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DIGITAL TRANSFORMATION IN INDUSTRY 4.0: A BIBLIOMETRIC ANALYSIS

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Abstract:

The Fourth Industrial Revolution, or Industry 4.0, has been driven by technological innovations and advancements. Existing literature demonstrates how Industry 4.0's efficiency capabilities promote growth and advancement. A portion of the universal set is represented by the expansion of the building sector. Thus, Industry 4.0 has a direct impact on the engineering and construction sector of the gross domestic product value. The purpose of this study was to map the current state of Industry 4.0 in the construction sector, pinpoint its focal points, and assess and scrutinize the available information. Scopus search was limited to the period between January 2019 and 2024. The terms "Industry 4.0" or "Industrial Revolution 4.0" AND TOPIC: "building" or "construction" had to be present in the search. A digital transformation framework can serve as a strategic roadmap for organizations. Organizations can use a digital transformation framework as a strategic guide to organize, carry out, and convey their efforts to adjust to the digital. The framework aims to offer organizations working in the digital economy a reproducible repositioning strategy, strategic planning, and implementation process. It provides a framework for continuously adjusting capabilities and offerings to meet shifting customer needs and strategic goals. In addition to increasing efficiency and streamlining company processes, a robust foundation for digital transformation facilitates constant communication amongst all business divisions. Organizations starting the process of digital transformation must have the proper mentality in order to change and grow.

Keywords:

Innovation; Industry 4.0; Digital; Framework

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Introduction

Industry 4.0,Digital Transformation Framework for the Fourth Industrial transformation, requires a transformation in modern building practices. The construction sector is about to enter a revolutionary era as the convergence of digital technology and sector 4.0 principles. After the Fourth Industrial Revolution, the construction sector must adopt a comprehensive digital transition formation framework. This paper offers a high-impact research evaluation of the application of Industry 4.0 technologies in the construction sector with the goal of enhancing productivity, sustainability, and creativity (W. S. Alaloul, et al. 2019). The construction business, which has always been associated with manual operations, is facing increasing difficulties in keeping up with the needs of a world that is changing quickly. A strong framework for digital transformation is needed to overcome these issues.AI and Machine Learning (ML). AI and ML algorithms empower construction processes by analyzing vast datasets to derive meaningful insights. Predictive analytics can optimize project scheduling, resource allocation, and risk management. AI-driven systems can also enhance safety by identifying potential hazards and implementing proactive measures. The construction business, which has always been associated with manual operations, is facing increasing difficulties in keeping up with the needs of a world that is changing quickly. A strong framework for digital transformation is necessary to handle these issues. The main objective is to smoothly incorporate cutting-edge technology into construction processes, like robots, artificial intelligence (AI), building information modeling (BIM), and Internet of Things integration. Because it connects devices and machinery and permits real-time data sharing, Industry 4.0 relies heavily on the Internet of Things (IoT). Constructing machinery with integrated smart sensors can provide invaluable insights on site conditions, equipment health, and usage patterns. This real-time data aids in predictive maintenance, which reduces downtime and boosts overall project performance, according to L. Stojanovska - Georgievska et al. (2022). The aim of this paper is to investigate the research dynamics related to digital transformation in Industry 4.0 in particularlly, the research questions of this study as below:

RQ1: What is the trend of research in digital transformation according to the year of publication?
RQ2: What are in general upward trend in number of publication yearly?
RQ3: Which the most frequent document by subject area?
RQ4: Which document by countries contribute significantly to the study on digital transformation?
RQ5: What are the most influential publications of network visualization map of keywords' co-occurrence?

Literature Review

The term "industry4.0" recently gained popularity to describe the trend in the industrial world toward automation and digitization. Considering the quick advances utilized in other industry sectors and COVID-19, which surely increased the urgency of this duty, the building industry is sluggish to incorporate these revolutionary changes into its normal procedures when compared to other industries' innovations. The construction industry faces numerous obstacles that hinder the adoption of Industry 4.0, despite the technology's many benefits and prospects. These obstacles stem from a range of issues. The construction sector would push the sector's performance to par with those of its manufacturing and automotive counterparts. Industry 4.0 has to be accepted since it is the way of the future. There's no substitute for digitalization. Meanwhile, BIM facilitates collaborative planning and design by acting as the digital

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framework of construction projects. By enabling stakeholders to produce an intricate three-dimensional model of the project, it promotes efficient collaboration and communication. Throughout the course of a project, BIM also helps with cost optimization, clash identification, and better decision-making (L.Stojanovska-Georgievska,*et.al*, 2022). Automation and robotics which is using robotics in construction processes greatly improves accuracy and efficiency. Robotics shortens project timeframes, decreases errors, and reduces labor-intensive jobs like automated bricklaying and autonomous vehicles for material transportation. There are several advantages to implementing an Industry 4.0 digital transformation framework in the building industry. Immediate benefits include increased output, enhanced project results, and decreased expenses. Furthermore, real-time resource use, trash reduction, and waste management monitoring make the incorporation of sustainable practices more practical.

Methodology
Bibliometrics is the process of organizing, combining, and analyzing bibliographic from scientific publications. It includes intricate methods like document co-citation analysis in addition to general descriptive data like publishing journals, publication year, and major. Domain of the bibliometric study . The literature review focuses on (i) digitalization as a concept and (ii) Industry 4.0 of digitalization on construction management. The aim of the literature review is to create a linkage between these concepts and indicate how digitalization impacts project management.

This study employed a screening sequence to determine the search terms for article retrieval. This study was initiated by querying the Scopus database with online TITLE-ABS-KEY ((era AND pandemic OR industry AND 4.0*) AND (digital AND transformation OR technology)), assembling 785 articles. Afterwards, the query string was revised so that the search terms most commonly co-occurring keyword search related to “Industry 4.0” OR “Industrial revolution 4.0” AND TOPIC “construction” OR “building”. This process yielded 785 results, which were additionally scrutinized to include only research articles in English and article reviews were also excluded. The final search string refinement included 785 articles, which were used for bibliometric analysis. As of December 2023, all articles from the Scopus database relating to learning and focusing on students were incorporated into the study.

TABLE 1
The Search String

Scopus	TITLE-ABS-KEY (era AND pandemic OR industry AND 4.0*) AND (digital AND transformation OR technology))

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Table 2
The Selection Criterion In Searching

Criterion	Inclusion	Exclusion
Language	English	Non-English
Timeline	2021 – 2023	< 2019
Literature type	Journal (Article)	Conference, Book, Review
Publication Stage	Final	In Press

Data sets containing the study publication year, publication title, author name, journal, citation and keyword in PlainText format were acquired from the period 2019 to December 2024 and were analyzed in VOSviewer software version 1.6.19. Using the VOS clustering and mapping techniques, this software was used for analysis and map generation. Van Eck and Waltman (2010) have proposed VOSviewer as a substitute for the Multidimensional Scaling (MDS) technique. Its goal is similar to that of the MDS technique, which is to arrange objects in low-dimensional spaces so that the relatedness and similarity of any two items are accurately reflected by the distance between them.Digital technologies in automation in construction, Digitalization in the Architecture, Engineering, and Construction (AEC) sector is slow due to significant challenges in technology adoption. The study aims to promote technology adoption by advancing the understanding of digital. This article presents the findings drawn from a quantitative scoping review that included 3,950 abstracts from the Scopus database that dealt with technology. This offers an initial evaluation of the volume of literature, geographical innovation hotspots, research lacunae, and major ideas in the AEC domain. Building information modeling (1,852 studies) appears to be the most popular topic in the literature, according to the results, but 3D printing (311) and the Internet of Things (227) are becoming more and more popular. The majority of research articles are produced in the United States (566 publications) and China (687 publications). Though there is a growing interest in developing technologies, putting them into practice frequently requires specialized skill sets. Therefore, increased emphasis on these technologies in the classroom and closer cooperation in the AEC sector are required from academia in the areas of digitalization, industry 4.0, technology, 3D printing, engineering education, architecture, engineering, construction sectors, and digital technologies. When studying the relevant literature, the components of Industry 4.0 are related to the fundamental procedures of Supply Chain Operations Reference (SCOR). Content studies were carried out in order to determine the primary contributions made by SCM elements, elucidate the mechanisms that support or incorporate SCM elements, and establish a connection between SCM elements and the fundamental procedures of the SCOR model. The elements of Industry 4.0 are connected to the core practices of Supply Chain Operations Reference (SCOR) when one studies the pertinent literature. A comprehensive survey of the literature led to the selection and examination of 293 publications. The main goals of content studies were to identify the contributions that SCM elements made, clarify the mechanisms that incorporate or support SCM elements, and establish a relationship between SCM elements. The assessment is an addition to the bibliographic database. Finding is the key components that contribute to SCM in the SCOR model's processes is another contribution. Large data, Industry 4.0, Internet of Things (IoTs), simulation, Industry 4.0 supply chain, and underpinning advanced technologies are becoming more and more important and are driving the digital transformation of businesses in a variety of industries. Simultaneously, a growing number of companies are adopting a temporary project-based approach to working, resulting in dynamic

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systems where projects serve as both strategy tools and process execution instruments for managing complicated business settings. Thus, it comes as no surprise that important that significant focus is being placed on the link between these concepts. With the aim of examining applications of digital technologies in project management, a comprehensive review was conducted on 188 academic articles published between 1991 and 2023 and indexed in the Web of Science database. The bibliometric method was used through co-occurrence, along with a visual representation of interconnected data. The findings drew focus on the most popular study areas in the fields of advanced project management in building projects, artificial intelligence and project success, managing information and production systems, and opportunities and challenges for project management in the digital era. The crucial significance of finding a balance between technology and interpersonal interactions to succeed in contemporary project management in the midst of the Industry 4.0 era is the last possible research topic. Two issues that need to be resolved for the AEC sector to have a prosperous future are causing a profound internal transformation. To be more precise, in order to lessen the substantial environmental effects that the AEC sector produces, its participants must dedicate themselves to sustainability. The AEC sector is experiencing sector need to commit themselves towards sustainability in order to reduce the significant impacts that the industry causes on the environment in terms of pollutant emissions. However, in order to increase their actual efficiency, work procedures need to be examined. As a result, the AEC sector's productivity rate is extremely low when compared to other industrial sectors. AEC actors are thinking about implementing Industry 4.0 more deeply in their companies in order to guarantee long-term company continuity based on the two pillars of productivity and sustainability. Indeed, it is acknowledged that Industry 4.0 technologies have a good effect on sustainability and operational performance in the AEC sector. As a result, it marks the beginning of the intriguing but little-used Construction 4.0 paradigm. Within this framework, the subsequent chapter endeavours to examine the modifications that some of Industry 4.0's most innovative and cutting-edge technologies provide in three stages of the building process. Hence, it determines the birth of the new Construction 4.0 paradigm, which is fascinating although scant adopted. In this context, the following chapter aims to analyze the changes that some of the most cutting-edge and revolutionary technologies of Industry 4.0 bring in three phases of the construction life cycle. Specifically, the chapter explores how such technologies allow the address of productivity and sustainability issues during the phases of architectural and design planning, works' execution, and support processes management, acting as levers for building more efficient and sustainable constructions.

Data Analysis

Data sets covering the period 2019 to December 2024 were obtained from the Scopus database and analyzed using VOSviewer software version 1.6.19. The data sets contained the research publication year, publication title, author name, journal, citation, and keyword in PlainText format. Using the VOS clustering and mapping techniques, this software was used for analysis and map generation. An alternative to the MDS method is VOSviewer. In contrast to MDS, which focuses on calculating similarity metrics like cosine and Jaccard indexes, VOS uses an approach that is better suited for normalizing co-occurrence frequencies, like the Association Strength (ASij). Therefore, after lowering the weighted sum of the squared distances, the VOSviewer uses this index to arrange elements in the form of a map.

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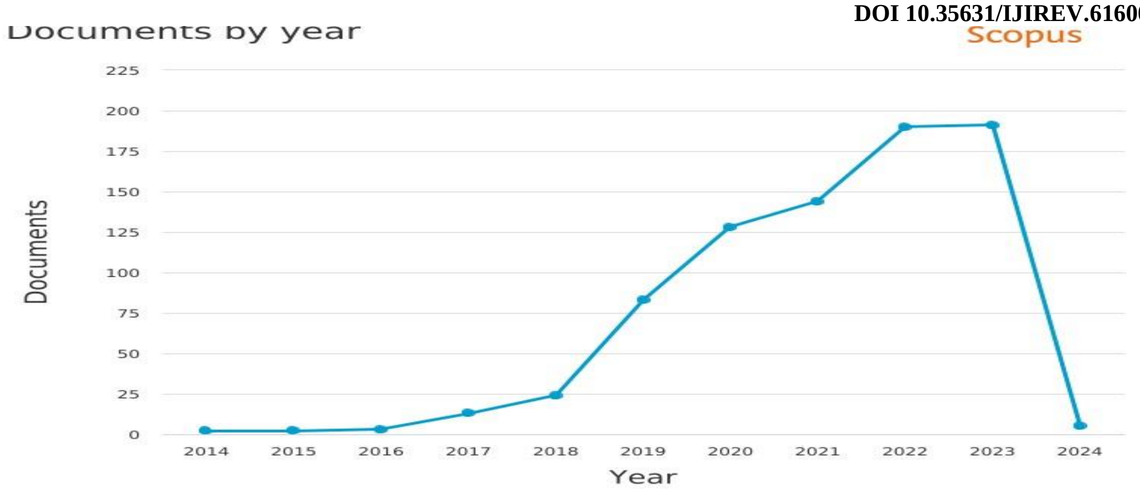

Figure 1. The Trend Of The Research Trends In Digital Transformation According To The Year Of Publication.

Figure 1 displays the number of digital transformation publications published each year between 2019 and 2024. The figure suggests that research on digital transformation is significant and relatively stable, ranging from 2 (2014) to 5 (2024).

Table 3. General Upward Trend In Number Of Publication Yearly

YEAR	No. Publication	PERCENTAGE
2024	5	0.6
2023	191	24.4
2022	190	24.3
2021	144	18.4
2020	128	16.3
2019	83	10.6
2018	24	3.1
2017	13	1.7
2016	3	0.4
2015	2	0.3
TOTAL	783	

Table 3 illustrates a general upward trend in the number of publications over the years, with a notable increase from 2018 onwards. However, the sudden drop in 2024 may warrant further investigation to understand the reason behind this decrease. It is essential to consider external factors, research trends, or any other variables that may have influenced these numbers.

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Table 4. Documents' Frequency By Subject Area

SUBJECT AREA	NO. OF DOCUMENTS
Engineering	376
Computer Science	353
Business, Management and Accounting	187
Decision Sciences	123
Social Sciences	102
Environmental Science	73
Energy	70
Mathematics	66
Economics, Econometrics and Finance	64
Physics and Astronomy	53
Chemical Engineering	41
Materials Science	37
Earth and Planetary Sciences	20
Medicine	17
Agricultural and Biological Sciences	11
Biochemistry, Genetics and Molecular Biology	11
Psychology	11
Arts and Humanities	9
Chemistry	8
Pharmacology, Toxicology and Pharmaceutics	5
Multidisciplinary	3
Immunology and Microbiology	2
Neuroscience	2
Health Professions	1

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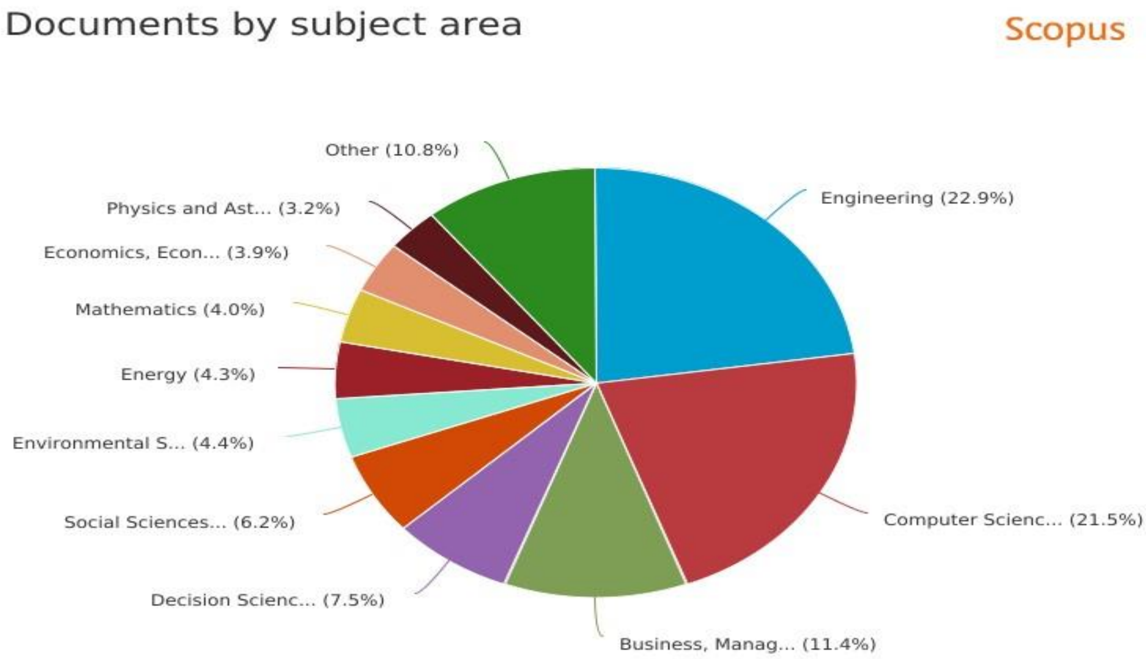

Figure 2. Documents By Area Subjects

Figure 2 illustrates the number of documents published by the author in various subject areas according to Scopus. The key observations are Engineering and Computer Science are the dominant subject areas, with 376 and 353 documents, respectively. This suggests that the author has a strong focus on these fields. There is a significant spread across other subject areas, with 123 documents in Decision Sciences, 102 in Social Sciences, and 73 in Environmental Science. This indicates that the author's research interests are diverse and not limited to a single field.Some subject areas have a smaller number of documents, such as Medicine (17), Agricultural and Biological Sciences (11), and Arts and Humanities (9). This could be due to various factors, such as the author's research focus, the availability of funding, or the publication preferences of journals in those fields.

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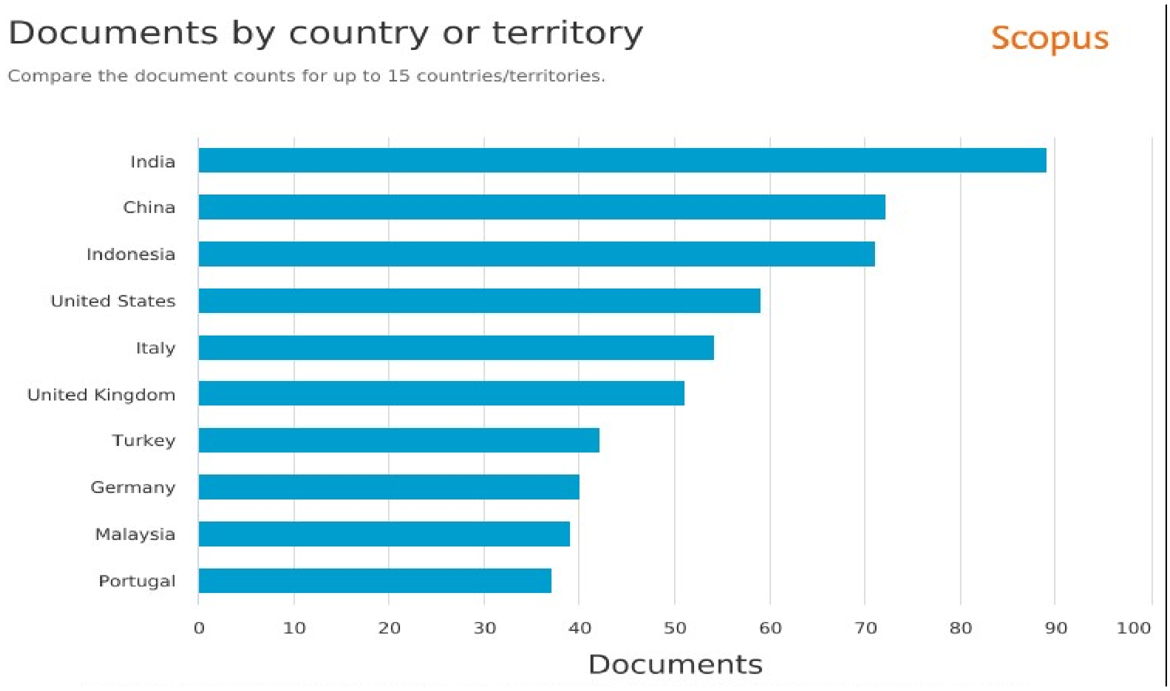

Figure 3. Document By Countries

Figure 3 summarizes the number of documents by country, and India is the most frequent. It is followed by China, Indonesia, and Portugal. The figure displays the number of documents published by the counties in various subject areas according to Scopus. Here are some key observations suggesting that India, China, and Indonesia are the three countries with the most documents in Scopus. This suggests that these countries are producing a large amount of research output. However, it is essential to remember that the number of documents is not the only measure of research output. Other factors, such as the quality of the research and the impact it has on other fields, are also important.

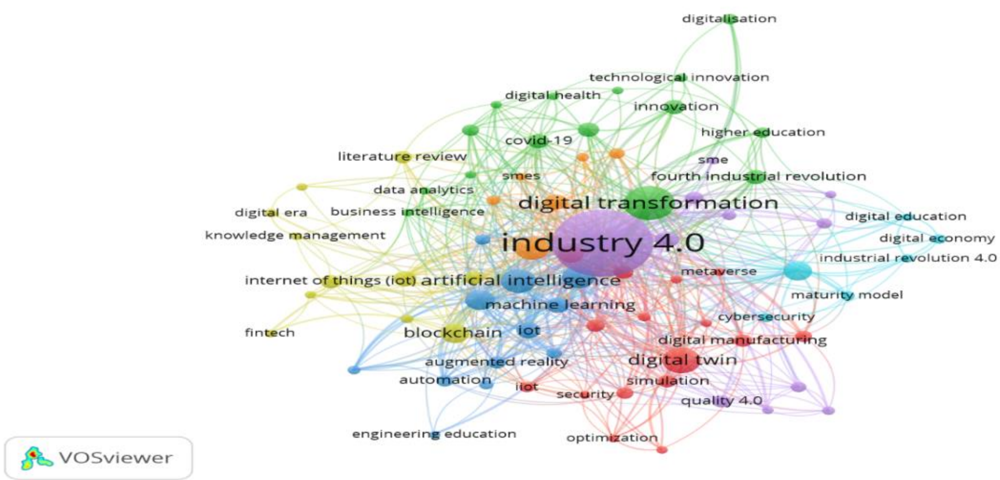

Figure 4. Network Visualization Map Of Keywords' Co-Occurrence

Figure 4 is the map indicates the relationships between different keywords based on how often they co-occur in the documents analyzed. The larger the circle representing a keyword, the more frequently it appears in the dataset. The thicker the lines connecting keywords, the more

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often they appear together. Some of the key clusters and themes in the map are central cluster. This cluster includes keywords such as “digital transformation,” “Industry 4.0,” “digitalization,” “technological innovation,” and “business intelligence.” These are all central concepts in the field of digital transformation in industry.On the Left cluster includes keywords such as “data analytics,” “internet of things (IoT),” “artificial intelligence (AI),” and “machine learning.” These keywords all relate to the technologies that are enabling digital transformation in the industry.On right cluster includes keywords such as “knowledge management,” “higher education,” and “engineering education.” These keywords suggest that digital transformation is also having an impact on the way we educate and train future workers.In addition to these main clusters, there are also a number of other interesting relationships between keywords in the map. For example, the keyword “cybersecurity” is connected to both the “digital transformation” and “Industry 4.0” clusters, suggesting that it is an important concern for businesses that are undergoing digital transformation.

Network Visualization Map Of Keywords’ Co-Occurrence

The map suggests the relationships between different keywords based on how often they co-occur in the documents will be analyzed. The larger the circle representing a keyword, the more frequently it appears in dataset. The thicker the lines connecting keywords, the more often they appear together. The key clusters and themes in the map is the cenntral cluster: This cluster includes keywords such as“digital transformation,” “Industry 4.0,” “digitalization,” “technological innovation,” and “business intelligence.” These are all central concepts in the field of digital transformation in industry.Left cluster is the cluster includes keywords such as “data analytics,” “internet of things (IoT),” “artificial intelligence (AI),” and “machine learning.” These keywords all relate to the technologies that are enabling digital transformation in the industry.Right cluster includes keywords such as “knowledge management,” “higher education,” and “engineering education.” These keywords suggest that digital transformation is also having an impact on the way we educate and train future workers.In addition to these main clusters, there are also a number of other interesting relationships between keywords in the map. For example, the keyword “cybersecurity” is connected to both the “digital transformation” and “Industry 4.0” clusters, suggesting that it is an important concern for businesses that are undergoing digital transformation.There is a significant spread across other subject areas, with 123 documents in Decision Sciences, 102 in Social Sciences, and 73 in Environmental Science. This indicates that the author’s research interests are diverse and not limited to a single field. Some subject areas have a smaller number of documents, such as Medicine (17), Agricultural and Biological Sciences (11), and Arts and Humanities (9). This could be due to a variety of factors, such as the author’s research focus, the availability of funding, or the publication preferences of journals in those fields. This duo led the pack with their 2017 paper introducing the concept of “Digital Twin Shop-Floor,” a ground breaking paradigm for smart manufacturing. These researchers comprehensively reviewed Industry 4.0 technologies in their 2019 paper, scanning the landscape and offering valuable insights for practitioners and academics alike. Their work has garnered over 700 citations, demonstrating its widespread impact. This team from Hungary examined the impact of Industry 4.0 and the IoT on business strategies within the value chain. Yong Li et al.(2021).This group delved into the environmental and economic implications of digital technologies in Industry 4.0. The team provided a timely review of digital twins-based smart manufacturing systems. These are just the top five authors on the list, and each of the remaining five has made significant contributions to the field. The map illustrates the relationships between different keywords based on how often they co-occur in the documents being analyzed. In addition to these main clusters, there are also a number of other interesting relationships between keywords in the map.

Results

The development of a digital transformation framework for small and medium-sized businesses (SMEs) is essential to guaranteeing their success in the current digital era. This framework is known as the "digital framework for SMEs." The framework should take into account the many types of SMEs and their distinct needs and capacities in addition to addressing the difficulties SMEs encounter while organizing, starting, and carrying out digital transformations. The framework ought to give SMEs the instruments, materials, and expertise required to properly start their digital transformation journey. The framework should also concentrate on enhancing the effectiveness of SMEs' dealings with partners, suppliers, consumers, and state authorities. By considering the organization of the enterprise's external and internal business processes, the framework can help SMEs streamline their operations and enhance their overall performance. Additionally, the digital transformation framework should also incorporate the concept of sustainability. The framework should emphasize the importance of achieving sustainable performance and include concepts such as environmental performance and sustainable production processes and products. There has been a general upward trend in the number of publications over the years, with a notable increase from 2018 onwards. However, the sudden drop in 2024 may warrant further investigation to understand the reason behind this decrease. It is essential to consider external factors, research trends, or any other variables that may have influenced these numbers. The framework, which considers the organization of the enterprise's internal and external business processes, can assist SMEs in increasing overall performance and streamlining their operations. Furthermore, the framework for the digital transformation needs to include sustainability. The framework ought to integrate concepts such as sustainable manufacturing processes and goods, environmental performance, and emphasize the significance of attaining sustainable performance. The number of publications has generally increased over time, with a significant increase beginning in 2018. However, more investigation could be required to identify the reason behind the sharp drop in 2024. It is critical to consider any external factors, study trends, or other factors that may have impacted these numbers.

Conclusion

The most remarkable finding is that, in the context of sector 4, the emergence of digital data and online digital access, which automatically gathers and processes electronic data into the value chain on discrete operations, has created a challenge for the construction industry. The findings suggest that the construction industry has a clear, evolving, and unfinished conversation on Industry 4.0. This review indicates how little is known about what Industry 4.0 means for the construction industry because it includes few unique studies. Rather than providing a solid theoretical framework for putting the implementation into practice, the material that has already been published has mostly focused on the idea of Industry 4.0 adoption in the construction sector. The majority of papers discussed the latest technologies in detail, as well as how different businesses or industries to change the integration of BIM with Industry 4.0 technologies, as well as the construction network and economics. The construction industry is transforming as a result of the introduction of Industry 4.0 and BIM, which will improve the quality and performance of the entire construction life cycle. This is a positive development for the sector. Therefore, to enable more experimental design research for the realization of

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BIM and industry, more qualitative study is required to investigate and comprehend the problems, difficulties, and future course of these new technologies.

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References

A. Entezari, A. Aslani, R. Zahedi, and Y. Noorollahi, "Artificial intelligence and machine learning in energy systems: A bibliographic perspective," *Energy Strategy Reviews*. 2023. doi: 10.1016/j.esr.2022.101017.

A. Guazzini, E. Guidi, C. Cecchini, and E. Yoneki, "Collaborative facilitation and collaborative inhibition in virtual environments," *Futur. Internet*, 2020, doi: 10.3390/FI12070118.

A. Indraprastha, "Encouraging Computational Skills: Evaluating BIM Course to Support Design Studio," 2020. doi: 10.2991/aer.k.200214.030.

Á. J. Rojas-Lamorena, S. Del Barrio-García, and J. M. Alcántara-Pilar, "A review of three decades of academic research on brand equity: A bibliometric approach using co-word analysis and bibliographic coupling," *J. Bus. Res.*, 2022, doi: 10.1016/j.jbusres.2021.10.025.

A. Paleyes, R. G. Urma, and N. D. Lawrence, "Challenges in Deploying Machine Learning: A Survey of Case Studies," *ACM Comput. Surv.*, 2022, doi: 10.1145/3533378.

A. Park, E. Treen, L. Pitt, and A. Chan, "Brand stories in marketing: a bibliographic perspective," *J. Strateg. Mark.*, 2023, doi: 10.1080/0965254X.2021.1963312.

A. R. C. Bedin, M. Capretz, and S. Mir, "Blockchain for Collaborative Businesses," *Mob. Networks Appl.*, 2021, doi: 10.1007/s11036-020-01649-6.

B. A. Barker Scott and M. R. Manning, "Designing the Collaborative Organization: A Framework for how Collaborative Work, Relationships, and Behaviors Generate Collaborative Capacity," *J. Appl. Behav. Sci.*, 2022, doi: 10.1177/00218863221106245.

B. Jachimczyk, R. Tkaczyk, T. Piotrowski, S. Johansson, and W. J. Kulesza, "IoT-based dairy supply chain - An ontological approach," *Elektron. ir Elektrotechnika*, 2021, doi: 10.5755/j02.eie.27612.

B. Levkovskyi, M. Hinrichs, B. Betzwieser, and M. C. Utesch, "Companies in transition: Understanding how the digital transformation affects business processes and their key performance indicators," in *27th Annual Americas Conference on Information Systems, AMCIS 2021*, 2021.

B. Simões, R. De Amicis, I. Barandiaran, and J. Posada, "Design and management of Digital Manufacturing & Assembly Systems in the Industry 4.0 era," *Int. J. Adv. Manuf. Technol.*, 2019.

C. Bianchi, G. Nasi, and W. C. Rivenbark, "Implementing collaborative governance: models, experiences, and challenges," *Public Manag. Rev.*, 2021, doi: 10.1080/14719037.2021.1878777.

C. Holden, "The Bibliographic Work: History, Theory, and Practice," *Cat. Classif. Q.*, 2021, doi: 10.1080/01639374.2020.1850589.

C. I. Wade *et al.*, "Endophthalmitis: a bibliographic review," *Int. Ophthalmol.*, 2021, doi: 10.1007/s10792-021-01967-y.

Volume 6 Issue 16 (March 2024) PP. 20-37
DOI 10.35631/IJIREV.616002
C. Janiesch, P. Zschech, and K. Heinrich, “Machine learning and deep learning,” *Electron. Mark.*, 2021, doi: 10.1007/s12525-021-00475-2.

C. K. Kreutz, M. Wolz, J. Knack, B. Weyers, and R. Schenkel, “SchenQL: in-depth analysis of a query language for bibliographic metadata,” *Int. J. Digit. Libr.*, 2022, doi: 10.1007/s00799-021-00317-8.

C. M. Feng, A. Park, L. Pitt, J. Kietzmann, and G. Northey, “Artificial intelligence in marketing: A bibliographic perspective,” *Australas. Mark. J.*, 2021, doi: 10.1016/j.ausmj.2020.07.006.

C. Marín-Palacios, O. Carrero Márquez, and R. P. Lohan, “Review of employment and disability: bibliographic analysis,” *Journal of Enterprising Communities*. 2022. doi: 10.1108/JEC-05-2021-0074.

C. N. Loes, “The Effect of Collaborative Learning on Academic Motivation,” *Teach. Learn. Inq.*, 2022, doi: 10.20343/teachlearninqu.10.4.

C. Rudin, C. Chen, Z. Chen, H. Huang, L. Semenova, and C. Zhong, “Interpretable machine learning: Fundamental principles and 10 grand challenges,” *Stat. Surv.*, 2022, doi: 10.1214/21-SS133.

C. Troussas, F. Giannakas, C. Sgouropoulou, and I. Voyiatzis, “Collaborative activities recommendation based on students’ collaborative learning styles using ANN and WSM,” *Interact. Learn. Environ.*, 2023, doi: 10.1080/10494820.2020.1761835.

D. Patel, C. Maiti, and S. Muthuswamy, “Real-Time Performance Monitoring of a CNC Milling Machine using ROS 2 and AWS IoT Towards Industry 4.0,” in *EUROCON 2023 - 20th International Conference on Smart Technologies, Proceedings*, 2023. doi: 10.1109/EUROCON56442.2023.10199020.

D. Rolnick *et al.*, “Tackling Climate Change with Machine Learning,” *ACM Computing Surveys*. 2023. doi: 10.1145/3485128.

E. CESUR, R. CESUR, and B. N. AYDOĞAN, “CNC TEZGAHLARININ DİJİTAL İKİZ MODELİ İLE KOMUT TAMAMLANMA SÜRELERİNİN TAHMİN EDİLMESİ,” *Int. J. 3D Print. Technol. Digit. Ind.*, 2023, doi: 10.46519/ij3dptdi.1215353.

E. de Boer, Y. Giraud, I. Millan, J. Salguero, J. Hoch, and K. George, “Global Lighthouse Network - Insight from the forefront of the 4th Industrial Revolution,” in *McKinsey & Company*, 2020.

E. Hendarwati, L. Nurlaela, B. S. Bachri, and N. Sa’ida, “Collaborative Problem Based Learning Integrated with Online Learning,” *Int. J. Emerg. Technol. Learn.*, 2021, doi: 10.3991/ijet.v16i13.24159.

E. Hysing, “Designing collaborative governance that is fit for purpose: theorizing policy support and voluntary action for road safety in Sweden,” *J. Public Policy*, 2022, doi: 10.1017/S0143814X2000029X.

E. Mayweg-Paus, M. Zimmermann, N. T. Le, and N. Pinkwart, “A review of technologies for collaborative online information seeking: On the contribution of collaborative argumentation,” *Educ. Inf. Technol.*, 2021, doi: 10.1007/s10639-020-10345-7.

E. Niederleithinger, “NDE 4.0 in Civil Engineering,” in *Handbook of Nondestructive Evaluation 4.0*, 2022. doi: 10.1007/978-3-030-73206-6_1.

F. Bologna, A. Di Iorio, S. Peroni, and F. Poggi, “Open bibliographic data and the Italian National Scientific Qualification: Measuring coverage of academic fields,” *Quant. Sci. Stud.*, 2022, doi: 10.1162/qss_a_00203.

F. Girotto, A. Galeazzi, F. Manenti, S. Gueguen, and L. Piazza, “Water–food–energy nexus: Assessing challenges in the trend toward digitalization: The case study of an Italian winemaking industry,” *Environ. Prog. Sustain. Energy*, 2022, doi: 10.1002/ep.13893.

Volume 6 Issue 16 (March 2024) PP. 20-37
DOI 10.35631/IJIREV.616002
F. Lolli, A. M. Coruzzolo, S. Marinello, A. Traini, and R. Gamberini, "A Bibliographic Analysis of Indoor Air Quality (IAQ) in Industrial Environments," *Sustainability (Switzerland)*. 2022. doi: 10.3390/su141610108.

F. Oksuz, M. Sanchez, M. Padilla, D. Schiemann, C. Scalise, and M. Trotter, "Chicago TARP McCook Main Tunnel: World's largest live tunnel connection is underway at Chicago's Tunnel and Reservoir Plan (TARP)," in *ITA-AITES World Tunnel Congress 2016, WTC 2016*, 2016.

G. Schiuma, S. Kumar, R. Sureka, and R. Joshi, "Research constituents and authorship patterns in the Knowledge Management Research and Practice: a bibliometric analysis," *Knowl. Manag. Res. Pract.*, 2023, doi: 10.1080/14778238.2020.1848365.

H. Wang and B. Ran, "Network governance and collaborative governance: a thematic analysis on their similarities, differences, and entanglements," *Public Manag. Rev.*, 2023, doi: 10.1080/14719037.2021.2011389.

I. H. Sarker, "Machine Learning: Algorithms, Real-World Applications and Research Directions," *SN Computer Science*. 2021. doi: 10.1007/s42979-021-00592-x.

J. da A. Moutinho and L. F. da Silva, "Knowledge management in project management: mapping bibliographic convergence," *Knowl. Manag. Res. Pract.*, 2022, doi: 10.1080/14778238.2021.1931502.

J. G. Cunha *et al.*, "From handcrafting to a certified and ergonomic collaborative workstation: The digital transformation process," in *ISR 2021 - 2021 IEEE International Conference on Intelligence and Safety for Robotics*, 2021. doi: 10.1109/ISR50024.2021.9419376.

J. Grimmer, M. E. Roberts, and B. M. Stewart, "Machine Learning for Social Science: An Agnostic Approach," *Annual Review of Political Science*. 2021. doi: 10.1146/annurev-polisci-053119-015921.

J. Liu, L. Chen, and R. Liu, "Research on multi-center intelligent manufacturing sharing cloud platform of furniture manufacturing enterprises," *J. For. Eng.*, vol. 6, no. 3, pp. 166 – 170, 2021, doi: 10.13360/j.issn.2096-l359.202003031.

J. M. Zhang, M. Harman, L. Ma, and Y. Liu, "Machine Learning Testing: Survey, Landscapes and Horizons," *IEEE Trans. Softw. Eng.*, 2022, doi: 10.1109/TSE.2019.2962027.

J. Robertson, L. Pitt, and C. Ferreira, "Entrepreneurial ecosystems and the public sector: A bibliographic analysis," *Socioecon. Plann. Sci.*, 2020, doi: 10.1016/j.seps.2020.100862.

J. Verbraeken, M. Wolting, J. Katzy, J. Kloppenburg, T. Verbelen, and J. S. Rellermeyer, "A Survey on Distributed Machine Learning," *ACM Computing Surveys*. 2020. doi: 10.1145/3377454.

J. Waring, C. Lindvall, and R. Umeton, "Automated machine learning: Review of the state-of-the-art and opportunities for healthcare," *Artificial Intelligence in Medicine*. 2020. doi: 10.1016/j.artmed.2020.101822.

J. Zhao, F. Zhuang, X. Ao, Q. He, H. Jiang, and L. Ma, "Survey of Collaborative Filtering Recommender Systems," *Journal of Cyber Security*. 2021. doi: 10.19363/J.cnki.cn10-1380/tn.2021.09.02.

J. Zysman, J. Murray, S. Feldman, N. C. Nielsen, and K. E. Kushida, "Services with Everything: The ICT-Enabled Digital Transformation of Services," *SSRN Electron. J.*, 2012, doi: 10.2139/ssrn.1863550.

K. Oswald and X. Zhao, "Collaborative Learning in Makerspaces: A Grounded Theory of the Role of Collaborative Learning in Makerspaces," *SAGE Open*, 2021, doi: 10.1177/21582440211020732.

Volume 6 Issue 16 (March 2024) PP. 20-37
DOI 10.35631/IJIREV.616002
K. Topuz, A. Bajaj, and I. Abdulrashid, "Interpretable Machine Learning," in *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2023. doi: 10.1201/9780367816377-16.

K. S. Al-Omoush, S. Ribeiro-Navarrete, C. Lassala, and M. Skare, "Networking and knowledge creation: Social capital and collaborative innovation in responding to the COVID-19 crisis," *J. Innov. Knowl.*, 2022, doi: 10.1016/j.jik.2022.100181.

L. Gualtieri, E. Rauch, and R. Vidoni, "Emerging research fields in safety and ergonomics in industrial collaborative robotics: A systematic literature review," *Robotics and Computer-Integrated Manufacturing*. 2021. doi: 10.1016/j.rcim.2020.101998.

L. Phan Tan, "Bibliometrics of social entrepreneurship research: Co-citation and bibliographic coupling analyses," *Cogent Business and Management*. 2022. doi: 10.1080/23311975.2022.2124594.

L. Phan Tan, "Mapping the social entrepreneurship research: Bibliographic coupling, co-citation and co-word analyses," *Cogent Bus. Manag.*, 2021, doi: 10.1080/23311975.2021.1896885.

L. Stojanovska-Georgievska *et al.*, "BIM in the Center of Digital Transformation of the Construction Sector—The Status of BIM Adoption in North Macedonia†," *Buildings*, vol. 12, no. 2, 2022, doi: 10.3390/buildings12020218.

L. Von Rueden *et al.*, "Informed Machine Learning - A Taxonomy and Survey of Integrating Prior Knowledge into Learning Systems," *IEEE Trans. Knowl. Data Eng.*, 2023, doi: 10.1109/TKDE.2021.3079836.

L. Y. Lu, C. E. Chang, C. L. Tung, C. Y. Lu, T. J. Su, and L. W. Lee, "Application of Digital Visualization in Traditional Manufacturing Transformation," *Sensors Mater.*, 2023, doi: 10.18494/SAM4372.

L. Zhou, Y. Song, W. Ji, and H. Wei, "Machine learning for combustion," *Energy AI*, 2022, doi: 10.1016/j.egyai.2021.100128.

M. G. Khan, N. Ul Huda, and U. K. Uz Zaman, "Smart Warehouse Management System: Architecture, Real-Time Implementation and Prototype Design," *Machines*, 2022, doi: 10.3390/machines10020150.

M. Gusenbauer, "Search where you will find most: Comparing the disciplinary coverage of 56 bibliographic databases," *Scientometrics*, 2022, doi: 10.1007/s11192-022-04289-7.

M. H. Huang and R. T. Rust, "A Framework for Collaborative Artificial Intelligence in Marketing," *J. Retail.*, 2022, doi: 10.1016/j.jretai.2021.03.001.

M. Hamalainen and A. Salmi, "Digital transformation in a cross-laminated timber business network," *J. Bus. Ind. Mark.*, vol. 38, no. 6, pp. 1251 – 1265, 2023, doi: 10.1108/JBIM-01-2022-0003.

M. Ihme, W. T. Chung, and A. A. Mishra, "Combustion machine learning: Principles, progress and prospects: Combustion machine learning," *Progress in Energy and Combustion Science*. 2022. doi: 10.1016/j.pecs.2022.101010.

M. Karakus, A. Ersozlu, and A. C. Clark, "Augmented reality research in education: A bibliometric study," *Eurasia J. Math. Sci. Technol. Educ.*, 2019, doi: 10.29333/ejmste/103904.

M. Nayak, P. P. Pratihari, S. Mahapatra, and S. S. Pradhan, "Intelligent Analytics in Cyber-Physical Systems," in *Intelligent Analytics for Industry 4.0 Applications*, 2023. doi: 10.1201/9781003321149-19.

M. O. K. Mendonça, S. L. Netto, P. S. R. Diniz, and S. Theodoridis, "Machine learning," in *Signal Processing and Machine Learning Theory*, 2023. doi: 10.1016/B978-0-32-391772-8.00019-3.

International Journal of Innovation and Industrial Revolution
EISSN: 2637-0972
IJIREV
Volume 6 Issue 16 (March 2024) PP. 20-37
DOI 10.35631/IJIREV.616002
M. Tsakalerou, D. Nurmaganbetov, and N. Beltenov, "Aircraft Maintenance 4.0 in an era of disruptions," in *Procedia Computer Science*, 2022. doi: 10.1016/j.procs.2022.01.211.
M. Visser, N. J. van Eck, and L. Waltman, "Large-scale comparison of bibliographic data sources: Scopus, web of science, dimensions, crossref, and microsoft academic," *Quant. Sci. Stud.*, 2021, doi: 10.1162/qss_a_00112.
M. Zhao *et al.*, "Blockchain in Online Learning: A Systematic Review and Bibliographic Visualization," *Sustainability (Switzerland)*. 2023. doi: 10.3390/su15021470.
M. Zhu *et al.*, "A review of the application of machine learning in water quality evaluation," *Eco-Environment and Health*. 2022. doi: 10.1016/j.eehl.2022.06.001.
N. Ulibarri, M. T. Imperial, S. Siddiki, and H. Henderson, "Drivers and Dynamics of Collaborative Governance in Environmental Management," *Environ. Manage.*, 2023, doi: 10.1007/s00267-022-01769-7.
Orphanet Report Series, "Prevalence and incidence of rare diseases: Bibliographic data.," *Orphanet Rep. Ser. Rare Dis. Collect.*, 2022.
P. A. Kirschner, J. Sweller, F. Kirschner, and J. R. Zambrano, "From Cognitive Load Theory to Collaborative Cognitive Load Theory," *Int. J. Comput. Collab. Learn.*, 2018, doi: 10.1007/s11412-018-9277-y.
P. Klimant, H. J. Koriath, M. Schumann, and S. Winkler, "Investigations on digitalization for sustainable machine tools and forming technologies," *Int. J. Adv. Manuf. Technol.*, 2021, doi: 10.1007/s00170-021-07182-4.
P. Linardatos, V. Papastefanopoulos, and S. Kotsiantis, "Explainable ai: A review of machine learning interpretability methods," *Entropy*. 2021. doi: 10.3390/e23010018.
R. H. Binsaeed, Z. Yousaf, A. Grigorescu, A. Samoila, R. I. Chitescu, and A. A. Nassani, "Knowledge Sharing Key Issue for Digital Technology and Artificial Intelligence Adoption," *Systems*, 2023, doi: 10.3390/systems11070316.
R. Kleminski, P. Kazienko, and T. Kajdanowicz, "Analysis of direct citation, co-citation and bibliographic coupling in scientific topic identification," *J. Inf. Sci.*, 2022, doi: 10.1177/0165551520962775.
R. J. Chase, D. R. Harrison, A. Burke, G. M. Lackmann, and A. McGovern, "A Machine Learning Tutorial for Operational Meteorology. Part I: Traditional Machine Learning," *Weather Forecast.*, 2022, doi: 10.1175/WAF-D-22-0070.1.
R. Naboni, "Cyber-Physical Construction and Computational Manufacturing," in *Structural Integrity*, 2022. doi: 10.1007/978-3-030-82430-3_22.
R. Pranckutė, "Web of Science (WoS) and Scopus: the titans of bibliographic information in today's academic world," *Publications*. 2021. doi: 10.3390/publications9010012.
R. Roscher, B. Bohn, M. F. Duarte, and J. Garcke, "Explainable Machine Learning for Scientific Insights and Discoveries," *IEEE Access*, 2020, doi: 10.1109/ACCESS.2020.2976199.
R. Vivona, M. A. Demircioglu, and D. B. Audretsch, "The costs of collaborative innovation," *J. Technol. Transf.*, 2023, doi: 10.1007/s10961-022-09933-1.
S. A. Khan, I. Naim, S. Kusi-Sarpong, H. Gupta, and A. R. Idrisi, "A knowledge-based experts' system for evaluation of digital supply chain readiness," *Knowledge-Based Syst.*, 2021, doi: 10.1016/j.knosys.2021.107262.
S. Kergroach, "Labour Market in the Context of Technological Transformations," *FORESIGHT STI Gov.*, 2017.
S. Leminen, M. Rajahonka, M. Westerlund, and M. Hossain, "Collaborative innovation for sustainability in Nordic cities," *J. Clean. Prod.*, 2021, doi: 10.1016/j.jclepro.2021.129549.

International Journal of Innovation and Industrial Revolution
IJIREV
EISSN: 2637-0972
Volume 6 Issue 16 (March 2024) PP. 20-37
DOI 10.35631/IJIREV.616002
S. Millatunnisa, "The 4.0 Industry Technology in Fashion Industries," in *Proceedings of the 4th International Conference on Innovation in Engineering and Vocational Education (ICIEVE 2021)*, 2022. doi: 10.2991/assehr.k.220305.068.
S. Raschka, J. Patterson, and C. Nolet, "Machine learning in python: Main developments and technology trends in data science, machine learning, and artificial intelligence," *Information (Switzerland)*. 2020. doi: 10.3390/info11040193.
S. Romero-Torres, "The role of digital transformation in achieving Pharma 4.0," *Eur. Pharm. Rev.*, 2021.
S. S. F. de Miranda, A. Córdoba-Roldán, F. Aguayo-González, and M. J. Ávila-Gutiérrez, "Neuro-competence approach for sustainable engineering," *Sustain.*, 2021, doi: 10.3390/su13084389.
S. Uddin, A. Khan, M. E. Hossain, and M. A. Moni, "Comparing different supervised machine learning algorithms for disease prediction," *BMC Med. Inform. Decis. Mak.*, 2019, doi: 10.1186/s12911-019-1004-8.
T. Baltrusaitis, C. Ahuja, and L. P. Morency, "Multimodal Machine Learning: A Survey and Taxonomy," *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 2019. doi: 10.1109/TPAMI.2018.2798607.
T. Sathiya Priya and C. L. Shilaja, "Collaborative learning," *Man India*, 2016, doi: 10.5367/000000000101294922.
T. Wang, A. P. C. Chan, Q. He, and J. Xu, "Identifying the gaps in construction megaproject management research: a bibliographic analysis," *Int. J. Constr. Manag.*, 2022, doi: 10.1080/15623599.2020.1735610.
V. A. Thomas Tarang, M. F. Mohammad, A. R. Nizam Akbar, and M. R. Mohamed, "Pertinent Internal and External Issues in Industrialised Building System (IBS) Construction Business in Malaysia," *Built Environ. J.*, 2022, doi: 10.24191/bej.v19i1.15990.
V. Batagelj and D. Maltseva, "Temporal bibliographic networks," *J. Informetr.*, 2020, doi: 10.1016/j.joi.2020.101006.
V. P. H. Pham, "The Effects of Collaborative Writing on Students' Writing Fluency: An Efficient Framework for Collaborative Writing," *SAGE Open*, 2021, doi: 10.1177/2158244021998363.
V. Rajaram Bankar and K. Nilkanth Nandurkar, "Implementation of IoT technology for quality improvement in an automotive industry," *Mater. Today Proc.*, 2023, doi: 10.1016/j.matpr.2023.03.485.
W. M. Alenazy, W. Mugahed Al-Rahmi, and M. S. Khan, "Validation of TAM Model on Social Media Use for Collaborative Learning to Enhance Collaborative Authoring," *IEEE Access*, 2019, doi: 10.1109/ACCESS.2019.2920242.
W. S. Alaloul, M. S. Liew, N. A. W. A. Zawawi, and I. B. Kennedy, "Industrial Revolution 4.0 in the construction industry: Challenges and opportunities for stakeholders," *Ain Shams Eng. J.*, vol. 11, no. 1, pp. 225–230, 2020, doi: 10.1016/j.asej.2019.08.010.
W. Utz and D. Falcioni, "Data Assets for Decision Support in Multi -Stage Production Systems Industrial Business Process Management using ADOxx," in *Proceedings - IEEE 16th International Conference on Industrial Informatics, INDIN 2018*, 2018. doi: 10.1109/INDIN.2018.8472033.
X. Lou, Z. Zhu, and J. Liang, "The Evolution Game Analysis of Platform Ecological Collaborative Governance Considering Collaborative Cultural Context," *Sustain.*, 2022, doi: 10.3390/su142214935.

Volume 6 Issue 16 (March 2024) PP. 20-37
DOI 10.35631/IJIREV.616002
X. Guo and X. Li, “A Study on Community Public Safety Collaborative Governance Regime in the Background of COVID-19: Empirical Analysis Based on China and South Korea,” *Sustain.*, 2022, doi: 10.3390/su142114000.
X. Yang, “A Historical Review of Collaborative Learning and Cooperative Learning,” *TechTrends*, 2023, doi: 10.1007/s11528-022-00823-9.
Y. Chen, C. Li, and H. Wang, “Big Data and Predictive Analytics for Business Intelligence: A Bibliographic Study (2000–2021),” *Forecasting*. 2022. doi: 10.3390/forecast4040042.
Y. Xu, Y. Zhou, P. Sekula, and L. Ding, “Machine learning in construction: From shallow to deep learning,” *Dev. Built Environ.*, 2021, doi: 10.1016/j.dibe.2021.100045.
Z. Cai, R. C. Poulos, J. Liu, and Q. Zhong, “Machine learning for multi-omics data integration in cancer,” *iScience*. 2022. doi: 10.1016/j.isci.2022.103798.
Z. Geng *et al.*, “All-optical OFDM demultiplexing with optical partial Fourier transform and coherent sampling,” *Opt. Lett.*, 2019, doi: 10.1364/ol.44.000443.
Z. H. Zhou, “Open-environment machine learning,” *National Science Review*. 2022. doi: 10.1093/nsr/nwac123.
Ž. Turk, “Interoperability in construction – Mission impossible?,” *Dev. Built Environ.*, 2020, doi: 10.1016/j.dibe.2020.100018.