A Theoretical Assessment on the Implementation of Artificial Intelligence (AI) for an Improved Learning Curve on Construction in South Africa

M G Phaladi1,6, X N Mashwama2, W D Thwala3, C O Aigbavboa4
1,2,3,4 Department of Construction Management and Quantity Surveying, University of Johannesburg, 25 Louisa Street, Doornfontein, 2028, South Africa

Email: phaladimg@gmail.com

Abstract. Generally, the construction sector is lacking behind with the usage of technological software. Artificial Intelligence(AI) technology is viewed as a technological tool that can improve the timeous delivery of construction project(s). Therefore, the study is a literature review on the assessment of the implementation of AI technology on South African construction projects. The qualitative approach and purposive sampling technique were adopted in this study. The primary findings emanating from this study reveals that the past other underground empirical studies have identified several important impacts of AI technology and how it can transform the construction industry. Furthermore, the study findings revealed that if AI technology is fully exposed and exploited on construction projects especially to both developed and developing countries it would certainly improve productivity, enhance efficiency, and performance issues. On the other hand, the level of implementation of AI technology in South Africa is still very low. Therefore, the study would contribute to the body of existing knowledge of AI technology on construction projects, especially in South Africa.

1. Introduction

The construction sector is one of the less digitalized industries in the world when compared to other industries. Adopting the latest technologies can be daunting for the construction teams. However, the construction sector is still lacking behind with the usage of digital technologies (Barbosa et al., 2017). In the past years, researches have been conducted regarding the possible methods that can be adopted to increase construction project productivity. On the contrary, the introduction of the Fourth Industrial Revolution (4IR) features to our daily lives, has forced the construction industry to implement those features to improve their level of competitiveness on the project(s). One of the recommended features is Artificial Intelligence(AI) technology. The majority of the developed countries have adopted the AI technology where its benefits have been realized when compared to the developing countries especially African countries. Furthermore, companies have been advised to adopt digital technologies to their construction activities to achieve ultimate efficiency. Gotthardt et al. (2019), justified that the implementation of AI technology increases efficiency and eliminates cost overruns. Previous studies have indicated that the adoption of AI on construction projects has increased over the past years. The application of AI on construction projects has benefits such as enhanced productivity growth (Jesuthasan, 2018), changes to the approach of work (Jariwala, 2015), improves decision making, improves profitability, reduces construction design errors, and eliminates accidents on site. Despite the positive influence AI has on construction projects, they are concerns about future employment opportunities especially for construction workers such as certain skills would be obsolete whilst the adoption of digital technologies might require experienced personnel who knows how to use AI systems. This brings uncertainty about whether the adoption of AI would be successful or not (Nickerson, 2019). This paper aims to assess the role of implementing AI on construction projects, and also to examine how AI technology can be used to enhance construction project productivity. This paper will further present a literature review, methodology, summary, conclusion, and recommendations for future studies.
2. Literature review

2.1 South Africa and the Construction industry

In 2020, the world has and still experiencing the disease called coronavirus pandemic which was firstly discovered in 2019 in China. Hui et al. (2020), further said that the disease is caused by "severe acute respiratory syndrome". However, construction companies in both developing and developed countries were drastically affected by the coronavirus pandemic where most of the firms were forced to shut down particularly small and medium enterprises. The situation has resulted in companies facing commercial and legal difficulties (Woertz, 2020). Most of the industries have experienced economic downfalls and recessions. According to Fernandes (2020), further stated that the effect of the pandemic on the economy has resulted in to decrease in Gross Domestic Product (GDP) by approximately 2-6% in some of the nations. Most of the workers were forced to operate remotely as a remedy for easing coronavirus infections. However, considering the type of activities performed on construction projects, it is always difficult to work remotely as a result of activities that have to be inspected and monitored by the project team. One of the critical challenges during the pandemic was that the majority of the people lost their employment. As for the construction sector, human laborers on-site lost their jobs as a result of lockdown (KHL, 2020). The coronavirus pandemic has affected the construction sector in various ways which include; shortage of supplies, high cost of materials, and late deliveries (Mordor Intelligence, 2020). Trowers and Hamlins (2020), added that a decrease in supply and demand resulted in to decrease in revenues where firms are forced with the tough decision of reducing the wages and dismissing the workers. That has led to construction projects being completed longer than anticipated. During the coronavirus pandemic, the rate of unemployment has increased in both developed and developing countries. Generally, the construction sector does not have a high number of the skilled and experienced workforce (Al-Amri and Marey-Perez, 2020).

On the other hand, the construction industry is one of the biggest sectors that create employment opportunities and contributes to the national economic growth in South Africa (Oyewobi et al., 2015). The construction industry in South Africa is not growing as expected due to various factors that hinder its progress. Some of the factors include the poor implementation of the latest technology on a construction project (Kapoor, 2011). Windapo and Cattell (2013), further stated that the South African construction industry is still lacking behind with the usage of technologies when compared to other developed nations. Again, the South African construction sector is still suffering from poor productivity. Factors affecting productivity growth include; lack of skilled manpower, inexperienced contractors, shortage of materials on-site, insufficient finances to proceed with construction works, and design errors, etc. Rust et al. (2013) opined that if productivity growth is poor on construction projects, the performance would massively be affected as well. Modares and Sepehri (2009), further postulated that the reasons for South Africa to experience productivity issues is because of the corruption, fraud, and lack of proper construction methods performed. Moreover, some of the contractors cannot afford to pay and maintain experienced personnel such as permanent supervisors and skilled laborers during the project life span (Ofori, 2013). Windapo (2016), stated that South African contractors have a problem paying experienced laborers, thus resulting in opting for inexperienced laborers to perform work on-site which has often led to defective works. For construction organizations to increase economic growth and to improve their construction projects, the government institutions have to take center stage by encouraging and financially supporting them to adopt the latest technologies to their projects.
2.2 The role of Artificial Intelligence on construction projects

Artificial Intelligence (AI) is defined “as the ability of a machine to mimic intelligent human behavior, this seeking to use human-inspired algorithms for approximating conventionally challenging problems” (Salehi and Burgueno, 2018). The implementation of AI technology on construction projects differs depending on each firm’s requirements. According to Marr (2019), said companies can adopt AI to enhance efficiency. Previous studies conducted found out that AI will enhance productivity (Jariwala, 2015), quality of activities performed would be improved (Lin and Hazelbaker, 2019), and creates employment opportunities (Greenman, 2017). Construction companies can use AI to achieve the client's objectives such as timeous delivery of the projects. However, the usage of AI in the construction sector is very incomplete (Blanco et al., 2018) compared to the other industries. The construction sector has lost its good reputation due to poor productivity, performance, and low usage of technological software. Moreover, AI is seen as a technological tool that can eliminate the industry's greatest predicaments such as safety issues, additional cost, and time (Blanco et al., 2018). Generally, the usage of AI technology on South African construction projects is very low since it is still at the development stage. The reason behind slow adoption is due to poor leadership and lack of faith by company owners. Besides, the high cost associated with the implementation of AI proves to be a major stumbling block for the majority of construction firms, particularly small and medium firms. Luo et al. (2018), claim that AI systems cannot produce the expected results. In contrast, AI technology would certainly improve the lack of productivity and efficiency on construction projects in the following ways;

2.2.1 Monitoring of construction activities

Construction projects often require supervision of activities where supervisors/construction project managers need to deliver the project on time, within the estimated budget, of good quality, and recommended safety to meet the client objectives. Artificial Intelligence technology can be used to monitor the activities happening on site such as workers who are not wearing personal protective clothing and also to store important information about the construction site. According to Strukova and Liska (2012), added that construction project managers can be able to access stored information.

2.2.2 Estimation of quantities and planning

With the usage of Artificial Intelligence systems project teams can be able to plan their tasks and estimate accurate costs on the project. The AI software will break down and plan the activities automatically which makes the work of construction project managers easier (CastroLacouture, 2009).

2.2.3 During the design phase

The application of Artificial Intelligence (AI) technology on construction projects would allow the contractors and project team to view designed structures in Three dimensions which reduces the design errors on-site (Castro-Lacouture, 2009). Engineers and Architects can leverage AI technology to eliminate unnecessary mistakes done by the contractors as a result of missing information on designed structures. Furthermore, the usage of smart technology can show a clear connection of pipework to avoid any future leakages of the pipes.

2.2.4 Controlling quality

The majority of the construction projects have been affected by a lack of quality on work done especially after few months of handing over the project to a client(s). This is caused by the low usage of technologies on construction projects to detect faults. However, the introduction of Artificial Intelligence (AI) technology brings the quality that has been lacking over the years on construction projects. The adoption of AI technology can be used to inspect the work if it is of good quality (Balaguer and Abderrahim, 2008).

2.2.5 Overcoming shortages of experienced labors

Construction projects are often facing the challenge of keeping experienced laborers because most of the contractors not willing to meet their wage demands. The investment in Artificial Intelligence (AI) machines by firm owners would replace the headache of maintaining experienced laborers. This is because the implemented intelligent machines on-site can be able to perform the tasks which were
performed by human beings (Boyd and Holton, 2017) which in return decreases the design errors caused by human labor.

3. Research Methodology
The study is a theoretical literature review that was conducted with the usage of previously published conference papers and journal articles. The main research study is still in progress. However, a qualitative research approach was selected. The qualitative data would be collected through in-depth interviews with the respondents to gain knowledge of AI technology directly from them. The preferred respondents are built environment professionals such as Architects, Quantity Surveying, Construction Project Managers, and Engineers. Purposive sampling was chosen as one of the sampling techniques. The respondents would be contacted and selected from the database list provided by professional regulatory bodies such as ECSA, SACPCMP, SACAP, and SACQSP.

4. Lesson learnt
The literature revealed that the construction sector plays a massive role in increasing economic growth and Gross Domestic Product. The implementation of the latest technological software such as Artificial Intelligence technology on South African construction projects is still lacking due to poor leadership display by government leaders, lack of improper infrastructure development, etc. Reviewed literature has outlined facts leading to low productivity and performance such as shortage of materials, design errors, lack of finances to proceed with construction activities. Most importantly, the timeous delivery of the project is the most rated factor experienced in developing and undeveloped countries. Modares and Sepehr (2009), pointed out that fraud and corruption in construction projects have become a norm to project teams. Hence, productivity and efficiency have not been easily achieved lately. The literature revealed has further stated that for construction projects to achieve maximum productivity, the latest technological software offered by the Fourth Industrial Revolution such as Artificial Intelligence technology has to be adopted to improve project timeous delivery. Also, the study has indicated that the usage of AI in South Africa is still very low as a result of a lack of faith in digital technology. Literature has revealed the benefits of using AI such as improved quality of work, enhanced productivity, elimination of design errors, and improved safety on construction projects. Moreover, the literature reviewed has also indicated how AI technology can be used on a construction project(s) for enhancing efficiency and productivity such as workers controlling the quality, during the design and construction phase. Literature has further revealed the impact of coronavirus pandemic on construction projects such as the majority of the workers losing their employment.

5. Conclusion and Recommendation
The study has successfully revealed the potential benefits of implementing AI technology on construction projects such as timeous delivery of the projects, enhanced productivity, elimination of cost and schedule overruns, etc. On the other hand, they are challenges of implementing AI technology such as loss of jobs by human labors, high cost associated with the adoption of AI which the study has successfully revealed. Again, the study has revealed how AI technology can be used on construction projects. The study recommends that the government institutions and professional regulatory bodies must encourage the company owners to use the Fourth Industrial Revolution features and also to financially support them particularly Small and Medium organizations. Further research has to be conducted on the stages of the project lifecycles on where AI technology can mostly be used to enlighten the construction firm owners on how to use AI technology from inception to completion of the project for improvement of productivity.

6. References
[1] Barbosa F, Woetzel J, Mischke J, Ribeirinrho M J, Sridhar M, Pearsons M, Bertram N and Brown S 2017 Reinventing construction: A route to higher productivity, Reinventing construction: A route to higher productivity (Accessed 25 March 2021).
[2] Blanco J L, Fuchs S, Parsons M and Ribeirinho M J 2018 Artificial intelligence: Construction technology’s next frontier Artificial Intelligence Construction technology’s next frontier.
[3] Greenman C 2017 Exploring the impact of artificial intelligence on the accounting profession. Journal of Research in Business, Economics, and Management 8(3) 14-51. Retrieved from:
http://scitecresearch.com/journals/index.php/jrbem/article/view/1063. (Accessed 20 March 2021).

[4] Gotthardt M, Koivulaakso D, Paksoy O, Saramo C, Martikainen M and Lehner O M 2019 Current state and challenges in the implementation of robotic process automation and artificial intelligence in accounting and auditing. *ACRN Oxford Journal of Finance & Risk Perspectives* 8 31-46. Retrieved from: http://www.acrn-journals.eu/resources/SI08_2019c.pdf (Accessed 08 January 2021).

[5] Jariwala B 2015 Exploring AI and the accountancy profession: Opportunity, Threat, both, neither? Retrieved from: https://www.ifac.org/knowledge-gateway/developingaccountancy/profession/discussion/exploring-artificial-intelligence (Accessed 07 February 2021).

[6] Jesuthasan R 2018 Future of work – reinventing jobs: A 4-step approach for applying automation to jobs Retrieved from https://www.willistowerswatson.com/en-GB/insights/2018/08/future-of-work-reinventing-jobs (Accessed 12 February 2021).

[7] Nickerson M A 2019 AI New risks and rewards Retrieved from https://sfmagazine.com/postentry/april-2019-ai-new-risks-and-rewards/ (Accessed 20 February 2021).

[8] Decanio S J 2016 Robots and humans–complements or substitutes? *Journal of Macroeconomics* 49 280-291.

[9] Marr B 2019 Why every company needs an artificial intelligence (AI) strategy for 2019 Retrieved from https://www.forbes.com/sites/bernardmarr/2019/03/21/why-every-company-needs-an-artificial-intelligence-ai-strategy-for-2019/#52cf3ead6__ (Accessed 23 February 2021).

[10] Ofori G 2013 Construction in developing countries Construction Management and Economics 25(1) 1–19 Available at https://doi.org/10.1080/01446190601141434. (Accessed 06 March 2021).

[11] Oyewobi L O, Windapo A O and James R O B 2015 An empirical analysis of construction organizations competitive strategies and performance Built Environment Project and Asset Management 5(4) 417–431. Available at: http://doi.org/10.1108/BEPM-10-2013-0045 (Accessed 23 January 2021).

[12] Rust F C, Botha C, Van Wyk L, Steyn W, Du Plessis C and Landman K 2013 *South African construction industry technology foresight study:* Summary report of a desktop study of CSIR Technical Report CSIR, Pretoria.

[13] Windapo A O 2016 Skilled labour supply in the South African construction industry: The nexus between certification quality of work output and shortages *SA Journal of Human Resource Management/SA* 14(1) 1–8.

[14] Windapo A O and Cattell K 2013 The South African construction industry: Perceptions of key challenges facing its performance development and growth. *Journal of construction in developing countries* 18(2) 65-79.

[15] Salehi H and Burgueño R 2018 Emerging artificial intelligence methods in structural engineering *journal of Engineering Structures* 171 170–189.

[16] Luo J, Meng Q and Cai Y 2018 Analysis of the impact of AI application on the development of accounting industry *Open Journal of Business and Management* 6(4) 850-856 Available from https://doi.org/10.4236/ojbm.2018.64063 (Accessed 27 February 2021).

[17] Al-Amri T and Marey-Pérez M 2020 Towards a sustainable construction industry: Delays and cost overrun causes in construction projects of Oman *Oman Journal of Project Management* 5(2) 87102.

[18] KHL 2020 Europe's Construction Industry. Retrieved from: https://www.khl.com/constructioneurope/86-of-sites-now-open-in-england-and-wales/144207/article (Accessed 27 March 2021).

[19] Trowers G and Hamllins N 2020 Covid-19: Employment update –Issues to consider in Oman Retrieved from https://www.trowers.com/insights/2020/april/covid-19---employment-update--issues-to-consider-in-Oman (Accessed 23 March 2021).
[20] Woertz E 2020 COVID-19 in the Middle East and North Africa: Reactions Vulnerabilities Prospects.

[21] Hui D S I, Azhar E, Madani T A, Ntoumi F, Kock R, Dar O and Zumla A 2020 The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health-The latest 2019 novel coronavirus outbreak in Wuhan, China *International Journal of Infectious Diseases* **91** 264-266.

[22] Fernandes N 2020 Economic effects of coronavirus outbreak (COVID-19) on the world economy. Available at: [www.SSRN 3557504](https://www.ssrn.com/series-3557504) (Accessed 21 March 2021).

[23] Mordor Intelligence 2020 Oman Construction Market Growth, Trends, and Forecast Retrieved from [https://www.mordorintelligence.com/industry-reports/oman-construction-market](https://www.mordorintelligence.com/industry-reports/oman-construction-market) (Accessed 27 March 2021).

[24] Balaguer C and Abderrahim M 2008 Trends in robotics and automation in construction.

[25] Struková Z and Líška M 2012 Application of automation and robotics in construction work execution AD ALTA *Journal of Interdisciplinary Research* **2** 121-5.

[26] Castro-Lacouture D 2009 Construction automation. In Springer handbook of automation (pp. 1063-1078) Springer Berlin Heidelberg.

[27] Boyd R and Holton R J 2017 Technology, innovation, employment, and power: Does robotics and artificial intelligence really mean social transformation? *Journal of Sociology* **1** 1–15.

Acknowledgements

Thanks to the National Research Foundation (NRF) for financially supporting me throughout the study and also to my supervisors for their expect guidance throughout the compilation of the research paper.