https://doi.org/10.51483/IJAIML.3.2.2023.57-73 ISSN: 2789-2557

SvedbergOpen
DISSEMINATION OF KNOWLEDGE

International Journal of Artificial Intelligence and Machine Learning

Publisher's Home Page: https://www.svedbergopen.com/

Research Paper **Open Access**

Revolutionizing Construction: The Impact of Artificial Intelligence on Productivity

Nwosu Obinnaya Chikezie Victor[1*]

[1]Department of Electrical and Electronics Engineering, Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg, 2006 South Africa. E-mail: 221548262@mycput.ac.za

Article Info

Volume 3, Issue 2, July 2023
Received : 17 January 2023
Accepted : 11 June 2023
Published : 05 July 2023
doi: 10.51483/IJAIML.3.2.2023.57-73

Abstract

The construction sector has begun to embrace the digital revolution, intending to improve efficiency. On the other hand, how should the industry adopt digital tools?. And how should the connection between humans and technology function?. This study aims to shed light on how the construction sector may bridge the gap. between AI deployments's potential and realised advantages. This paper presents research based on a comprehensive review of the literature, case studies of Speller Metcalfe, a design-build and refurbishment project in Malvern, England, Jacobsen Construction, a project digitising the planning process in Salt Lake City, Utah, USA, and Menkes Development Inc., real-time visibility to the construction site insights and data-driven decision-making in Toronto, Canada. The experiences gained via this study show that it is feasible to acquire expertise while adopting sophisticated technologies, such as Artificial Intelligence (AI), by installing fundamental digital tools. However, when it comes to AI, the level of trust between humans and machines will be the deciding element in its success. This paper is a pioneering effort to examine the deployment of AI and how people and technology should interact. This study is limited to three case studies, three digital technologies. To further the study, it is suggested to debate the adaptation of AI on the user's premises, gather more empirical data, and examine case studies from different sectors.

Keywords: *Digital transformation, AI deployment in construction, Human-technology interaction*

1. Introduction

The construction industry is transitioning from hierarchical, conventional building sites to more autonomous, digital ones. A digital revolution is underway, and the advancement of digital technology is accelerating at

* *Corresponding author: Nwosu Obinnaya Chikezie Victor, Department of Electrical and Electronics Engineering, Faculty of Engineering and the Built Environment, University of Johannesburg, Johannesburg, 2006 South Africa. E-mail: 221548262@mycput.ac.za*

such a rate that the industry needs help to keep up. This paper is part of a collection of ground-breaking research. As it examines the application of artificial intelligence. Artificial intelligence is a relatively new field of study, particularly in the construction sector. AI can automate many processes and improve the efficiency of the construction process (Abiodun *et al.,* 2020). This is consistent with the lean philosophy, which places a premium on reducing waste and increasing value. Based on the above, this article aims to shed light on how the construction the industry may bridge the gap between AI deployment's potential and realized advantages (Agarwal *et al.,* 2016).

The construction enterprise has usually been one of the most crucial sectors in any economy, and it plays an essential role in shaping the built environment. But this area has faced numerous challenges, such as inefficiencies, delays, and excessive costs. With the appearance of AI, the development enterprise is now witnessing a brand-new era of innovation that's transforming the way initiatives are deliberated, designed, and carried out. AI is being utilized in numerous ways to improve productivity inside the construction enterprise. For instance, it can be used to analyze tremendous amounts of data to identify patterns and developments that may be used to optimize task schedules and reduce delays. AI can also automate habitual obligations, including website surveys and excellent management, which may help to lessen errors and improve accuracy. Moreover, AI-powered tools can assist production professionals in collaborating more effectively, decreasing the need for physical conferences and allowing them to work remotely. This may help to enhance productivity and reduce fees, especially in regions where travel and lodging can be steeply-priced. In the end, the adoption of AI within the construction industry is helping to optimize productivity, reduce fees, and improve the satisfaction of projects. Because the era keeps evolving, we will likely see even more progressive programs. Two research topics have been created to identify a method to close the gap (Agarwal *et al.,* 2020).

1. What are the possible advantages of incorporating artificial intelligence into the building industry?
2. How is the construction sector now reaping the rewards of AI implementation?

This paper is limited to case studies of Speller Metcalfe, a design-build and refurbishment project in Malvern, England; Jacobsen Construction, a project digitizing the planning process in Salt Lake City, Utah, USA; and Menkes Development Inc., a project providing real-time visibility to construction site insights and data-driven decision-making in Toronto, Canada. Five digital tools are the subject of the case studies (Fieldwire, Touchplan, Procore, CISCO packet tracer, and PVsyst photovoltaic). Additionally, the authors drew on data on lean manufacturing, Last Planner System (LPS) adoption, levels of digitalization, and other sectors. The paper is structured as follows: a method chapter, a theoretical framework, results and discussion, and a conclusion and recommendations for further study (Sururah *et al.,* 2021).

2. Literature Review

Science is about improving on what has already been discovered. Research and literature searches were conducted to gain a general overview of the most recent research and literature. The primary research on implementation procedure and widespread digitalization of construction project planning were mapped out. by the literature search and analysis. The paper was limited to AI-based technologies based on the available literature, the chosen case studies, and the author's interest in artificial intelligence (Abiodun *et al.,* 2020). The literature review used reliable databases, journals, conference papers, articles, books, snowballing, and supervisory recommendations. After discussions and supervision, the proposed content was selected as a starting point for additional research utilizing search engines. The search engines used were Scopus, Elsevier, Science Direct, Mendeley, Google Scholar, and Google. A more thorough overview of the databases is available via search engines. The chance of finding relevant content increased due to the size of the databases examined. However, a search method must be devised to find relevant content in all databases (Agarwal *et al.,* 2016). The author started by doing an extensive search of the most widely read and quoted literature Later, only credible and relevant information was included in the investigation. The following queries were used to assess the relevancy and caliber of sources: (1) Is the literature relevant to the topic? (2) In what places was the material released? (3) In what year was the book released?; (4) Is the literature subjected to peer review?; (5) Is the IMRAD 4 format used in the literature?; (6) Is the research approach reputable?; (7) Has the author consulted up-to-date, trustworthy sources? (8) What is the author's h-index? Figure 1 shows the search terms employed in this literature review were meticulously chosen to encompass the relevant aspects of AI, productivity, and

the construction industry. Specifically, three primary search terms were utilized: "artificial intelligence" (AI) yielded 1200 hit counts, "optimum productivity" resulted in 800 hit counts, and "construction industry" garnered 600 hit counts on the Scopus database. These hit counts provide a rough indication of the volume of research available for each search term, suggesting the prominence and significance of AI and productivity within the construction sector.

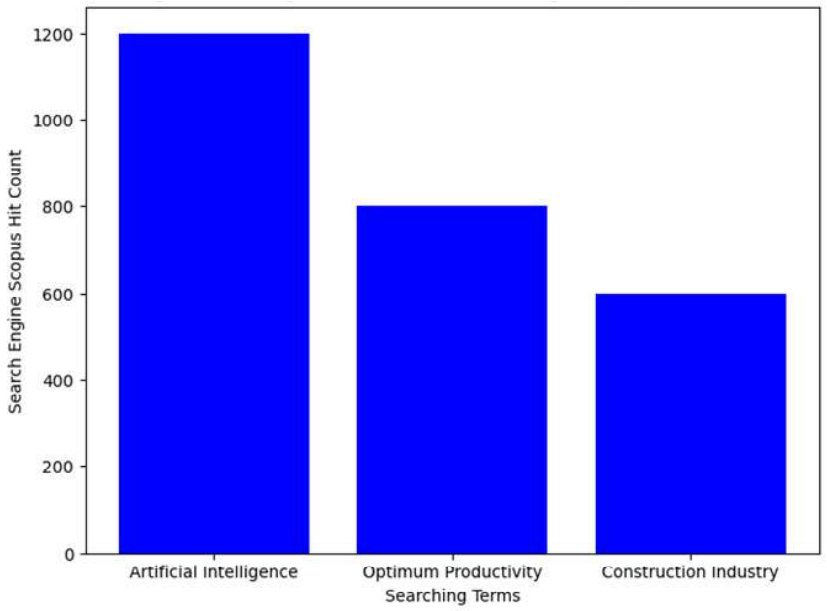

Figure 1: Searching Terms and the Search Engine Scopus Hit Count

The chosen literature was read under the minimum quality and relevance requirements mentioned in the previous list. The cmd (f) search function was used to find relevant information in digital books and articles. The literature was further evaluated utilizing the Reliability-Objectivity-Accuracy-Aptitude framework (ROAA). In addition to passing the ROAA principle evaluation, most of the bibliography comprises sources that match the criteria in the preceding list. Figure 2 presents an overview of the sources cited in the literature, categorized

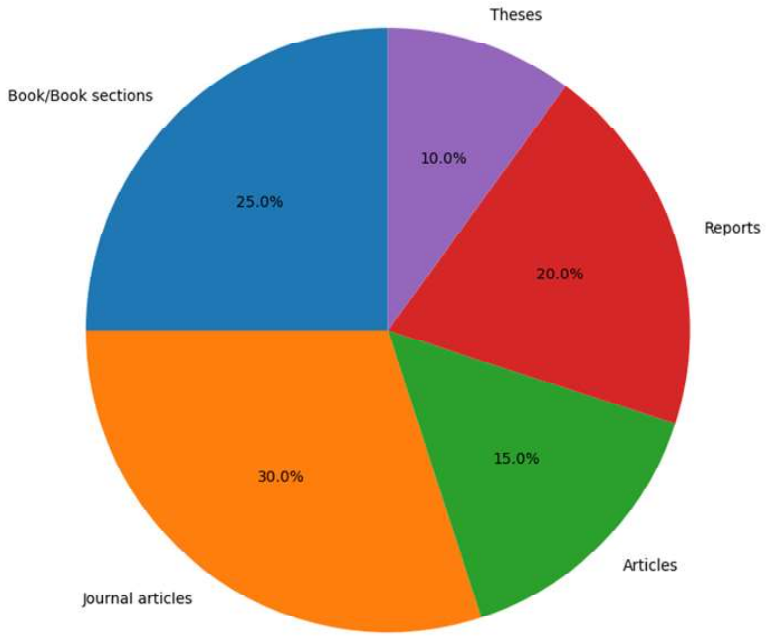

Figure 2: The Presentation of Sources

into five main groups: books/book sections, theses, reports, articles, and journal articles. This breakdown illustrates the distribution of sources in the field, shedding light on the preferences and trends in research methodologies and publication types. Need for adequate digital knowledge and technology. Adoption in construction has been linked to cost inefficiencies, project delays, poor quality performance, ill-informed decision-making, and poor productivity, health, and safety performance. In recent years, it has been clear that the construction business must embrace digitization and swiftly improve technical skills. In recent years, AI has enhanced corporate operations, service processes, and industrial production. AI has automated processes and brings competitive advantages over older approaches. Machine learning, NLP, Robotics, computer vision, optimization, automated planning, and scheduling are AI sub-fields used to solve complex problems and make decisions based on real-world concerns. Industry 4.0 focuses on automation, data-driven technologies, and AI methodologies in manufacturing. This revolution has improved processes, reduced costs, shortened production times, improved safety, and helped companies fulfil sustainability goals. Despite these difficulties, AI has yet to benefit construction. Artificial intelligence and its subfields have been used to solve building challenges for decades. Machine learning monitors health and safety, evaluates costs, optimizes supply chains and logistics, and forecasts risks. Robots monitor and analyze site performance, conduct offsite assembly, and handle construction materials, plants, and equipment. Knowledge-based systems can assess bids, mediate disagreements, manage risk and waste, and evaluate sustainability. Construction is one of the least digitalized industries globally, and it needs help to integrate AI and other digital technologies. Several studies attribute the need for AI adoption to cultural challenges, high initial prices, trust, security, talent, shortages, computer capacity, and internet availability. Artificial intelligence applications, future potential, and adoption difficulties in the construction industry include various grey areas. China, the US, and India account for 57% of global construction demand, which accounts for 13% of global GDP (Agarwal *et al.*, 2020). Global infrastructure investment might reach $3.4 tn annually by 2030, or 4% of GDP. The industry accounts for 3% of Nigeria's overall economic production, 4.3% of Germany's, 6% of the UK's, 4.1% of the UK, and 6.8% of the US's. According to the Project Management Institute, a project is a temporary endeavor to develop a unique product, service, or result. Early project management ideas trace back to the ancient Egyptians' pyramid building and have since been refined into an established discipline. Due to their intricacy and changeability, building projects generally yield unique things, not mass-produced ones. Companies started using specialized tools and processes for projects in the 1950s. Despite a lengthy history of project management, building projects worldwide have needed better performance, including cost overruns, schedule delays, and low-quality products. This requires a rigorous analysis of the industry's present project management procedures and the identification of opportunities for improvement. Planned construction projects are necessary and complex because they include a sequence of processes that must be completed concurrently to satisfy the project's objectives. The source says project planning comprises requirements, technology accessibility, specified scope and resource allocations, team building, and identifying procedures that cause these associated tasks to be completed. For details, A construction project plan must address all construction elements from the beginning to the end.

Figure 3 shows the relationship between the beliefs and assumptions, research philosophies, and research design of our study on the adoption of artificial intelligence for optimum productivity in the construction industry. We begin with the beliefs and assumptions, which form the foundation of our research. These beliefs and assumptions include the importance of adopting AI in the construction industry, the potential benefits of AI, and the challenges that must be overcome to achieve successful adoption.

Next, we present our research philosophies, which guide the design and implementation of our study. These philosophies include positivism, interpretivism, and critical theory. Positivism emphasizes the use of objective, empirical methods to study social phenomena, while interpretivism emphasizes the subjective, interpretive perspective of researchers. Critical theory, on the other hand, focuses on the analysis of power relations and the critique of dominant ideologies.

Finally, we describe the research design of our study, which includes the research questions, the sampling method, the data collection and analysis methods, and the ethical considerations. Our research design is guided by the research philosophies and aims to provide a comprehensive understanding of the adoption of AI in the construction industry.

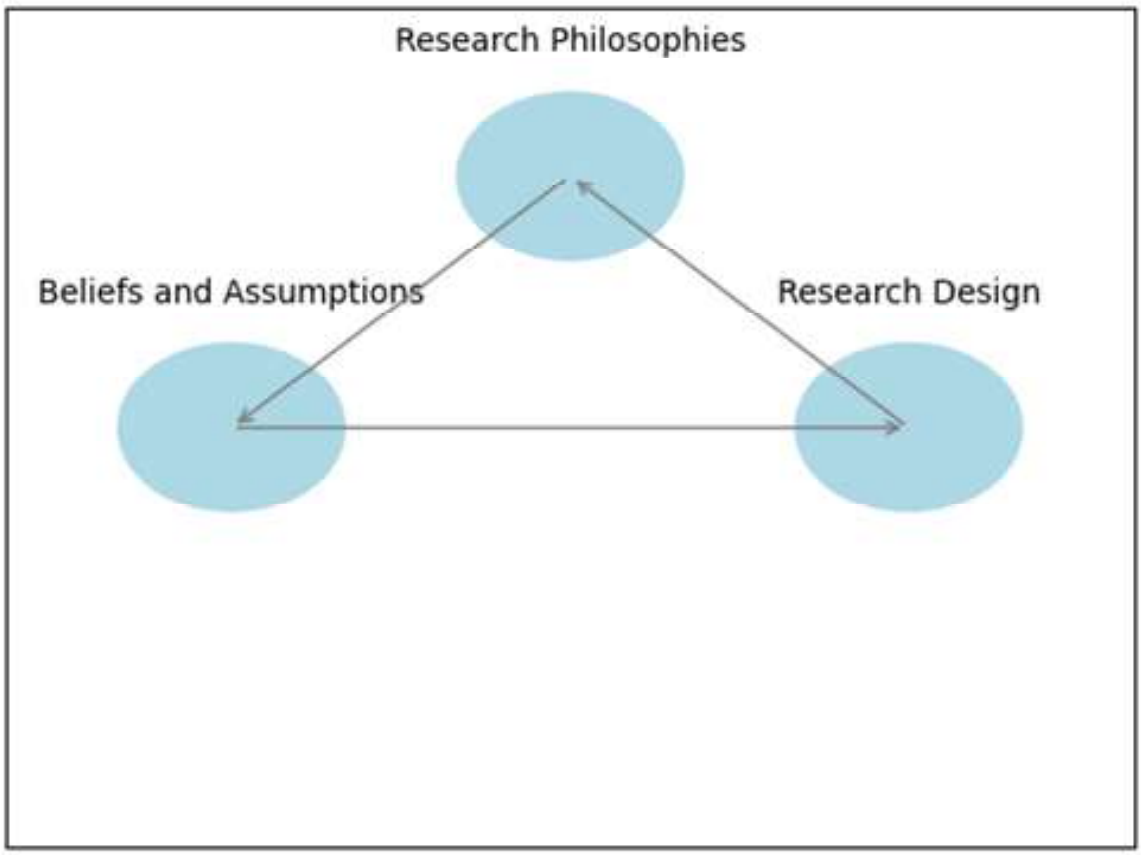

Figure 3: Research Philosophies Relationships

3. Methodology

This paper explains the research methodology. Research methodology addresses the research topic using an organized work plan. This includes data gathering, creating linkages between variables, and accuracy before objective assessment. Correct research begins with a thorough review of existing studies and literature. Literature reveals a knowledge gap. Creating research topics helps bridge the knowledge gap (Khobragade, 2018). Many methodological considerations must be made for high-quality, trustworthy research. Each choice influences the next. Research philosophy is "beliefs and assumptions regarding knowledge development." As with everything else in life, our beliefs and assumptions impact our everyday choices. We create assumptions at every level of research, which impacts the researcher's approach, data collection, and analytic data. Reflection is needed to determine the research philosophy. This shows where the researcher's views overlap or deviate from the five philosophies.

The HARP tool facilitates this contemplative process. It helps define study values and explains and justifies the research design. Research philosophy is the researcher's views and assumptions regarding knowledge development. Our beliefs and assumptions impact our everyday choices, consciously or not. At every level of research, we make assumptions that affect the researcher's technique, data collection, analysis, and utilization. Reflection is needed to determine the research philosophy. This shows where the researcher's views overlap or deviate from the five philosophies. The HARP tool facilitates this contemplative process. It helps define study values and explains and justifies the research design. Due to the vague study questions, purpose, and knowledge gap revealed throughout the literature search, this investigation was also qualitative. Qualitative research involves a comprehensive design. Uncharted territory means a vast amount of data is needed for a quantitative approach. Comparatively, qualitative procedures are more subjective. Inaccuracy may originate from the author's interpretation of the data. Triangulation, comprising literature reviews and case studies, was used to increase the research's validity and reliability. A literature review was used to find prior research on the topic, identify knowledge gaps, and improve the author's understanding.

The literature search revealed no written material on AI in building project planning, highlighting the necessity for a thorough research design and qualitative methods (Samer and. Mohamed, 2018). Since AI-based initiatives in England, the US, and Canada need a lot of data, quantitative approaches are hard. The research focused on three AI-savvy companies (Fieldwire, Touchplan, and Procore). Given the project participants' awareness of AI, the amount of digital tool deployment, and the purpose of the study, case studies are a good data collection method (Samer and. Mohamed, 2018). Three firms were asked about AI-based construction planning. To get expertise and experience, we contacted three firms. Case studies allowed informal talks and observations alongside the methodical investigation. The author attended webinars on all five digital tools (Fieldwire, Procore, Touchplan, CISCO packet tracer, and PVsyst). The author attended a course called "Artificial Intelligence in the 4IR" to learn more about AI. Even though they weren't organized research, case studies, webinars, and the AI course helped the paper. Choose a research approach that best answers the study questions and project's objectives. Project management uses experiment, survey, archival research, history, and case studies. The case study method is used to explain why social phenomena behave as they do. This paper attempts to connect existing and future AI construction implementations. Three case studies were chosen for data gathering and analysis depending on the research's goal. Conscious data collection from several sources improves study quality and validity (Samer and. Mohamed, 2018).

Instance studies may be a series or a single case. Numerous case studies gather data from diverse contexts, such as multiple building projects. One case study compiles data from a particular building project. In the absence of research on a phenomenon's extent and context, a single case study may be useful. The two main problems with a single case study are less transferrable results and the effect of other circumstances. Many case studies were chosen due to a lack of research. The case study's tale and background must be presented as a narrative for the research analysis and outcomes to be convincing. The following facts were acquired from construction software vendor websites, live webinars, slide notes from a Fieldwire senior manager, emails from Procore (formerly INDUS.AI) and a Touchplan senior business development person assigned to the project. Choose a research approach that best answers the study questions and project's objectives. Project management uses experiment, survey, archival research, history, and case studies. The case study method is used to explain why social phenomena behave as they do. This project intends to connect existing and future AI construction implementations.

Three case studies were chosen for data gathering and analysis depending on the research's goal. Conscious data collection from several sources improves study quality and validity. Instance studies may be a series or a single case. Numerous case studies gather data from diverse contexts, such as multiple building projects. One case study compiles data from a particular building project. In the absence of research on a phenomenon's extent and context, a single case study may be useful. The two main problems with a single case study are less transferred results and the effect of other circumstances. Many case studies were chosen due to a lack of research. The case study's tale and background must be presented as a narrative for the qualitative research analysis and outcomes to be convincing. The following facts were acquired from construction software vendor websites, live webinars, slide notes from a Fieldwire senior manager, emails from Procore (formerly INDUS.AI) and a Touchplan senior business development person assigned to the project (Kayid, 2020).

4. Theoretical Framework

Need for adequate digital knowledge and technology. Adoption in construction has been linked to cost inefficiencies, project delays, poor quality performance, ill-informed decision-making, and poor productivity, health, and safety performance. In recent years, it has been clear that the construction business must embrace digitization and swiftly improve technical skills. In recent years, AI has enhanced corporate operations, service processes, and industrial production. AI has automated processes and brings competitive advantages over older approaches. Machine learning, NLP, Robotics, computer vision, optimization, automated planning, and scheduling are AI sub-fields used to solve complex problems and make decisions based on real-world concerns. Industry 4.0 focuses on automation, data-driven technologies, and AI methodologies in manufacturing. This revolution has improved processes, reduced costs, shortened production times, improved safety, and helped companies fulfil sustainability goals. Despite these difficulties, AI has yet to benefit construction. Artificial intelligence and its subfields have been used to solve building challenges for decades. Machine learning monitors health and safety, evaluates costs, optimizes supply chains and logistics, and

forecasts risks. Robots monitor and analyze site performance, conduct offsite assembly, and handle construction materials, plants, and equipment. Knowledge-based systems can assess bids, mediate disagreements, manage risk and waste, and evaluate sustainability. Construction is one of the least digitalized industries globally, and it needs help to integrate AI and other digital technologies. Several studies attribute the need for AI adoption to cultural challenges, high initial prices, trust, security, talent, shortages, computer capacity, and internet availability. Artificial intelligence applications, future potential, and adoption difficulties in the construction industry include various grey areas. China, the US, and India account for 57% of global construction demand, which accounts for 13% of global GDP (Agarwal *et al.*, 2020). Global infrastructure investment might reach $3.4 tn annually by 2030, or 4% of GDP. The industry accounts for 3% of Nigeria's overall economic production, 4.3% of Germany's, 6% of the UK's, 4.1% of the UK, and 6.8% of the US's. According to the Project Management Institute, a project is a temporary endeavor to develop a unique product, service, or result. Early project management ideas trace back to the ancient Egyptians' pyramid building and have since been refined into an established discipline. Due to their intricacy and changeability, building projects generally yield unique things, not mass-produced ones. Companies started using specialized tools and processes for projects

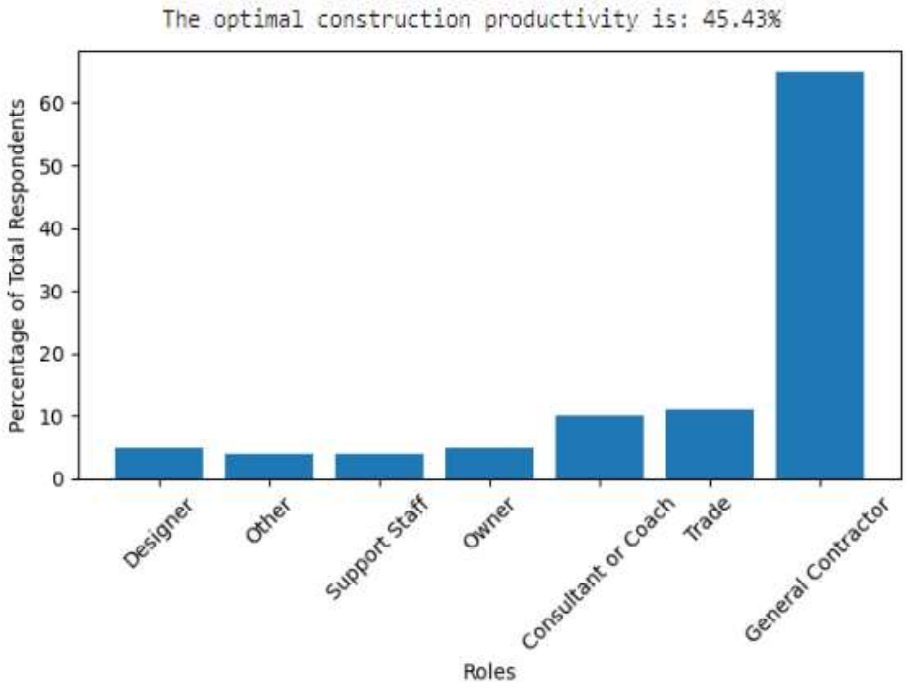

Figure 4: Percentage of Total Respondents by Role

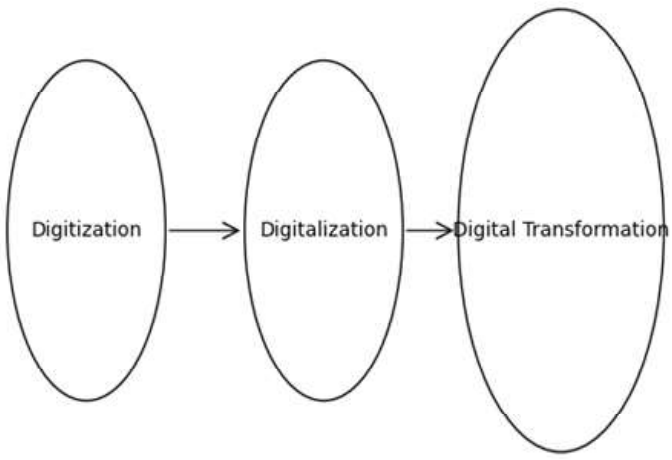

Figure 5: Digitization, Digitalization and Digital Transformation (Made by the writer)

in the 1950s. Despite a lengthy history of project management, building projects worldwide have needed better performance, including cost overruns, schedule delays, and low-quality products. This requires a rigorous analysis of the industry's present project management procedures and the identification of opportunities for improvement. Planned construction projects are necessary and complex because they include a sequence of processes that must be completed concurrently to satisfy the project's objectives. The source says project planning comprises requirements, technology accessibility, specified scope and resource allocations, team building, and identifying procedures that cause these associated tasks to be completed. For details, A construction project plan must address all construction elements from the beginning to the end.

5. Findings

Touchplan is a daily construction planning program that increases the predictability and profitability of project results. Touchplan is the most collaborative platform for planning, replanning, and optimizing daily recuperation, with the most up-to-date data and insights from the work site. Touchplan has conducted a poll to determine the effect that construction planning software has on construction project management. This survey was done in conjunction with the Lean Construction Institute and was sent to members on February 18, 2022. Over 110 individuals from 63 of the major companies in the United States responded to this study (Knotten *et al.,* 2014). 86% of respondents reported using digital planning tools to oversee their building projects. As a result of using construction planning software, 95% of respondents are confident that it has a favorable return on investment and pays for itself quickly. This thesis examines how Touchplan was created to give a more organized method that helps you attain more confidence and predictability. Utilizing construction planning software will save time on projects. This significantly reduces the amount of rework required to accomplish a project. Reduce the number of project hand-offs that are missed. Normalize your procedures. Reduce daily phone calls, text messages, and email. The majority of respondents to the poll are general contractors (65%) (Knotten *et al.,* 2014).

The majority of poll participants support Lean Construction and the Last Planner System® (65%). The construction industry in 2022 is plagued with pandemic hangovers: delayed or cancelled projects; supply chain problems; pricing rises; delivery delays; and most urgently, a manpower crisis accompanied by an unprecedented mass exodus. As burdensome as the epidemic is, it has pushed the sector into the digital arena. In the face of a labor shortage of crisis proportions, enterprises are prioritizing technology to maximize efficiency, enhance profitability, improve work site quality and safety, and retain top personnel. As evidence of this digital shift, construction technology investors' financing hit a new high of $2.1 bn in 2021, an increase of more than 100% from the previous year. As the industry responds simultaneously to these difficulties and new digital opportunities, construction technology continues to bring workers together to allow improved cooperation across the whole project life-cycle. This portion of the thesis examines in detail how our clients distinguish themselves from their competition by enabling their employees to do their best job using Procore. By supporting more collaborative project delivery from pre-construction through close out, our clients unlock the productivity of their staff for more predictable and lucrative business (United Solutions, 2019).

We think that, in the end, this book will assist you to do what creation has continually executed: figure out a way to resolve the problems of building the global and our future collectively. A worldwide survey of 2,687 Procore customers, inclusive of those from North, primary, and South the united states, the Caribbean, Asia, Europe, Australia, and New Zealand. The facts includes all sizes of trendy contractors, distinctiveness contractors, and proprietors are protected in the statistics. All survey solutions are self-pronounced, and except in any other case said, all references to customers, users, or some other stakeholder institution discuss with the population polled (Vandenberghe, 2004).

Lean Construction is a set of principles that aim to optimize project delivery by eliminating waste and enhancing efficiency (Figure 6). This research categorizes the level of AI adoption in the construction industry into four groups: Not started (4.8%), starting in the next few years (11.5%), started last year (21.2%), and committed (62.5%). These categories represent the industry's varying degrees of commitment to adopting AI technologies to enhance Lean Construction Principles.

Theoretical Frameworks: This study employs several theoretical frameworks to analyze the adoption of AI in the construction industry.

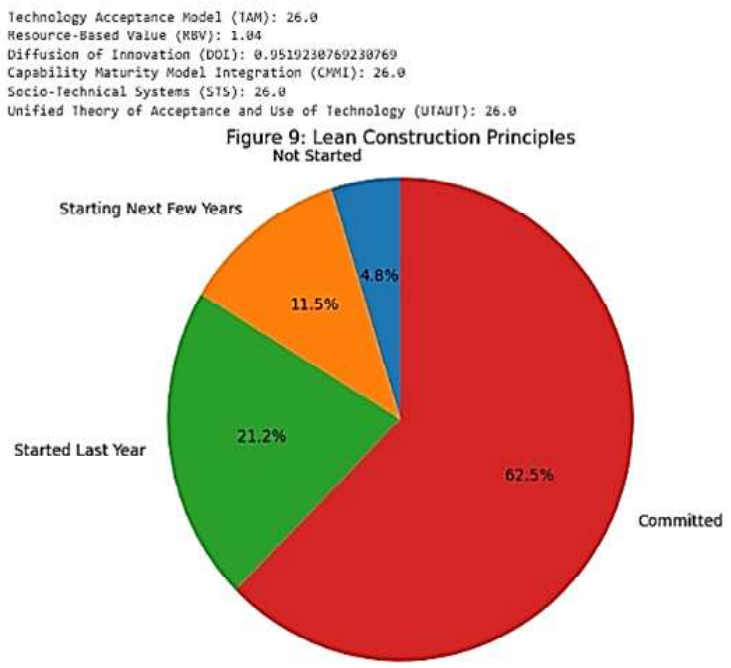

Figure 6: Lean Construction Principles

Technology Acceptance Model (TAM): The TAM score of 26.0 suggests that the willingness of construction professionals to embrace AI is relatively high. This indicates that attitudes toward AI technology play a pivotal role in its adoption in construction projects.

Resource-Based Value (RBV): The RBV score of 1.04 signifies the importance of having the necessary resources to implement AI in construction effectively. Access to AI technologies and the ability to leverage these resources are key determinants of success.

Diffusion of Innovation (DOI): With a DOI score of 0.95192, this framework emphasizes the importance of how new ideas and innovations, such as AI in construction, spread within the industry. It highlights the need for effective communication and collaboration among stakeholders.

Capability Maturity Model Integration (CMMI): The CMMI score of 26.0 suggests that the construction industry is at a relatively high maturity level in terms of its capability to integrate AI into project workflows. This demonstrates the industry's readiness to adopt AI.

Socio-Technical System (STS): STS has a score of 26.0, indicating that the adoption of AI in construction projects is not solely a technological matter. It involves a complex interplay between technological and social aspects, underscoring the significance of considering both aspects for successful implementation.

Unified Theory of Acceptance and Use of Technology (UTAUT): The UTAUT score of 26.0 highlights the importance of understanding end-users' perceptions and intentions regarding AI adoption in construction. It suggests that end-user acceptance and usage play a substantial role in determining the success of AI integration.

The geographical distribution of the survey participants is proven within the parentheses (Figure 7). Most members have been from the US (87%) observed via Canada (8%), APAC (Asia Pacific) (1%), EMEA (Europe, Middle East, and Africa) (2%), and LATAM (Latin America) (2%). The survey was performed globally, and the high illustration of individuals from the US and Canada is probable because of the high adoption of era and AI within the construction industry in these areas.

The top-rated construction productivity for the US is 87%, which is extensively higher than other areas. This can be due to the advanced generation and infrastructure available within the US, as well as the excessive level of investment in studies and improvement. The excessive productivity inside the United States can also be attributed to the adoption of lean construction principles and the use of advanced technology, including BIM and CAD.

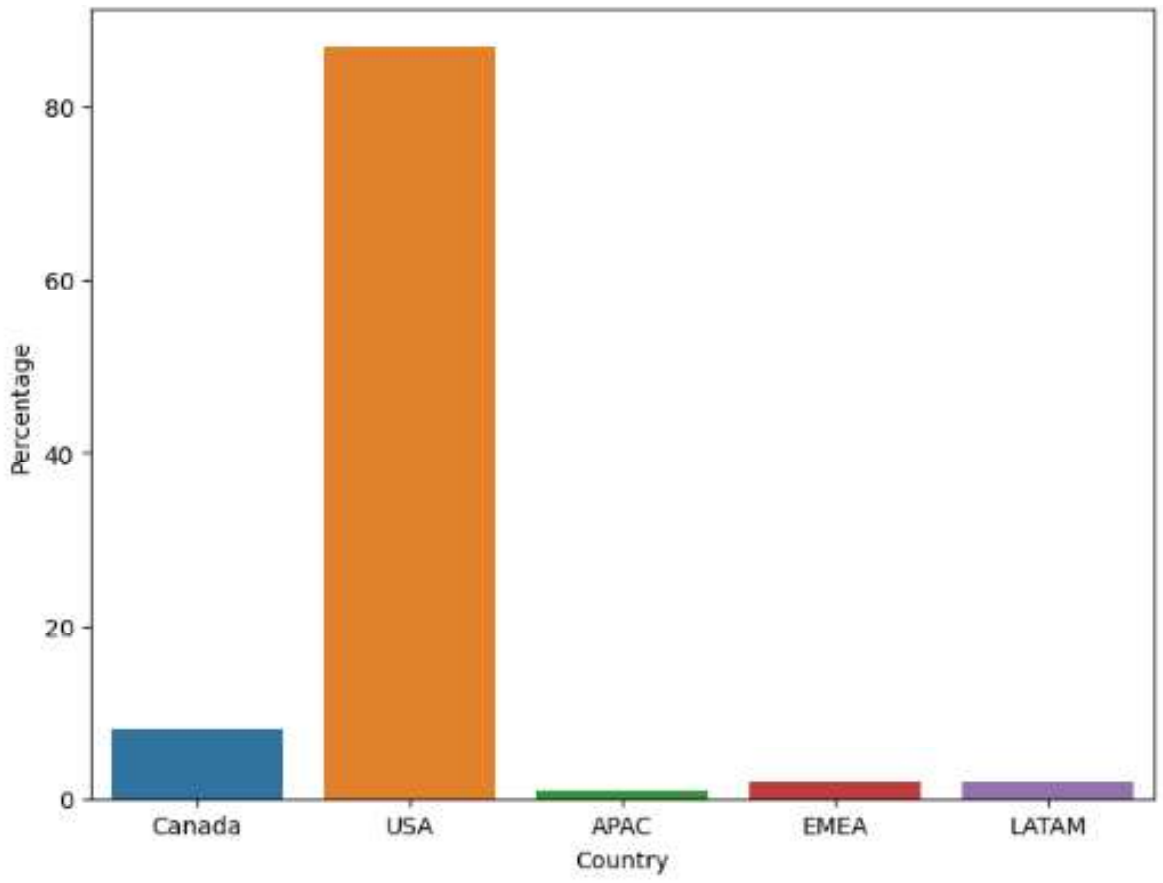

Figure 7: Geographical Representation of Global Survey Participants

The generation popularity version (TAM) and Diffusion of Innovation (DOI) may be used to give an explanation for the adoption of AI within the construction industry. TAM suggests that perceived usefulness and perceived ease of use are the number-one determinants of era adoption. The excessive level of perceived usefulness and simplicity of use within the USA can contribute to the high adoption of AI inside the construction industry. DOI indicates that the fee for adoption is stimulated through factors consisting of relative benefit, compatibility, complexity, trialability, and observability. The excessive degree of relative advantage, compatibility, and observability inside the United States can also contribute to the high adoption of AI within the construction industry.

The Resource-Based View (RBV) shows that corporations that have a unique set of resources and abilities may have an aggressive advantage. The excessive productivity in the USA can be attributed to the particular set of sources and competencies that companies in this place own, together with advanced generation, infrastructure, and funding in studies and development.

The Capability Maturity Model Integration (CMMI) is a framework for evaluating the adulthood of an organization's methods. The high level of procedural adulthood within the US can contribute to excessive productivity inside the creation enterprise.

The Socio-Technical System (STS) is a framework for understanding the interplay between technology and society. The excessive stage of adoption of AI in the construction industry inside the US can be attributed to the favorable social and cultural context that helps the usage of technology in construction.

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a framework for knowledge about the determinants of generational attractiveness and use. The excessive degree of recognition and use of AI in the construction enterprise within America can be attributed to the favorable psychological, social, and organizational context that supports the use of AI in creation.

Figure 8 below offers an outline of the construction industry in terms of annual quantity and capital spend variety. It indicates that the development enterprise can be extensively categorized into three segments: rising, mid-market, and business enterprise. Emerging corporations, with annual construction quantity of $20 mn or less, are generally small to medium-sized agencies which might be just beginning to explore the usage of AI in construction. These agencies often have restricted assets and budgets, however they're eager to embody new technologies that can assist them live aggressive.

Mid-market agencies, with annual creation quantity between $20 mn and $100 mn, are commonly large than emerging corporations, but still have restricted resources compared to business enterprise groups. those companies are beginning to undertake AI in a greater great way, but can also nonetheless face challenges in terms of implementing and integrating these technology into their present workflows.

Company agencies, with annual creation volume of $101 mn or extra, are the largest and most established players inside the production industry. those businesses have the sources and budgets to invest within the maximum superior AI technology, however may additionally face challenges in phrases of adapting to new technology and integrating them into their current operations.

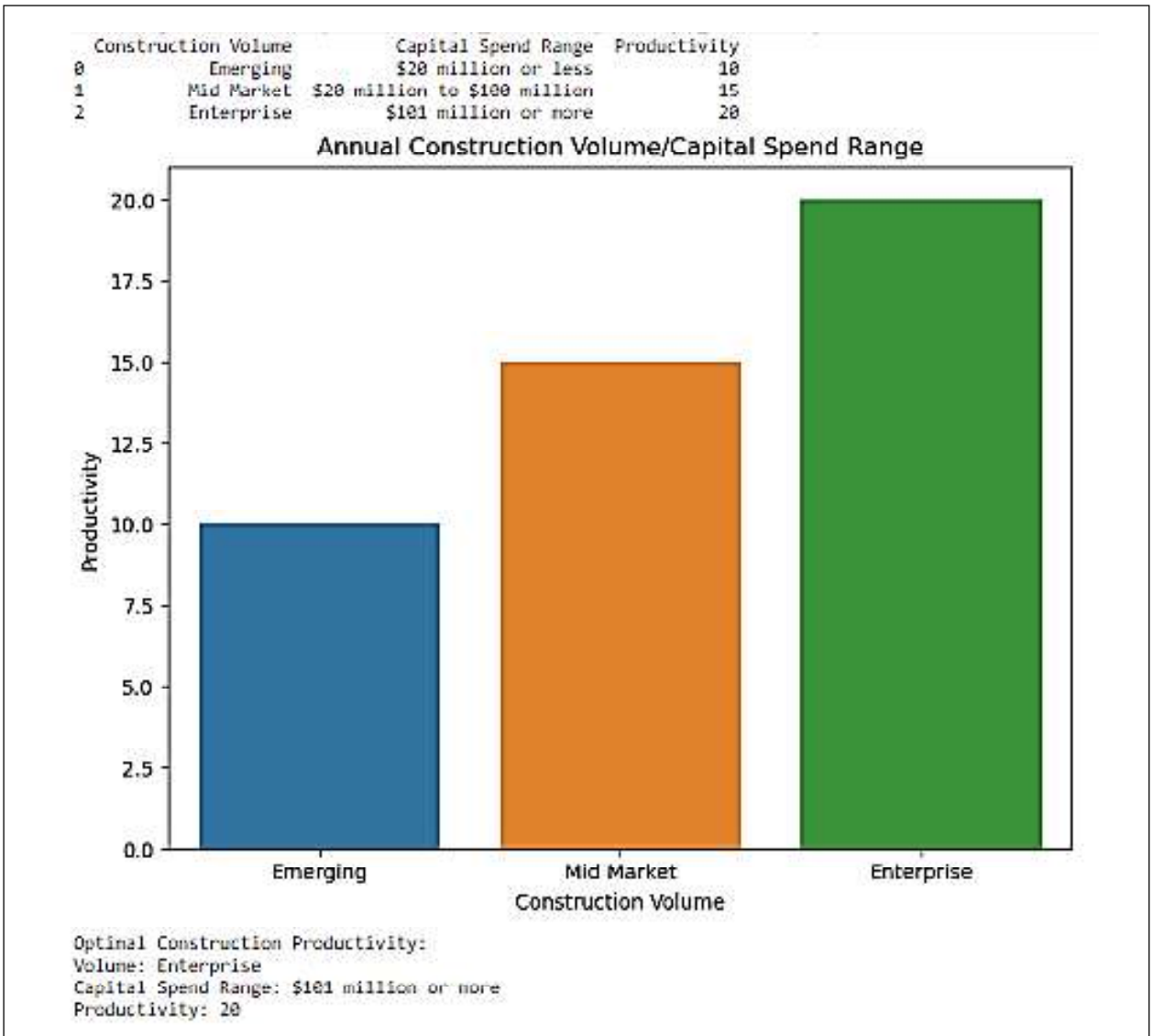

Figure 8: Annual Construction Volume/Capital Spend Range

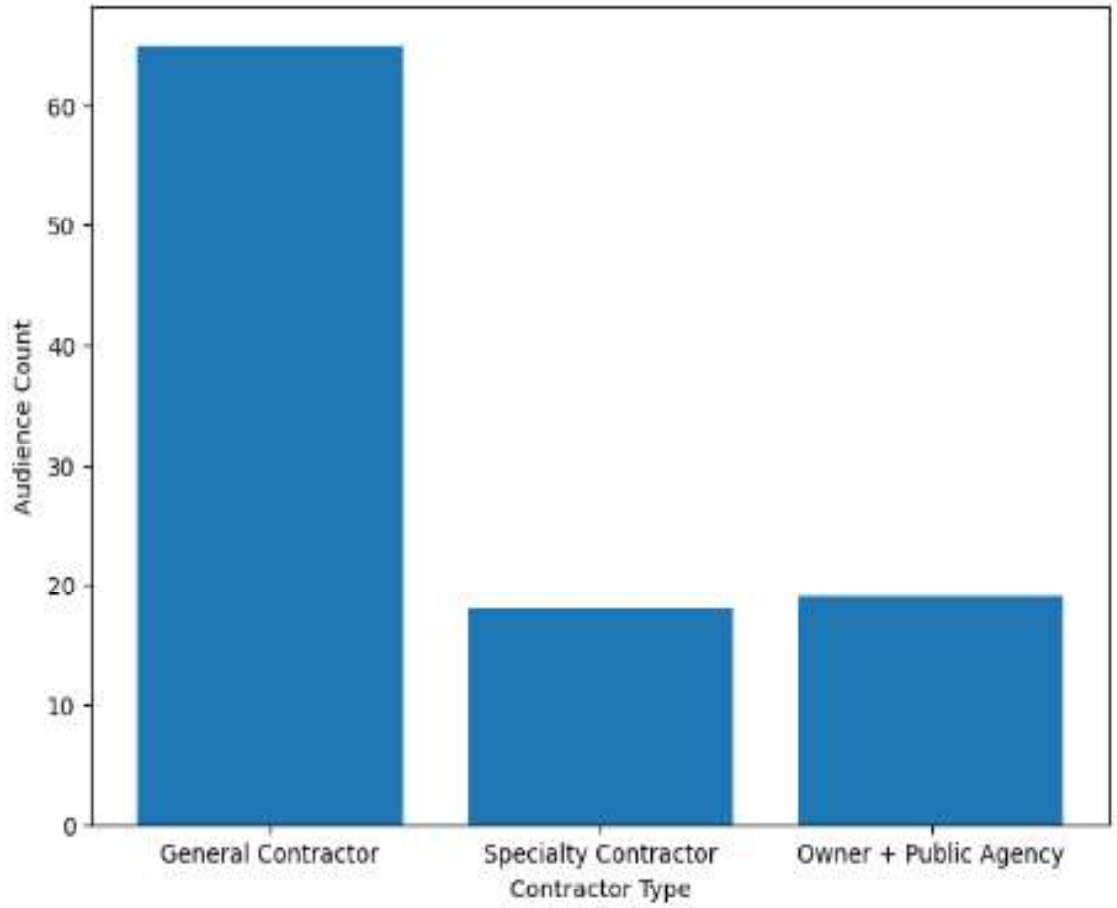

Figure 9: Audience Between General Contractor, Specialty Contractor and Owner + Public Agency

In Figure 9, an examine carried out with the aid of the construction industry Institute found that the most useful construction productiveness will be executed whilst all stakeholders, including fashionable contractors, strong point contractors, and proprietors/public businesses, collaborate effectively. The have a look at suggests that AI can play a critical position in facilitating this collaboration and enhancing productiveness through leveraging AI technologies consisting of device studying and predictive analytics, stakeholders can advantage insights into project performance, perceive capacity bottlenecks, and make records-pushed selections to optimize workflows and enhance productivity. The consequences of this studies are vast for the development enterprise, because it shows that AI has the capacity to revolutionize creation productivity and force huge improvements in project results.

Figure 10 represents the relationship between different elements mentioned in the paper topic "Revolutionizing Construction: The Impact of Artificial Intelligence on Productivity" in terms of technology, process, and culture. It illustrates the flow of concepts starting from analyzing big data and continuous learning in the technology aspect, to decision-making and quality-check support in the process aspect, and finally, action-based on data and better communications in the culture aspect.

6. Discussion

This phase demonstrates diverse AI-based production sector programs. The capacity of system mastering to study huge facts sets and analyze from enjoy can be used as a selection-making resource. amongst other applications, pattern popularity may be used for web page monitoring and creation verification. monitoring the site can also improve site safety, whilst construction verification is probable to store loads of hours compared to human verification. Several startups comparing the usage of machine gaining knowledge of and sample recognition at the moment are trying to input the market (Venkat Narayana Rao, 2021). This studies also

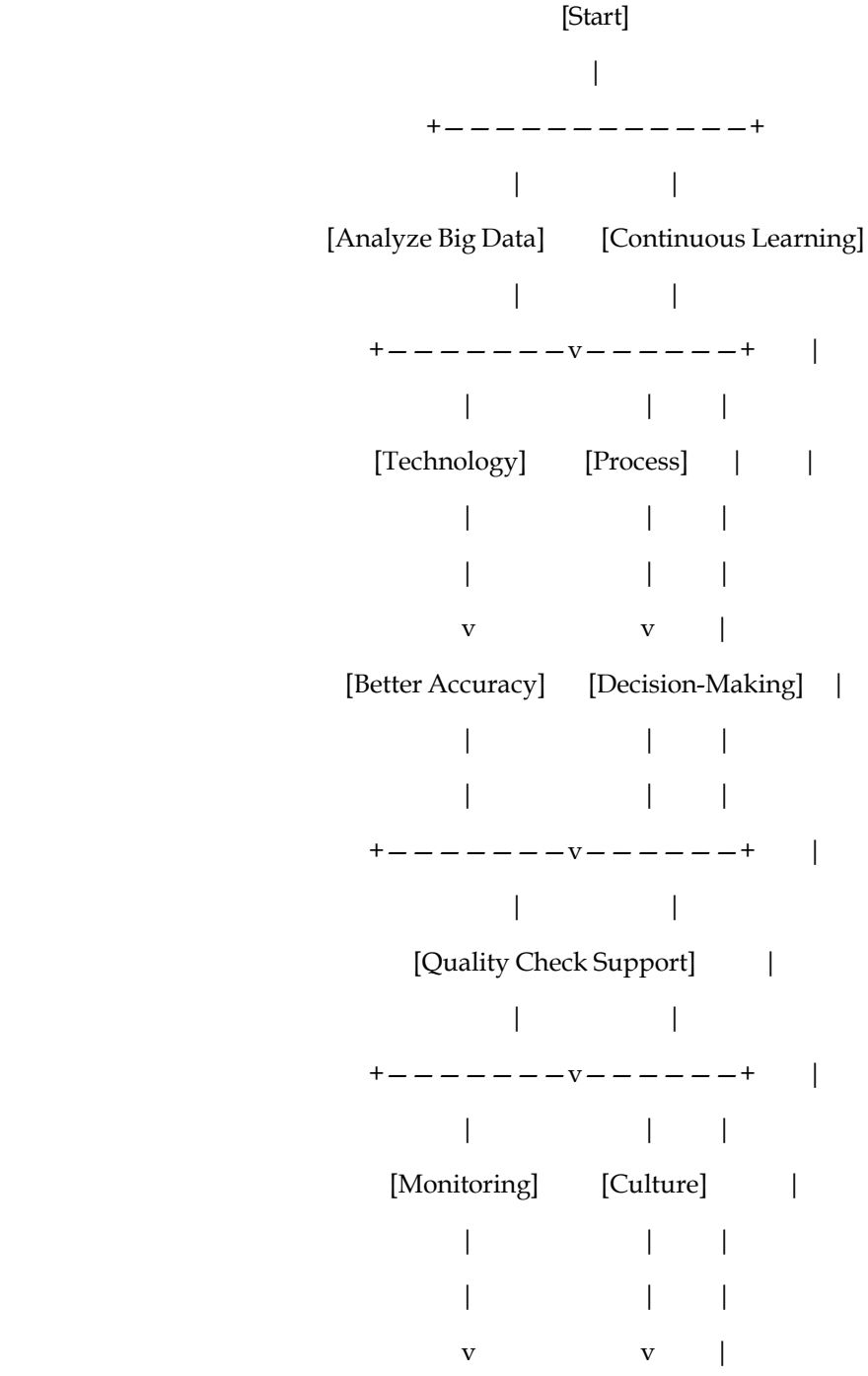

Figure 10: Analyzing Big Data, Decision-Making, and Data-Driven Culture in Revolutionizing Construction with AI

demonstrates that robots may be used on constructing sites. but, they're handiest employed to do repetitive jobs in a controlled putting at present. To recognize the advantages, various barriers ought to be eliminated. The subsequent section will complex. Any AI gadget (which includes machine studying, pattern popularity, and robotics) must have good enough facts, and the perfect variables. The results suggest that pattern reputation is usually used in the healthcare business to discover ailments of their earliest tiers. Globally, medical workplaces and hospitals are partnering to continually generate more information (Wandersman, 2012).

Consequently, AI-structures are continually developing extra accurate, unique, and thus dependable. Can the construction commercial enterprise use these training and advantage knowledge from the healthcare sector? One may also argue that each constructing challenge is particular, but the human frame includes same elements. Given that every building task is precise, it is going to be tough to acquire facts that can be nicely transferred across initiatives. To position it any other way, it is apparent that each constructing mission is particular when visible from a holistic perspective. They may be positioned in numerous geographic places and feature awesome appearances, including facades, home windows, and so on. But, when each creation project is damaged down into its component elements, is each assignment as unique and difficult because it first seems? It's far feasible to disassemble the complete shape into smaller additives. We begin with the aid of looking at the whole structure, then the concrete shape, then all of the concrete slabs, and finally a single concrete slab (Wang, 2021). How many methods are there to assemble a concrete slab? No longer quite as several because the number of illnesses which could increase inside the human body, an awful lot less the variety of reasons for those issues. The more facts is furnished to an AI device, the more exact and dependable its findings could be. Logically, the collection of records might be expanded if numerous construction initiatives create facts simultaneously, a lot as scientific workplaces and hospitals all through the globe collaborate.

Because of the competitive nature of the development zone, close cooperation among organizations has not been the norm. Nevertheless, the tilt mind-set, with its emphasis on cooperation and growing performance via removing non-effective factors, has now penetrated the construction quarter. Collaboration between agencies to collect information can be visible as an act of removing what is ineffective (Wang, 2019). Which groups will personal the acquired records might be a giant topic of debate and a problem to be addressed within the future? As assert, is a partnership based totally on agreements enough to assure that all businesses maximize the gain of all companions? How subcontractors should be paid if the AI machine figures out the most secure, maximum

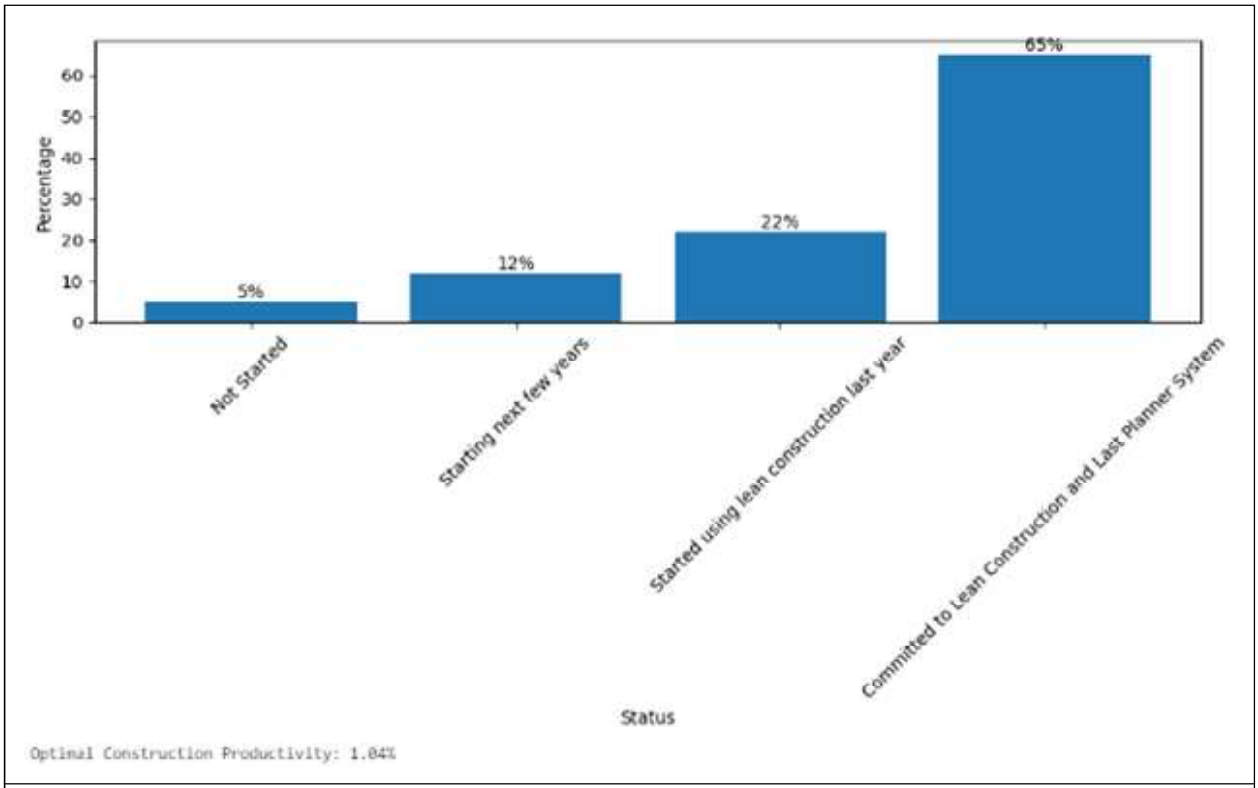

Figure 11: Optimal Construction Productivity

productive, and least highly-priced manner to build a certain element? Even greater essential than the amount of statistics generated is the nice of the statistics produced. Consistent with, it isn't sufficient to have a significant amount of facts from earlier times; the records need to reflect the actual situation. It have to be accurate for you to assist human beings in their jobs considering AI-primarily based algorithms study from the furnished information and create predictions primarily based on the statistics discovered. given that the construction industry is challenge-based and includes a massive quantity of specialized co-workers running at the equal construction challenge for a brief time period, communicating the importance of providing correct enter records can be difficult (Warszawski, 1984).

Figure 11 illustrates the distribution of production organizations based on their adoption of lean production and the ultimate planner gadget. In many of the surveyed firms, 5% haven't begun to provoke these practices, at the same time as 12% have plans to start imposing them within the close to destiny. Furthermore, 22% have already begun utilizing lean creation strategies inside the beyond the year. Remarkably, the general public of companies, constituting 61%, have confirmed their commitment by using adopting each lean creation and the ultimate planner system, indicating a robust force closer to optimizing creation productiveness via advanced methodologies.

7. Conclusion and Further Research

This next section provides responses to the two research questions and clarifies the goal of this report on the doctorate thesis, as outlined in the first chapter of the report (the introduction). In conclusion, several suggestions are offered regarding the direction of future study. This thesis is a groundbreaking piece of work since it analyses the use of Artificial Intelligence (AI) in the construction sector and how people and AI-based technology should operate together (Wei and Li, 2011). The investigation has been carried out in the form of a review of the relevant literature and several separate case studies. The employees who were selected come from a wide range of backgrounds in terms of their jobs, levels of expertise, ages, and general views regarding AI. Because there were employees from a variety of backgrounds, it is reasonable to infer that the results of this research may be extrapolated to future projects both in Norway and in other countries, such as South Africa (Wille Schoeman, 2021).

The purpose of this study was to provide answers to the research questions that were based on the difficulties that are present in the current practices of construction project planning, the AI solutions that are currently available, and the justification for a better and more widespread implementation of AI in construction project planning (Wood, 2022). The first research question, which will be answered in the next part, is as follows: What are the possible advantages of applying AI in the construction industry? It is possible to draw the conclusion that AI is here to stay, and there are many advantages associated with putting AI into practice. The study that has been carried out suggest, however, that in the future there will be tighter cooperation across nations. In this vein, it could be fascinating to study issues of ownership and trust amongst individuals who have either never met each other in person or have done so just a limited number of times. The scope of this research was restricted to examine how artificial intelligence-based technology is being used in the construction business.

References

Abiodun Ganiyu, A., Olusola, L.O. and Adelakun, A.A. (2020). BIM Competencies for Delivering Waste-Efficient Building Projects in a Circular Economy. *Developments in the Built Environment*, 4, 1-17. https://doi.org/10.1016/j.dibe.2020.100036

Agarwal, A., Chakraborty, S. , Kumar, M. and Praveen Kumar, P.K.P.(2016). The Digital Future of Construction. Oct. [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/1478077120934126?journalCode=jaca. [Accessed August 8, 2021].

Agarwal, A., Chakraborty, S., Kumar, M., Praveen Kumar, P.K.P.and Abhay Kumar, C.S. (2020). Generative Systems in the Architecture, Engineering and Construction Industry: A Systematic Review and Analysis. June 29, [Online]. Available: https://journals.sagepub.com/doi/abs/10.1177/1478077120934126?journalCode=jaca. [Accessed Aug. 8, 2021].

Sururah A. Bello, Lukumon, O.O., Olugbenga, O.A., Muhammad Bilal, Juan Manuel Davila Delgado, Lukman, A. Akanbi, Anuoluwapo, O. Ajayi and Hakeem, A. Owolabi (2021). Cloud Computing in Construction Industry: Use Cases, Benefits and Challenges. *Automation in Construction*, 112, 103441.

Agarwal, A., Chakraborty, S. , Kumar, M. and Praveen Kumar, P.K.P. (2016). The Digital Future of Construction. Oct. [Online]. https://journals.sagepub.com/doi/abs/10.1177/1478077120934126?journal Code=jaca. [Accessed August 8, 2021].

Agarwal, A., Chakraborty, S. , Kumar, M., Praveen Kumar, P.K.P. andAbhay Kumar, C.S. (2020). Generative Systems in the Architecture, Engineering and Construction Industry: A Systematic Review and Analysis. June 29, [Online]. https://journals.sagepub.com/doi/abs/10.1177/1478077120934126?journalCode=jaca. [Accessed August 8, 2021].

Khobragade, A.N.M.N.S.M. (2018). Analyzing the Housing Rate in a Real Estate Informative System: A Prediction Analysis. *International Journal of Civil Engineering and Technology*, 9(5), 1156-1164.

Samer BuHamdan, A.K. and Mohamed, A.A.B.W.M. (2018). Mobile Augmented Reality Applications for Construction Projects. *Construction Innovation,* 18(2), 152-166.

Kayid, A. (2020). The Role of Artificial Intelligence in Future Technology. 10.13140/RG.2.2.12799.23201

Kiranyaz, A., Ince, T. and Gabbouj, M. (2014). *Multidimensional Particle Swarm Optimization for Machine Learning and Pattern Recognition*, 1st Edition, Springer, Berlin, Heidelberg.

Kirsch, A. (2018). Explain to Whom? Putting the User in the Center of Explainable AI, Tübingen, Workshop Proceedings. CEUR.

Knotten, A. *et al.* (2014). Integrated Methodology for Design Management – A Research Project to Improve Design Management for the AEC Industry in Norway. in Proceedings from the Annual Conference of the International Group for Lean Construction (IGLC), Oslo.

United Solutions. (2020). What is Procore?. 2019@United Solutions Group, May 5 [Online]. https://blog.u-s-i.com/blog/what-is-procore. [Accessed February 7, 2021].

Vandenberghe, S.B. and L. (2004). *Convex Optimization, The Edinburgh Building*, Cambridge University Press, Cambridge, New York.

Venkat Narayana Rao, A.G.M.K.K.S.T. (2021). Reliance on Artificial Intelligence, Machine Learning and Deep Learning in the Era of Industry 4.0. in Smart Healthcare System Design: Security and Privacy Aspects, 281-299, D.S.SK Hafizul Islam, Ed., Scrivener Publishing LLC, Beverly, MA.

Wandersman, D.C.M.J.A.D. (2012). The Quality Implementation Framework: A Synthesis of Critical Steps in the Implementation Process. *Society for Community Research and Action*, 50(3-4), 462-480.

Wang, T. (2019). China: Construction Industry's Contribution Share to GDP 2018-2021. *Statista,* December 12. [Online]. https://www.statista.com/statistics/1068213/china-construction-industry-GDP-contribution-share/. [Accessed November 13, 2021].

Wang, T. (2021). Value Added of US Construction as a Percentage of GDP 2018. *Statista*, April 27. [Online]. https://www.statista.com/statistics/192049/value-added-by- us-constructionas-a-percentage-of-gdp-since-2007/. [Accessed November 13, 2021].

Warszawski, A. (1984). Application of Robotics to Building Construction. *Computer Science*, Pittsburgh. https://doi.org/10.22260/ISARC1984/0003

Wei, C. and Li, Y. (2011). Design of Energy Consumption Monitoring and Energy-saving Management System of Intelligent Building Based on the Internet of Things. in the 2011 International Conference on Electronics, Communications and Control (ICECC), Beijing.

Wille Schoeman, R.M.Y.S.a.D.J.Y.J. C. (2021). Artificial Intelligence is South Africa Ready? July. [Online]. Available: https://www.accenture.com/_acnmedia/pdf-107/accenture-ai-south-africa-ready.pdf. [Accessed August 8, 2021].

Wood, L. (2022). Key Trends and Opportunities in the South African Construction Industry to 2025: Rebound Forecast for 2022 - ResearchAndMarkets.com, Research and Markets, 21 February. [Online]. https://www.businesswire.com/news/home/20220221005249/en/Key-Trends-andOpportunities-in-the-South-African-Construction-Industry-to-2025-Rebound-Forecast-for-2022—-ResearchAndMarkets.com#:~:text=The%20construction%20industry%20in%20South,during%20the%20e. [Accessed July 19, 2022].

Wysocki, R.K. (2013). Effective Project Management: Traditional. *Agile, Extreme*, 7th Edition, John Wiley & Sons, Inc., New Jersey.

Xianfei Yin, H.L.Y.C.M.A.-H. (2019). Building Information Modelling for Off-site Construction: Review and Future Directions. *Automation In Construction*, 101, 72-91. https://doi.org/10.1016/j.autcon.2019.01.010

Cite this article as: Nwosu Obinnaya Chikezie Victor (2023). Revolutionizing Construction: The Impact of Artificial Intelligence on Productivity. *International Journal of Artificial Intelligence and Machine Learning*, 3(2), 57-73. doi: 10.51483/IJAIML.3.2.2023.57-73.