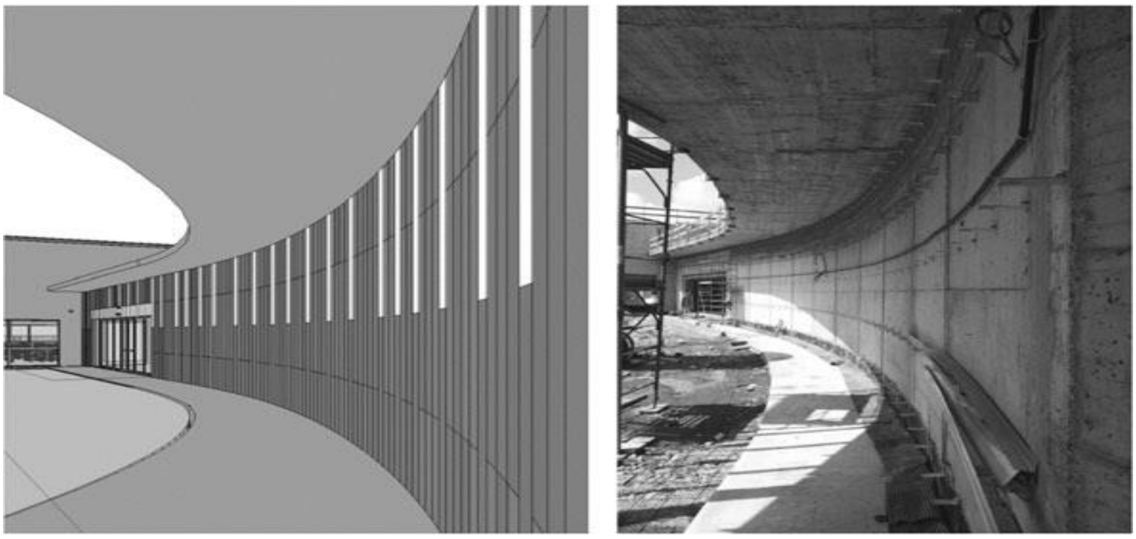

FIG: 2. BIM model façade and onsite façade. (Di Giuda et al. 2020: 170)

Lee and Lee (2020) designed a framework to assess the return on investment (ROI) derived from BIM integration based on preventing rework in the construction phase. The study disclosed that applying the framework demonstrated that a primary ROI of 167.8%. based on averted rework costs. The overall effect of integrating BIM was about 476.72%. Furthermore, the expert engaged in the study believed the framework could be employed as a practical process to evaluate the performance of BIM in this context. Habte and Guyo's (2021) study found that BIM enables easy construction work drawing extraction during the construction process from the BIM workflow. Thus, it is an outstanding contribution and an advantage over the conventional method.

Zulkifli, Takim and Nawawi (2016) initiated an Automated Safety Rule Checking (ASRC) BIM-based framework for Malaysian construction projects. This development was grounded in the existing ASRC model of the United States (US), Finland, China, and Thailand. The model was developed to mitigate possible construction hazards that could arise from "falls, being hit by an object, electrocution, being stuck in/between the object and fire, and safety parameters (i.e., Occupational Safety & Health Act 1994, and the Factory & Machineries Act 1967)" (Zulkifli, Takim and Nawawi 2016: 65). The authors' findings with the developed model noted that optimal safety could be ensured on-site using the BIM-based model. These, in turn, contribute to the safety of construction workers and the safe use of machines. Carvalho, Villaschi and Bragança (2021) developed a BIM-based decision-making framework for designers to assess construction projects' economic, environmental and functional performance. This model enables automation of the life cycle assessment (LCA) and life cycle cost (LCC) evaluation of the project during the project's construction phase and life cycle. The authors concluded that the integration of the model could significantly reduce the required time, errors and efforts when performing LCA and LCC analysis, providing designers with real time decision support data and making an important contribution to the use of BIM for sustainability purposes.

Lee, Park and Song (2018) developed a BIM-based framework to manage site information generated during the construction phase. The framework analyzes the information generated from construction sites and stores the structured information for future use. Nikmehr et al. (2021) conducted a review on using BIM-based tools to manage construction and demolition waste (CDW). The authors found that BIM has played a significant role in CDW. It provides a platform that enables the documentation of waste that could be suitably reused during the project's construction phase. Kivits and Furneaux's (2013) findings disclosed that BIM adoption had shaped the AEC construction process through "collaborative engineering knowledge management, designed to facilitate sustainability and asset management issues in design, construction, asset management practices, and eventually decommissioning for the AEC industry". The AEC is encouraged to continually invest in digital capabilities such as BIM to uninterruptedly improve productivity and effectiveness through improved collaboration at every stage of the construction lifecycle (Toyin and Mewomo 2022b). Duarte-Vidal et al. (2021) studied the "Interoperability of Digital Tools for the Monitoring and Control of Construction Projects" during the construction phase. The authors found that the BIM platform can host and document the various technological tools used to assist BIM and store their data for future use. Figure 3 shows the different techniques used during the construction phase and the area in which they function, such as:

Locate: used to track the location of materials and humans in space and time.

Automate: entails total or partial implementation of technological tasks without human involvement.

Communicate: used to convey data, information, or knowledge to a human.

Transfer data: longitudinal transferability of information of interest among stakeholders.

Rebuild: translates an existing physical system into a digital model.

Simulate: represents the behaviour of a given process.

Visualize: allows for a digital visual model to be made available to interested parties.

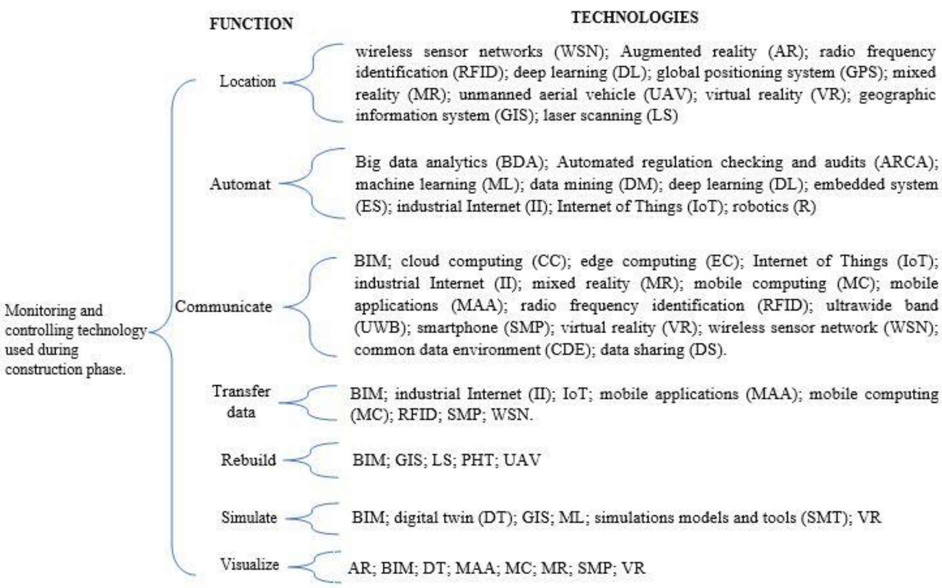

FIG. 3: Technologies used for monitoring and control during the construction phase. Adopted from (Perrier et al. 2020; Duarte-Vidal et al. 2021)

Porwal and Hewage (2012) proposed using the BIM model to manage rebar waste with an optimization technique. The authors adopted a simulated "annealing heuristic" approach to resolve the cutting stock challenges experienced in the construction industry. The authors submit that the model was successful. These have helped to reduce the cost and amount of cutting losses. Feng and Hsu (2017) proposed a framework suitable for assembling scaffolding systems on-site to automate the information generation process; this framework was basically for material management. The authors employed an ontology model and dynamo modules to generate detailed information for assembling scaffolding. Feng and Lin (2017) proposed using BIM for mechanical, electrical and plumbing (MEP) material management. The authors developed a fire-fighting ontology model. Basically, the BIM model was used as an information integration tool that delivers the required information to the components. The study by Ocheoha and Moselhi (2013) evaluated the impact of BIM on "just-in-time (JIT) material delivery." The findings reveal that the BIM model can help improve the implementation of JIT and reduce the cost of material management.

Furthermore, the author concluded that the BIM model could help to identify constructability issues and resolve potential clashes between sub-trades (Azhar 2011; Mirarchi et al. 2020); reduce field coordination problems (Chan, Olawumi and Ho 2019); coordinate material handling equipment (Abd, Khamees and Liu 2017); avoid site congestions and plan material deliveries (Mäki and Kerosuo 2015); and generate more delivery schedules and accurate material quantities (Ocheoha and Moselhi 2013). Choi et al. (2014) suggested a 4D BIM framework for the workspace planning process to integrate the construction plan, activity characteristics, and workspace. This framework was subjected to a live case study. The authors drew the following conclusion: it enabled easy identification of possible workspace problems; thereafter, an appropriate resolution strategy was suggested for each workspace problem. Subsequently, it improved the accuracy of workspace status prediction and workspace problem identification by introducing the workspace occupation concept. Sinaga and Husin (2021) investigated the suitability of the BIM model for time optimization during the construction stage. The authors reveal that the BIM model could estimate the buffer time, generate 3D modelling of implementation methods and 4D simulation models, determine the critical chain, and estimate the required project management duration. Therefore, the study found that the BIM model reduces time spent on the project since it allows early detection of work clashes. The study by Hasan and Rasheed (2019) revealed that the 5D-BIM model has a considerable advantage over the traditional approach in material estimation through increased collaboration among project stakeholders, increased detailed visualization of construction works and linking 3D with time and cost. Increased understanding of the project allowed for better estimation of cost and time, reduced change order and a 5D model provided effective quantity takeoff (QTO).

Studies by Hartmann and Fischer (2008) and Kivits and Furneaux (2013) concluded that BIM technology allows easy tracking of work in real-time, enhances site management, and speeds the flow of resources. In addition, it enables improved monitoring of cash flow and cost control, mainly for larger projects. Enshassi, Hamra and Alkilani (2018) noted that the BIM model could be used to control effective construction processes, construction life cycle cost, environmental issues, decision-making support, and better customer service, design and quality improvement (Dmitriev *et al.* 2019). According to the findings of Begić, Galić and Dolaček-Alduk (2022), the following uses of BIM for the management of construction projects have been identified: information and graphical views management; provision of a collaborative environment and information sharing platform; simulation of the construction process; on-time cost estimates at any stage; and the possibility to simulate the project's management. Lee and Lee (2020) developed a framework for evaluating return on investment (ROI) based on BIM-integrated projects to prevent rework. The framework was subjected to a live case study. The findings of the professional's verification revealed that the effective cost estimates and thorough contents successfully obtained a degree of conformity that contractors could accept. This means BIM technology could help eliminate rework during the construction phase using the developed framework.

4. BIBLIOMETRIC ANALYSIS AND DISCUSSION.

Bibliometric analysis is a vital research technique that shows the various field of bibliometric mapping of published articles. It looks for representations of logical links within a constantly evolving scientific knowledge system. It is worth noting that the advent of scientific databases like Web of Science and Scopus has made obtaining large volumes of bibliometric data relatively simple, and bibliometric software like VOSviewer, Leximancer, and Gephi allows for efficient analysis of such data, resulting in a recent surge in scholarly interest in bibliometric analysis (Donthu et al. 2021).

The extracted articles will use the following analysis tools and approaches:

- Scopus (CSV data) and Microsoft Excel
- VOSViewer software (version 1.6.18): Network mapping

The collected data and findings of the study will be presented using tables, figures, graphs and charts.

4.1 Analysis and discussion.

The retrieved 409 articles were identified and assessed using the search keywords "BIM in construction" or "factors influencing BIM" or "BIM" and "construction phase." In Scopus's database, Figure 4 shows the trend of publications per year. These indicated that concentration on BIM in the construction phase started in the year 2011 and reached its peak in 2020. The most significant years of publication fell between 2011 to 2022. However, 2022 was yet to actualize fully during this study's final search (15/05/2022).

FIG. 4: Publications per year

4.2 Co-occurring keywords network

Keywords are terms, nouns and phrases that are the core contents of an article or publication and shows the advancement of research topics over time (Xiang, Wang and Liu 2017). In the Scopus database, there are two types of keywords: (i) "author keywords", which are supplied by authors, and (ii) "index keywords", which are identified by the journals. Both types of keywords from the 409 bibliographic records were used to construct a network of co-occurring keywords. Co-occurrence might also comprise likely keywords based on the same topic but not the same meaning; the closeness of keywords is precisely related to the degree of co-occurrence (Xiang, Wang and Liu 2017). A total of 2069 keywords were identified using the VOSviewer software. After that, inclusion criteria were set to a minimum number of occurrences of a keyword: 8.64 meet this threshold. Figure 5 shows the network of the co-occurring keywords. Table 1 shows the 64 co-occurring keywords with their associates clusters and occurrences. The keywords were grouped into five (5) clusters, identified with different colours in Figure 5. Each cluster was further named according to the identified variables. Hence, cluster 1 (red zone): BIM integration and sustainability (BIM IS), cluster 2 (green zone): BIM design and construction (BIM DC), and cluster 3 (purple zone): BIM information and management (BIM IM) and cluster 4 (yellow zone): BIM benefit and impact (BIM BI) contained 13, 12, 9 and 7 keywords, respectively. "Architectural design" with ID number 41 has the highest occurrence (118) and total link strength (596), and "construction industry" with ID number 260 is the second-highest with occurrence (66) and total link strength (348).

TABLE 1: Co-occurrence keywords of the complete cluster

Cluster 1 (Red) 19 (Building and site management)	Cluster 2 (Green) 15 (Construction capital management)	Cluster 3 (Blue) 15 (Construction Design)	Cluster 4 (Yellow) 8 (BIM management)	Cluster 5 (Purple) 7 (Sustainable construction)
accident prevention	budget control	application programs	automation	3D modeling
buildings	building information model – BIM	architectural design	BIM	building information modelling
data handling	collaboration	augmented reality	building information modeling	building life cycle
decision making	construction management	BIM technologies	civil engineering	construction
design and construction	construction projects	computer aided design	construction phasis	construction process
electronic data interchange	cost estimating	construction industry	lean construction	environmental impact
facilities	contractors	construction phase	lean production	sustainable development
facilities management	costs	construction progress	waste management	
frequency modulation	general contractors	construction sites		
information management	housing	design		
information theory	managers	intelligent computing		
Integration	pre-construction phase	structural design		
intelligent buildings	project management	three-dimensional computer graphics		
Interoperability	quality control	virtual reality		
life cycle	scheduling	visualization		
operation and maintenance				
robotics				
semantics				
Surveys				

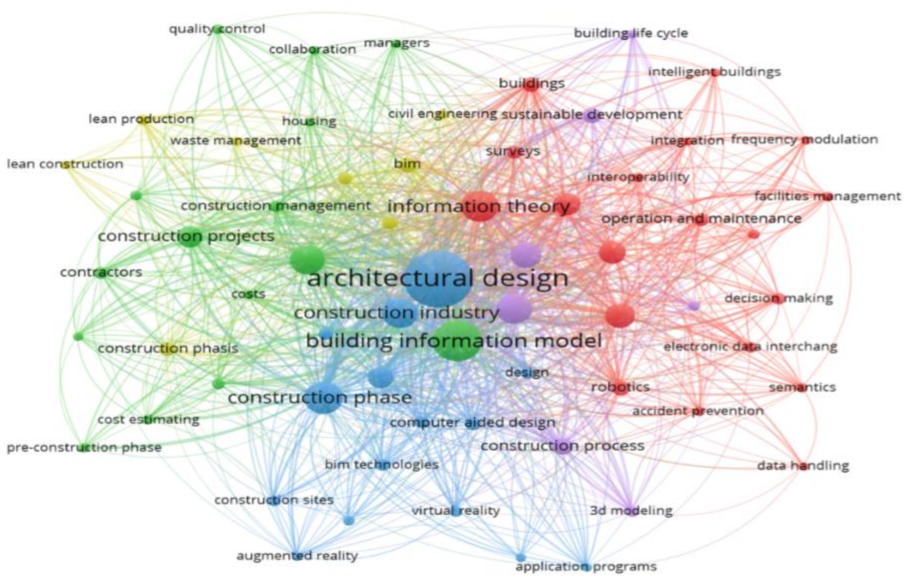

FIG. 5: Network of co-occurrence keywords.

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4.3 Network of Author Co-citation

Author co-citation analysis is used to evaluate the evolution of research communities by identifying linkages between authors whose publications are mentioned in the same article. Figure 6 shows the author's co-citation network, which has 929 linkages and a total link strength of 26288. Initially, 6499 authors were found in the 409 documents that were recovered. Thereafter, inclusion criteria were set at a minimum of 35 citations for an author. Forty-four authors met this threshold. Authors are frequently co-cited in some documents; the authors total link strengths ranged from 510 to 3904. The link reflects the connection between the authors co-cited in one or more documents. The links between authors do not represent indirect cooperative relationships. Authors were grouped into four clusters, differentiated by colours. The colours indicate the cluster to which they belong. Cluster 1 (red zone) had 15 authors, cluster 2 (green zone) had 12 authors, cluster 3 (blue area) had nine authors, and cluster 4 (yellow zone) had eight authors. Hence, Figure 6a (red) shows the network linkage of the authors in cluster 1, with Eastman, C. being the most cited author with 43 links, 2112 total link strength and 160 citations. Figure 6b (green) shows the network linkage of the authors in cluster 2, with Wang, X. being the most cited author with 43 links, 2421 total link strength and 147 citations. Figure 6c (blue) shows the network linkage of the authors in cluster 3, with Sacks, R. being the most cited author with 43 links, 3904 total link strength and 244 citations. Figure 6d (yellow) shows the network linkage of the authors in cluster 4, with Akinci, B. being the most cited author with 43 links, 2240 total link strength and 114 citations.

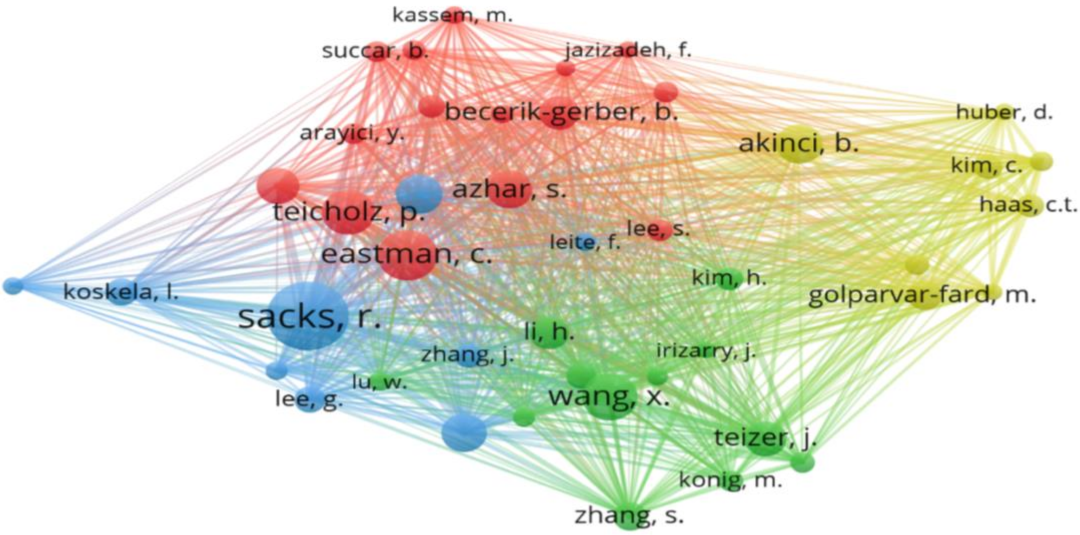

FIG. 6: Author Co-citation mapping.

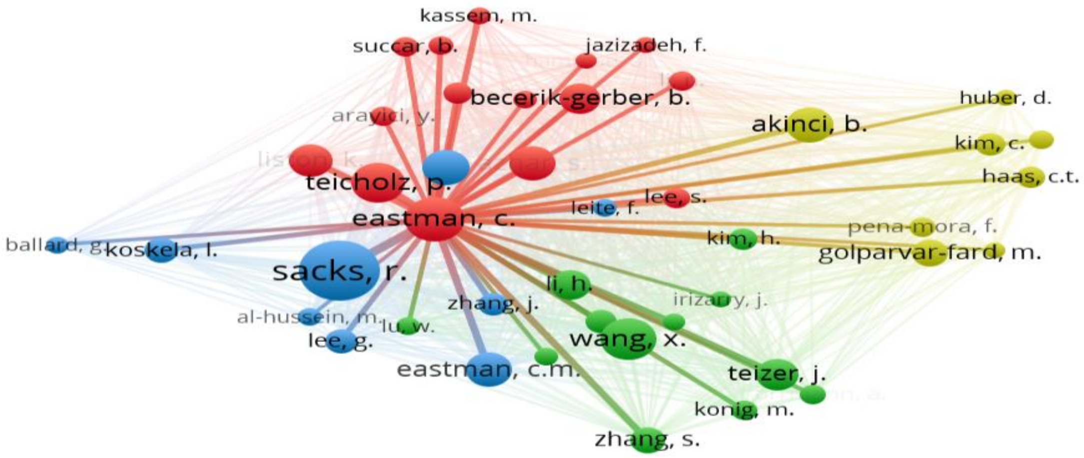

FIG. 6: Cluster 1.

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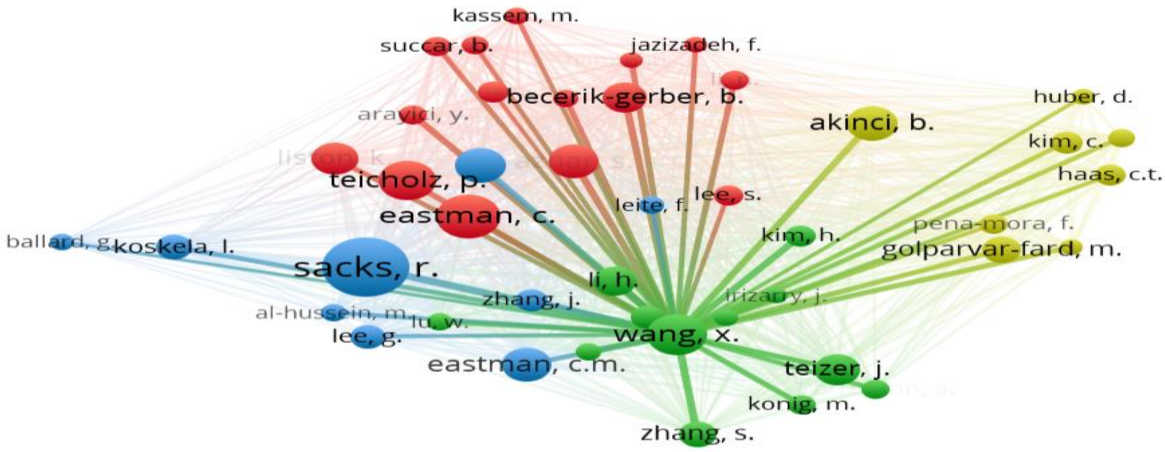

FIG. 6b: Cluster 2.

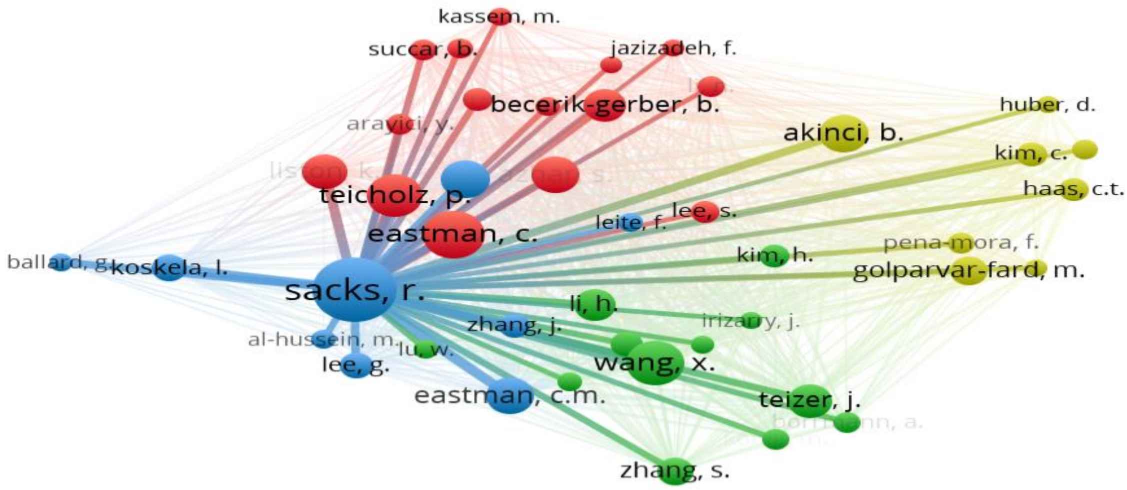

FIG. 6c: Cluster 3.

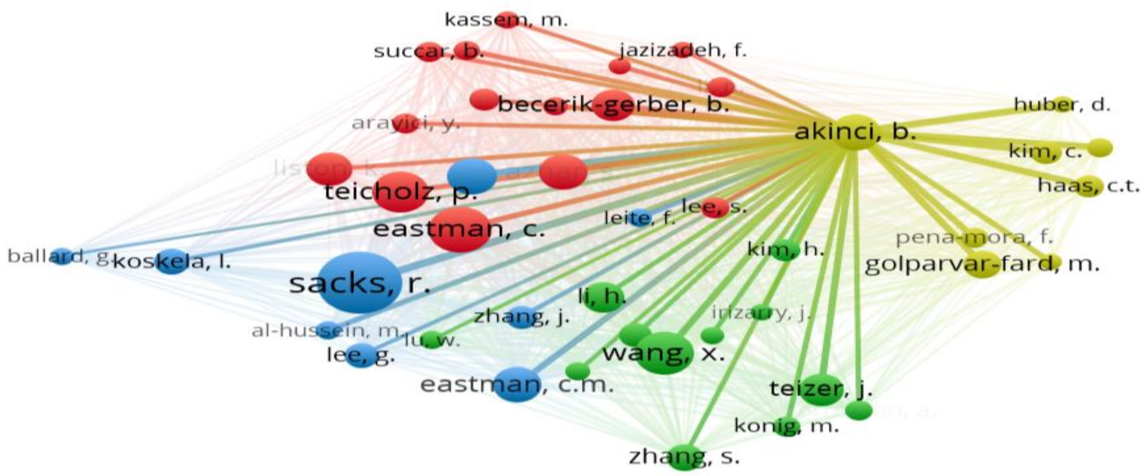

FIG. 6d: Cluster 4.

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4.4 Citation per source

This section unveils the contribution of the various sources from which the documents emanated, as seen in Figure 7. Two hundred-two sources were initially found. Inclusion criteria were set to identify the most contributing sources. The minimum number of documents from a source was set to 1, and the minimum number of citations per source was set to 105; nine sources met this threshold. Whereas automation in construction, with 24 documents and 1126 citations, was seen as the most contributing document source, while the least contributing document sources were the Journal of Cleaner Production and Journal of Management in Engineering, with 3: 123 and 4:110 document and citations, respectively.

Furthermore, the Journal of Construction Engineering and Management and the Journal of Construction Innovation had six documents, each with 445 and 109 citations, respectively. The trio of journals: the Journal of Civil Engineering and Management; the Journal International Archives of Photogrammetry; and the Journal Engineering, Construction, and Architectural Management had seven documents, each with 210, 139, and 108 citations, respectively. In addition, Proedria Engineering had eight papers with 136 citations.

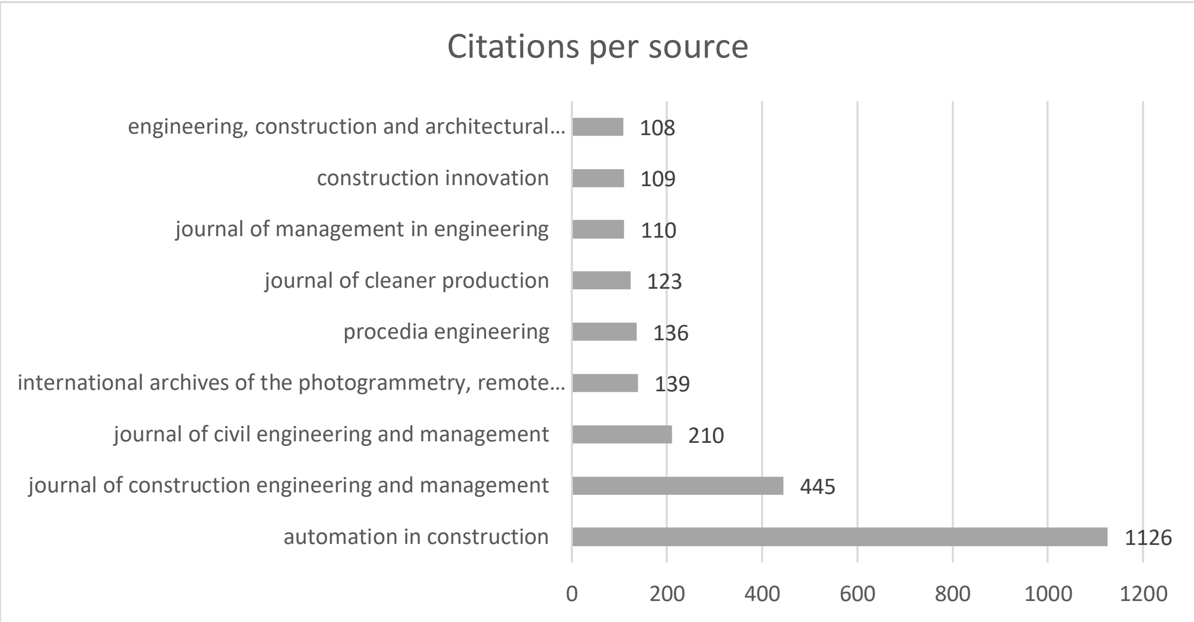

FIG. 7: Citation per source.

4.5 Citation and publication per country

This section provides a breakdown of the citations and publications per country as extracted from the 409 documents used in the bibliometric network analysis. Evaluating the citations and publications per country in this study is important; this reviews the country with more research interest. A total of 54 countries were involved. The inclusion criteria were set at a minimum of one document and a minimum of citations. Twelve countries fell within this threshold, with the following citations and publications: the United States, 1619 citations and 78 articles, China 695 citations and 62 articles; South Korea, 479 citations and 26 articles; Italy, 439 citations and 36 articles; United Kingdom 439 citation and 35 articles; Taiwan 252 citations and 28 articles; Australia 218 citations and 15 articles; Germany195 citations and 25 articles; Hong Kong 171 citations and nine articles; Egypt 136 citations and six articles; Spain 129 citation and 11 articles; and Finland 124 citations and five articles. Figure 8 shows the graphical mapping. These indicated that the United States is the most cited and contributing country, followed by China in the context of this study. While Hong Kong, Egypt, Spain, and Finland have fewer citations and documents. The increased use of BIM within the construction industry globally indicates that BIM is becoming more widely acknowledged.

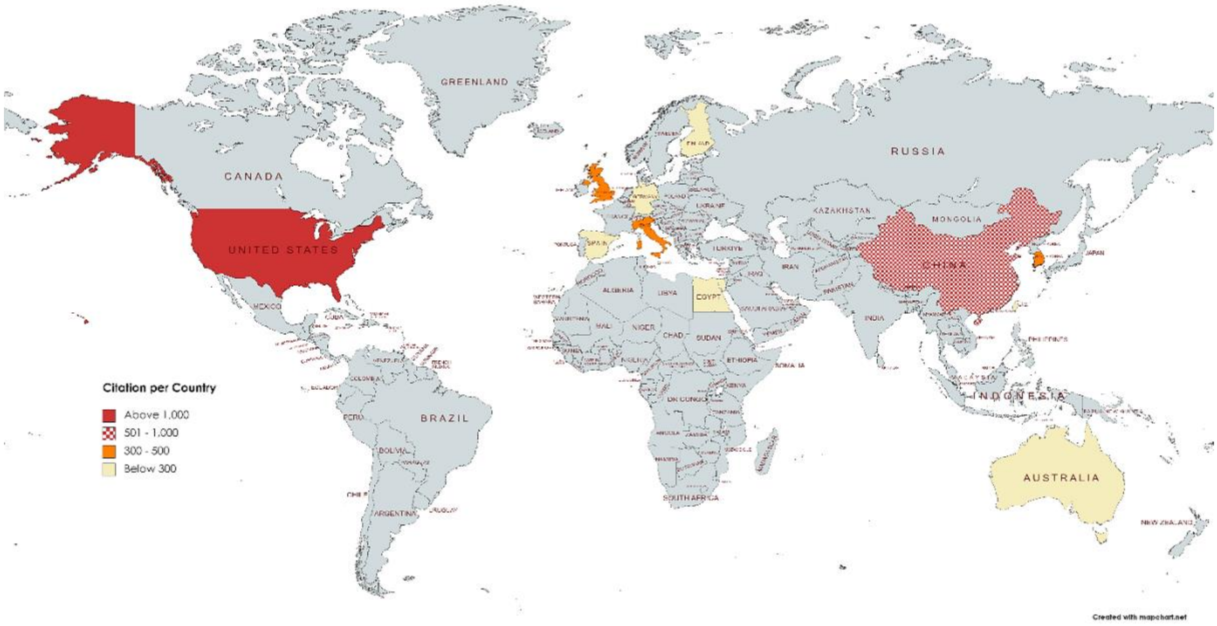

FIG. 8: Citation per country.

5. CONCLUSIONS AND SUGGESTIONS FOR FUTURE STUDIES

This study systematically evaluates articles related to BIM with a focus on the construction phase, from which BIM contributions and uses were drawn. Subsequently, publication trends and bibliometric network analysis were investigated. The findings revealed the various uses and contributions BIM has brought to the AEC industry by integrating different models and frameworks. We found that the BIM models and framework enable professionals to simulate each stage of the construction process, allowing the display of a virtual representation of the building and site, visualizing the progress and management of construction work, enhancing communication and collaboration among the stakeholders, supporting the Quantity Surveyour's quick generation of reliable and accurate cost estimates, assist in the fast realization of ROI and aiding optimal safety on-site, among other uses and contributions. The bibliometric analysis disclosed the contributions of various scholars (authors), countries, document sources, and trends in the network of keywords over time.

Based on this study's findings, the following gaps and suggestions for future studies could be drawn:

- BIM integration for supply chain management during the construction phase is still missing. This needs urgent investigation. The integration may assist in adequately coordinating the building resources.
- Validation of the highlighted uses and contributions of BIM in the AEC industry by seeking the viewpoints of BIM experts and construction firms in the AEC industry should be investigated.
- Scholars should collaborate with BIM experts and AEC professionals to investigate BIM use for material management, safety control and workforce monitoring through real-life case studies.

The study is limited to analyzing published articles from 2008 to 2022 on BIM with a focus on the construction phase from which the contributions and uses of BIM in the AEC industry were drawn.

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