A Literature Review on Digital Transformation in the Construction Industry

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Abstract

Purpose: The goal of this study is to systematically examine research reference trends related to digital transformation in the construction industry from 2016 to 2022. This research will focus on the development trend of digital transformation research in the construction industry on Google data-based scholar.

Design/methodology/approach: A mixed method approach was used in this study, combining bibliometric methods and a literature review. From 2016 to 2022, 43 international publications with the keyword digital transformation in the construction industry were sourced from the Google scholar database via web scraping.

Findings: According to the findings of this study, studies on digital transformation in the construction industry are dominated by several fields of study such as architecture, construction, management, engineering, digital technology, hotel industry, industry policy, financial, business, and economy. According to the findings of this study, there are at least four major perspectives that are commonly used when discussing digital transformation in the construction industry. However, this does not imply that no other perspectives are used in addition to these findings.

Research limitations/implications: The research's limitation is the scope of the articles used, which were sourced from the Google Scholar database. The recommendations in this study can be used as hypotheses in the future, in addition to research with broader literature sources, and comprehensive and in-depth follow-up research can be conducted. The study's findings are expected to be useful to academics researching digital transformation in the construction industry.

Keywords
digital transformation, construction industry, systematic review, bibliometric analysis, google scholar database

1. Introduction

Digital transformation is unavoidable in the 4.0 industrial era. The Covid-19 pandemic has also aided in the acceleration of digitalization for economic growth. As a result of regulatory, customer, and competitor pressure, digital transformation has become a must for organizations today. The process of using information and communication technology to make changes to the process of community, business, and government activities in conducting business processes is known as digital transformation. Furthermore, digital transformation is a process that seeks to improve an entity by causing significant changes in its properties through the use of information technology, computing, communication, and connectivity (Vial 2019). According to Verina and Titko (2019), there are three dimensions of digital transformation: technology, processes and management, and people. Meanwhile, according to Brynjolfsson and Hitt (2000), digital transformation can improve organizational performance by providing product or service offerings that can adapt to customer desires, increase customer satisfaction, and reduce costs. Change and transformation are fueled by digital technology and built on it. Digital transformation is defined within an enterprise as an organization's shift to big data, analytics, cloud, mobile, and social media platforms. While organizations continue to transform and evolve in response to changing business landscapes, digital transformation is a change that is built on the foundations of digital technology and ushers in distinct changes in business operations, business processes, and value creation (Nwankpa and Roumani 2016).

Verhoef et al. (2021), on the other hand, identified three stages of digital transformation: digitization, digitalization, and digital transformation. Digitization is defined as the process of converting analog data into digital data (Verhoef et al 2021, Bumann and Peter 2020). Digitization is mostly about data and various converters (Savic 2019). People who are affected by digitization and digitization are given more attention in digital transformation (KUMARI 2021; Turkova et al. 2020; Lee 2020). This transformation process necessitates the integration of traditional business processes with digital businesses. The increasing customer demand for speed of service, which results in sophisticated applications, is one of the triggers for digital transformation. For example, digital can be used to order food, book a reservation, or purchase a new car. Digitization typically digitizes internal and external documentation processes but does not affect value creation activities (Verhoef et al. 2021).

Digitalization refers to the use of information technology or digital technology to alter existing business processes (Owusu et al. 2022; Prebanić and Vukomanović 2021; Hewavitharana et al. 2021). The focus of digitalization is on the automation of various business processes and operations, as well as on information processing (Savic 2019). Companies use digitization to optimize existing business processes by enabling more efficient process coordination and/or by creating additional customer value through improved user experience. The use of digital technology and digitized data alters how a business interacts with its customers. In this case, the role of IT is critical in developing a digital tool that will result in a new strategy for digital business implementation. Purchasing a product, for example, could previously only be done directly. With digitalization, everything becomes digital, making it easier to purchase a product using only digital tools. As a result, digitization includes not only cost savings but also process improvements that can improve customer experience (Verhoef et al. 2021). Digital transformation is a company-wide phenomenon with broad organizational implications, in which digital technology can change a company's core business model (Chiew 2022; Xia 2022; Casini 2021, Cherian and SJ 2021). Doing things differently, creating entirely new business models using modern information and computer technology, is what digital transformation is all about. Digital transformation makes use of existing knowledge to profoundly transform the essence of an organization, its culture, management strategy, technology mix, and operational arrangements (Savic 2019). Companies seek and implement innovative business models in their pursuit of digital transformation.

The construction industry is one that will undoubtedly be impacted by digital transformation. However, digital adoption in the construction industry has been much slower than in other industries. Cost efficiency and productivity, quality improvement, and time accuracy have always been challenges in the construction industry from year to year (Intakindo 2022). The Construction Digitization Era is one of the most recent construction sector breakthroughs. Construction digitization refers to construction development activities that use innovative, creative methods that are easily understood by service users and facilitate construction as well as internet-based and big data integration. BIM is one application of construction digitization (Building Information Modeling). BIM is currently leading the way for the construction industry to enter the digitalization era.

BIM is a collection of technologies, processes, and policies that work together to create a digital model. Obviously, translated as a three-dimensional image, with data related to quantity, price, and schedule for all elements in the image. Furthermore, BIM enables project participants to collaborate, optimizing HR productivity and project activities quickly, precisely, accurately, effectively, and efficiently throughout the building's life cycle. The preceding context demonstrates how important digitization is in the construction industry. Based on this phenomenon, the purpose of this study is to systematically examine research references related to digital

transformation in the construction industry from 2016 to 2022. This study will specifically look at the development trend of digital transformation research in the construction industry using data from Google Scholar.

2. Literature review

2.1. Digital Transformation

Verhoef et al. (2021) identify three major reasons why businesses must transform digitally: changes in digital technology, increased digital competition, and changes in consumer behavior in response to the digital revolution. Digital transformation is also thought to be capable of assisting an organization in gaining a competitive advantage. According to Morakanyane et al. (2017), one of the effects of digital transformation on an organization is the development of competitive advantage. They also state that digital transformation must be viewed as a comprehensive organizational approach, rather than simply changing form to online or analog to digital. Digital transformation is viewed as a never-ending process.

2.2. Bibliometric analysis and literature review

Bibliometric analysis is a quantitative method for analysing bibliographic data in articles/journals. This analysis is commonly used to investigate references to scientific articles cited in a journal, map the scientific field of a journal, and categorize scientific articles according to a research field. This method is applicable in sociology, humanities, communication, marketing, and management, among other fields. In bibliometric analysis, the citation analysis approach is used to find one article cited by another, whereas the co-citation analysis approach is used to find two or more articles cited by one. The words used in a document (co-words) can reveal the scientific concept contained within it. The co-occurrence of words or keywords in two or more documents used to index documents is the basis for co-word analysis (Effendy et al. 2021). While the literature in this study is based on data from Scopus publications, it is critically reviewed using a literature review approach. This research method is a critical analysis method used to conduct research on specific topics, in this case innovation management theory, by utilizing various literature sources (Knopf, J. W. 2006; Randolph, J. 2009; Booth, A., Sutton, A., and Papaioannou, D. 2016). This method is widely used in a variety of fields, including economics, management, and information technology.

3. Method

A mixed method approach was used in this study, combining bibliometric methods and a literature review (see Figure 1). From 2016 to 2022, this study makes use of international publication data from the Google scholar database with the keyword digital transformation in the construction industry (see Figure 2).
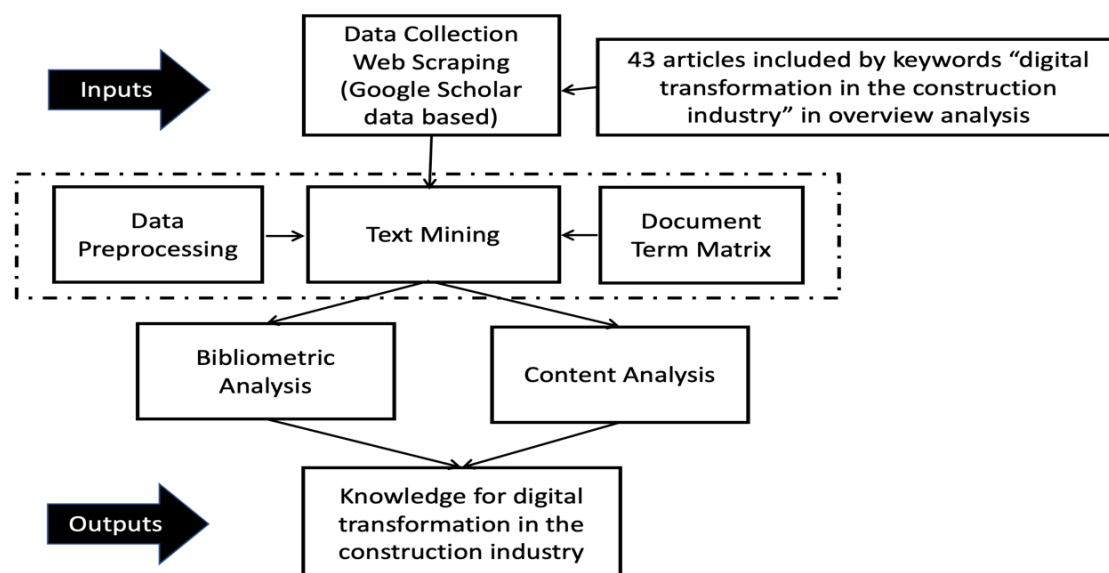

Figure1. Literature review and bibliometric flow chart. Source: The author's own study, 2022

Litmaps was also used to examine data on the number of publications per year, journals with articles, authors, and topics. In addition, VOS viewer software is used to analyze the development trend of international publications,

followed by qualitative content analysis. VOS viewer is software for creating and visualizing bibliometric networks. Individual journals, researchers, or publications can be included in these networks, which can be built on citations, bibliographic aggregations, co-citing, or co-authoring relationships. Text mining functionality is also included in VOS viewer for creating and visualizing co-occurring networks of key terms from scientific literature.

4. Result and discussion
4.1. Corpus profile
According to the context, Figure 1 depicts the number of articles used in this study. According to the review, digital transformation studies in the construction industry grew steadily between 2016 and 2022. Despite being less well-known than the topic of digitalization research in other industries. This distribution trend, on the other hand, suggests that academics or researchers in the construction sector are paying more attention to this topic. Despite the fact that only one article has been published each year since 2016 and 2017, This trend, however, accelerated in 2018, with four articles. Meanwhile, in 2019, the increase was approximately 25%, or 5 articles. The following year, the increase was 60%, or eight articles. According to reports, the year 2021 will be the most productive, with the number of articles in this context reaching 21 and increasing by 150 percent. Despite the fact that this data was collected in the middle of the year, only three references were discovered in 2022. This data indicates that, in general, the trend of research in this field is steadily increasing. The distribution of literature on the topic of digital transformation in the construction industry is depicted in the Figure 2 below.
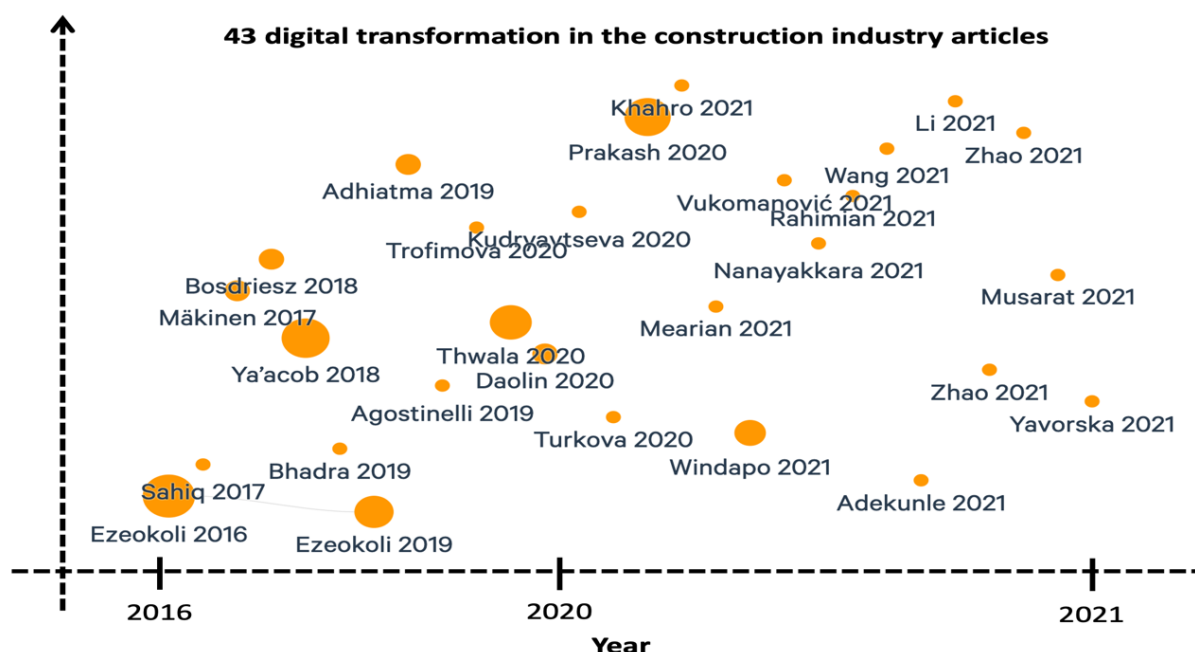

Figure 2. Distribution trend of scientific literature digital transformation in the construction industry period 2016-2022. Source: The author's own study, 2021

Figure 1 shows that research on digital transformation in the construction industry is becoming a popular topic among researchers and academics. At least, this is demonstrated by the distribution, which continues to rise year after year. However, based on the network of articles, the picture shows that there are several researchers or articles that receive adequate attention or are widely cited by other authors. "Strategizing for digital transformation: a case study of the digital transformation process in the construction industry," "State of readiness of the Nigerian construction industry towards digital transformation: The construction professionals' perception," and "Digital transformation using blockchain technology in the construction industry" are among these articles. Nodes or circle illustrations in each article are fairly uniform in size, though some appear larger than others but are not significant. Some references have a relationship or cite each other, demonstrating the relationship between the articles. This relationship demonstrates that this scope is discussed on a regular basis. This correlation is critical for an issue in order for it to be studied thoroughly and integrated from various perspectives or fields of science.

4.2. The current trend of digital transformation in the construction industry research
In addition, the content of the articles or references used will be scrutinized, especially in terms of title and context. During this phase, the entire literature will be analyzed and classified as a text or corpus based on topic and context.

This review uses DTM as the text mining process's output, which is visualized and analyzed qualitatively with VOS viewer.

4.3. The most recent publication in the field of digital transformation in the construction industry.

43 publications were obtained based on Google scholar data search results for the keyword digital transformation in the construction industry with the categories of article title, abstract, and keywords from 2016 to 2022. It is known that the most publications at ICCREM 2021 published references related to digital transformation in the construction industry, with as many as three articles being published. Meanwhile, the IOP Conference Series and the Journal of Engineering Research both have articles with up to two references on this topic. Table 1 displays research on the advancement of digital transformation in the construction industry published in the three most prestigious journals, as shown below.

Table 1. Top 3 latest journals in the scope of digital transformation in the construction industry period 2016-2022. Source: The author's own study, 2022

No.	Journal Name	Number of articles
1	ICCREM 2021	3
2	IOP Conference Series	2
3	Journal of Engineering Research	2

Table 1 shows that the majority of the journals that discuss the issue of digital transformation in the construction industry have a background or scope of science and engineering. According to this data, there is no dominant journal or publisher discussing digital transformation in the construction industry. This means that research in this area is still dispersed across different journals or publishers. What this review reveals is that digital transformation in the construction industry, whether in theory or in practice, is frequently discussed through various scientific backgrounds. This finding also indicates that this context requires additional attention in terms of research management.

4.4. Comprehensive network analysis of digital transformation in the construction industry research

During this session, all articles will be bibliographically analyzed using the VOSviewer tool. The network and density of articles will be visualized in this analysis. Figure 3 shows that the development map of the field of digital transformation in the construction industry from 2016 to 2022 can be divided into 24 clusters based on co-word analysis.

Aec, ac industry, architecture, assessing digital transformation, bim gis adoption, building industry, construction, construction supply chain management, digital transformative tool, digitized design, drone, engineering, engineering industry, integrated, logistics, new tool, proposition, supply chain, Swedish aec industry, topic, virtual design, and virtual reality are among the 22 topic items in Cluster 1. Cluster 2 is shown in green and includes 18 topic items such as Concept, construction market, construction organization, construction profession, construction supply chain, development, digital economy, feature, formation, hybrid cloud approach, ibm, Nigerian construction industry, open built, own transformation, partner, readiness, state, and successful company. Attention, case, catalyst, China, countermeasure, difficulty, digital technology, dilemma, hotel industry, hotels industry, industry policy outlook, influence, management change, organization, shen, survey, and technology platforms are among the 17 topic items in the yellow cluster 3. Cluster 4 is a bright yellow cluster with 15 topic items such as advanced digital transformation technology, challenge, decline, fall, financial crisis, gas extraction industry, impact, labor productivity, Malaysian construction industry, impediment, Oil, production volume, prospect, role, and world oil prices.
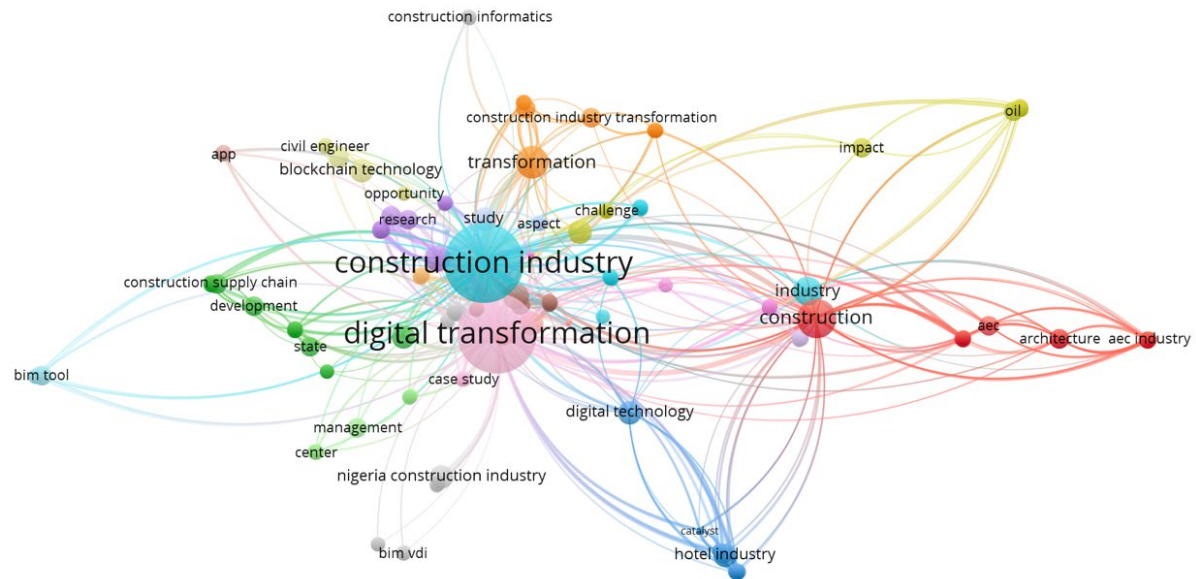
Figure 3. Text network analysis of digital transformation in the construction industry research.
Source: The author's own study, 2022

Acceptance, advancement, development situation, digitalization, knowledge, lack, main problem, model, research, technology, unified theory, use, user, and link comprise Cluster 5. Cluster 6 is light blue in colour and contains 13 topic items such as conceptual framework, construction industry, CSCM, Industry, investigation, it digital transformation, lot digital transformation, potential business, status, supply chain management, technology opportunity, theoretical foundation, and white papers. Cluster 7 is yellow and includes 12 topic items such as Barrier, construction industry transformation, digital construction collaborative innovation teaching system, digital divide, digital future, equity, gap, major, practice, reconstruction, transformation, and upgrading. Cluster 8 is light yellow and contains 11 topic items: analysis, guidance, building information modelling, construction stakeholder, keyword, Malaysia, post, potential, pre-construction, review, and segment.

Cluster 9 is purple, and it contains ten topic items: Basis, building information model cantered big data platform, digital information, Dutch construction company, exploration, medium, reference, smart industry, transition, and upgrading path. Cluster 10 is a light yellow cluster with ten topic items that include 3ds, Application, construction management, content, digitization, disparity, engineering management, information technology, order, and tools. Cluster 11 is yellow, and it contains nine topic items: Centre, company, digital transformation project, enterprise, innovative activity, management, methodology, modern condition, and Russian. Cluster 12 is light yellow in colour and contains eight topic items: Aspect, benefits, bibliometric review, construction firm, fourth industrial revolution, Nigeria, scorecard, and study.
Cluster 13 is blue, and it contains eight topic items such as blockchain technology, civil engineering, high productivity, ice, institution, London, opportunity, and productivity. Cluster 14 is light yellow and contains seven topic items: advanced technology, aeco industry, comprehensive guidelines, new opportunities, ongoing digital transformation, operation, and tools. Cluster 15 is green and is made up of seven topic items: guidance tool, clear line, construction industry implementation, digital tool, organizational structure, report, and value. Cluster 16 is a light-yellow cluster with seven topic items: digital meetings, hot topics, needs, project platforms, stakeholder management, systematic reviews, and web.

Cluster 17 is green and includes six topic items: App, cohort, construction technologies, new digital technology firm, Russian construction industry, and significant growth potential. Cluster 18 is purple, and it contains five topic items: case studies, digital strategy, digital transformation, digital transformation, and traditional industry. Cluster 19 is green and is made up of four topic items: construction informatics, digital delivery, IDD, and productive technology. Cluster 20 is purple and contains four topic items: construction profession, extent, Nigeria construction industry, and professionals' perspective.

Cluster 21 is purple, and it contains three topic items: bim vdi, blatt, and the construction industry first guideline. Cluster 22 is a light yellow cluster with three topic items: construction industry economy, context, and innovative development. Cluster 23 is light yellow in color and contains three topic items: e-commerce, potential, and

prospective assessment. Cluster 24 is light yellow in colour, consisting of two topic items including digital architecture and thought.

The network analysis results are depicted in Figure 4, which show that the correlation between nodes was divided into eight network clusters. Inner cores are clusters with a high number of nodes and heavy edges. This cluster is a visual representation of the most frequently discussed issues in the construction industry regarding digital transformation. An outer core, on the other hand, is a cluster with a low node occurrence frequency and a low edge weight. This cluster represents the issues that receive the least attention in the literature on digital transformation in the construction industry.

This review also shows that the weights of nodes and edges in the inner core network vary, as shown by the size scale of circles and connecting lines. The thicker the line connecting the two nodes and the larger the circle, the greater the weight or degree. Large-scale nodes and edges, it can be said, are frequently discussed issues at the heart of the topic of digital transformation in the construction industry. Labeling each node, as indicated by the identity token, emphasizes this visualization. These tokens or nodes represent topics that have received significant attention in the literature.

According to the definition, digital transformation is the conversion of analog processes to digital processes through the use of technology. In the digital world, digital transformation refers to how new areas of technology such as machine learning, big data, and the internet for everything are revolutionizing business. In the business world, this type of digital transformation has transformed client engagement, commerce, marketing, and other areas. The visualization of the network analysis above is contextually related to the application or implementation of digital transformation in the construction industry, based on this concept. As a result, some of the nodes that appear are associated with the digital transformation and the construction industry.

The VOS viewer tool also visualizes density-based analysis. This means that based on the color density in the visualization area, this illustration will make it easier to identify the contexts that are most frequently studied.
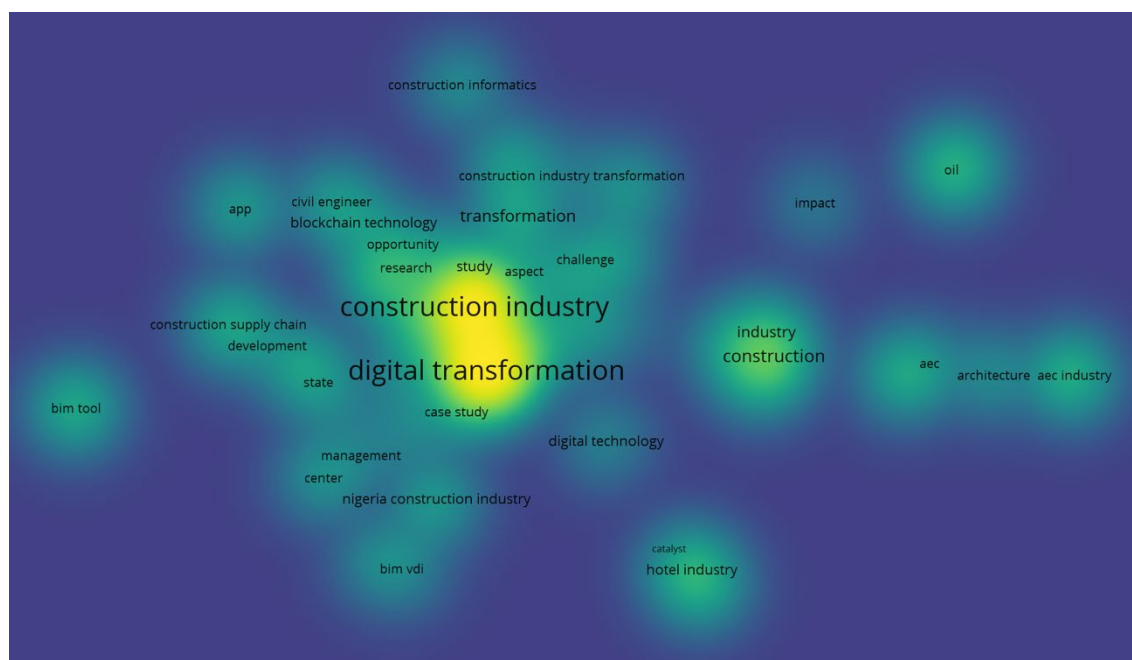

Figure 4. Density analysis of digital transformation in the construction industry research.
Source: The author's own study, 2022

The review provides some critical information that can be classified into at least four major issues. First, based on the research location, it's worth noting that the majority of the countries or cities that have served as research locations in the last six years have been Sweden, Nigeria, China, Malaysia, London, the Netherlands, and Russia. Meanwhile, based on the research approach used, the results of data analysis show that the majority of the research employs an empirical study approach and a case study. The selected locations are generally objects that implement

digital transformation in the construction industry or locations that have been assessed or analyzed as having the potential to implement digital transformation in the context of the construction sector. Comparative analysis and causal relationships are two examples of research methods used. In other words, some studies compare the loci under study to objects that have successfully implemented digital transformation. Furthermore, several studies have been conducted to examine the impact of implementing digital models on a variety of factors, including efficiency and productivity. In this field, descriptive qualitative methods are still the most commonly used approach. Although quantitative methods are still used, particularly in case studies to assess the success of digital transformation.

Third, in terms of context or research scope, studies related to include architecture, construction, management, engineering, digital technology, hotel industry, industry policy, financial, business, and economy. According to the findings of the review of the field of study, this issue is frequently studied across a wide range of scientific disciplines. In other words, the context of this study is multidimensional or cross-disciplinary. As a result, when studying digital transformation in the construction industry, some researchers take multiple approaches.

Fourth, according to the review's findings, the following issues are frequently raised: BIM GIS adoption, building industry, construction supply chain, digital transformative tool, digitized design, engineering industry, virtual design, virtual reality, construction market, construction organization, construction profession, digital economy, hybrid cloud approach, IBM, management change, technology platform, advanced digital transformation technology, gas extraction industry 3D's, Application, engineering management, bibliometric review, construction firm, fourth industrial revolution, blockchain technology, civil engineer, high productivity, AECO industry, organizational, innovative development, e-commerce, digital architecture and thought.

This study confirms that the visualizations that appear in network analysis are representations of issues that are frequently discussed based on the topics that are frequently researched. However, this review does not argue that low frequency is a minor issue. On the other hand, perhaps these issues (the outer core) are under-researched areas of study or approaches that are rarely used. This cluster may require additional attention in future research.

This study comprehensively and systematically formulates knowledge clusters that are frequently used to support studies related to digital transformation in the construction industry, based on the framing of network analysis contexts and supported by various digital transformations in the construction industry literature. The results of the analysis are shown in the Table 2 below.

Table 2. Perspectives and variables on the concept of digital transformation in the construction industry.
Source: The author's own study, 2022

Main Concept	Digital transformation in the construction industry			
Perspective	Architecture, construction, management, and engineering	Business, economics, finance and hospitality	Industry policy	Digital technology
Variable	Integrated 4D BIM-GIS Adoption, Construction supply Chain Management, Stakeholder Management, innovative activity, modern conditions, Engineering Management, Course System	Innovative development, industry economy, Hotel Industry, Technology Platform, potential business	Manufacturing industry	Readiness, Organisational Structure, Value, Innovative development, Construction Industry empowering

According to Table 2, the review's findings revealed at least four major perspectives that were commonly used in discussing digital transformation in the construction industry. However, this does not imply that no other perspectives are used in addition to these findings. Of course, many unexplored perspectives remain unexplored because they are not dominant perspectives. This is especially true when one considers how some researchers tend to use multiple approaches. As a result of this analysis, the contexts that are frequently discussed are also interdisciplinary or multidisciplinary issues. This means that when discussing an issue, a study will typically employ more than one viewpoint.

5. Conclusion

Based on the findings and discussion of this study, it is concluded that the highest growth development in the topic field of digital transformation in the construction industry occurred in 2021, reaching 21 articles or an increase of up to 150 percent between 2016 and 2022. Furthermore, the review reveals that the majority of the journals that discuss the issue of digital transformation in the construction industry are science and engineering journals. This research also demonstrates that there is no dominant journal or publisher addressing the issue of digital transformation in the construction industry. This means that research in this area is still dispersed across different journals or publishers. Furthermore, development maps are classified into 24 clusters based on co-occurrence and keywords. This review, on the other hand, summarizes the research trend of digital transformation in the construction industry into four major issues.

First, based on the research location, it's worth noting that the majority of the countries or cities that have served as research locations in the last six years have been Sweden, Nigeria, China, Malaysia, London, the Netherlands, and Russia. Meanwhile, based on the research approach used, the results of data analysis show that the majority of the research employs an empirical study approach and a case study. The selected locations are generally objects that implement digital transformation in the construction industry or locations that have been assessed or analysed as having the potential to implement digital transformation in the context of the construction sector. Comparative analysis and causal relationships are two examples of research methods used.

In other words, some studies compare the loci under study to objects that have successfully implemented digital transformation. Furthermore, several studies have been conducted to examine the impact of implementing digital models on a variety of factors, including efficiency and productivity. In this field, descriptive qualitative methods are still the most commonly used approach. Although quantitative methods are still used, particularly in case studies to assess the success of digital transformation.

 Third, in terms of context or research scope, studies related to include architecture, construction, management, engineering, digital technology, hotel industry, industry policy, financial, business, and economy.

Finally, this study discovers that at least four main perspectives are dominantly used when discussing digital transformation in the construction industry. However, this does not imply that no other perspectives are used in addition to these findings. Of course, many unexplored perspectives remain unexplored because they are not dominant perspectives. This is especially true when one considers how some researchers tend to use multiple approaches. As a result of this analysis, the contexts that are frequently discussed are also interdisciplinary or multidisciplinary issues. The scope of the articles used, which were sourced from the Google Scholar database, is the research's limitation. In the future, it is strongly advised to conduct research using a broader literature source. Furthermore, the findings of this study can be used as hypotheses, and comprehensive and systematic follow-up research is being conducted. The findings of this study are expected to serve as a resource for academics researching digital transformation in the construction industry.

References

Booth, A., *Searching for qualitative research for inclusion in systematic reviews: a structured methodological review*. Systematic reviews, 5(1), 1-23, 2016.

Brynjolfsson, E., and Hitt, L. M., Beyond computation: Information technology, organizational transformation and business performance. *Journal of Economic Perspectives*, 14(4), https://doi.org/10.1257/jep.14.4.23, 23–48, 2000.

Casini, M., *Construction 4.0: Advanced Technology, Tools and Materials for the Digital Transformation of the Construction Industry*. Woodhead Publishing, 2021.

Cherian, T. M., and SJ, C. J. A., Digital Transformation in Supply Chain Management: A conceptual framework for construction industry. *Indian Journal of Economics and Business*, 20(3), 2021.

Chiew, W. J., Prospects and Challenges of Digital Transformation in the Malaysian Construction Industry (*Doctoral dissertation, Tunku Abdul Rahman University College*), 2022.

Hewavitharana, T., Nanayakkara, S., Perera, A., and Perera, P., *Modifying the Unified Theory of Acceptance and Use of Technology (UTAUT) Model for the Digital Transformation of the Construction Industry from the User Perspective. In Informatics* (Vol. 8, No. 4, p. 81), Multidisciplinary Digital Publishing Institute, December, 2021.

KUMARI, I., DIGITAL TRANSFORMATION IN CONSTRUCTION INDUSTRY (*Doctoral dissertation, Delhi Technological University*), 2021.

Knopf, J. W., Doing a literature review. *PS: Political Science & Politics*, 39(1), 127-132, 2006.

Lee, K. B., Readiness of Digital Transformation in Malaysian Construction Industry (Doctoral dissertation, UTAR), 2020.

Morakanyane, R., Grace, A. A., and Reilly, P. O., *Conceptualizing Digital Transformation in Business Organizations: A Systematic Review of Literature*. AIS Electronis Library, 2017.

Nurjanah, S., Peranan Manajemen inovasi dalam meningkatkan kinerja organisasi pendidikan. *In Conference in Business, Accounting, And Management (CBAM)* (Vol. 2, No. 1, pp. 27-33), May 2015.

Owusu, E. K., Chan, A. P., Chen, L., and Amoah, P., Digitization, Digitalization, and Digital Transformation (3Ds): Explicating the Disparities and Applications of the 3Ds in the Construction Industry. *In Construction Research Congress 2022* (pp. 161-170), 2022.

Prebanić, K. R., and Vukomanović, M., Realizing the Need for Digital Transformation of Stakeholder Management: *A Systematic Review in the Construction Industry. Sustainability*, 13(22), 12690, 2021.

Randolph, J., *A guide to writing the dissertation literature review. Practical Assessment, Research, and Evaluation*, 14(1), 13, 2009.

Tidd, J., and Bessant, J. R., *Managing innovation: integrating technological, market and organizational change.* John Wiley & Sons, 2020.

Turkova, V. N., Archipova, A. N., and Fedorovna, Z. G., Digital transformation of the Russian construction industry. *In IOP Conference Series: Materials Science and Engineering* (Vol. 880, No. 1, p. 012083), IOP Publishing, June, 2020.

Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., and Haenlein, M., Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122 (July 2018), https://doi.org/10.1016/j.jbusres.2019.09.022, 889–901, 2021.

Verina, N., and Titko, J., Digital transformation: conceptual framework. *Vilnius Gediminas Technical University*, https://doi.org/10.3846/cibmee.2019.073, May, 2019.

Vial, G., *Understanding digital transformation. Managing Digital Transformation*, https://doi.org/10.4324/9781003008637-4, 13–66, 2019.

Xia, Z., Xiaoling, J., Chengjie, L., Luyue, H., Zhaojun, R., and Na, L., *Reconstruction and Practice of Digital Construction Collaborative Innovation Teaching System under the Background of Construction Industry Transformation and Upgrading. Frontiers in Educational Research*, 5(3), 2022.

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