HP
JAESR2024
Hummingbird Publications
Journal of Agricultural & Env. Sci. Research
www.hummingbirdjournals.com
© November, 2024
Vol. 6 No. 1

The impacts of technology integration in construction for project delivery

Idowu Albert[1], Olaniyi Alake[2], Prince Akanni[3] & Samuel Emmanuel Onimisi[4]
[1,2, &3]Department of Building, Federal University of Technology Akure.
[4]Department of Software Engineering, Nigeria-Korea Friendship Institute of Vocational and Advanced Technology, Lokoja
Corresponding Author: idowualbertino@yahoo.com

Key words: Construction, Cost, Project, Quality, Technology, Time

Abstract

This research examines the influence of technology integration on the construction industry, with a specific focus on its implications for project delivery, timelines, cost management, and quality control. Given the prevalent challenges of cost overruns, schedule delays, and quality issues in traditional construction management practices, the study highlights the potential of technology to enhance project efficiency through better planning, resource allocation, and communication. Utilizing a quantitative approach, data was collected from 195 construction professionals in Lagos State via an online questionnaire, achieving a response rate of 76%. The findings reveal that technology significantly improves project delivery timelines, with tools such as Building Information Modelling (BIM) and real-time progress monitoring being particularly effective. Cost management benefits from enhanced cost estimation accuracy and real-time tracking, while quality control is bolstered by advanced defect detection technologies. Despite the clear advantages, challenges such as high initial costs and resistance to change remain barriers to widespread adoption. The study concludes with recommendations for optimizing technology integration, emphasizing the importance of identifying best practices to overcome these challenges and enhance the overall efficiency of construction project delivery.

Introduction

The construction industry faces numerous challenges in project delivery, including cost overruns, schedules delays, and quality issues (Famiyeh *et al*., 2017; Johnson & Babu, 2020; Albert *et al*., 2021). These challenges are often exacerbated by traditional manual processes and fragmented communication methods prevalent in construction management practices. In recent years, there has been a growing recognition of the potential for technology to address these challenges and improve overall project efficiency (Oluwaseun & Oluwatobi, 2020). However, the extent to which technology integration enhances construction management efficiency remains a critical research problem. One of the primary issues in construction management is the effectiveness of technology integration (Oyedele *et al*., 2018). While various technological tools and systems have been introduced to the industry, their impact on project processes and outcomes is not fully understood (Magaba *et al*., 2014). Questions arise regarding how these technologies influence project planning, scheduling, resource management, and communication, and whether they lead to measurable improvements in efficiency (Chen *et al*., 2021).

The need to understand the benefits and challenges associated with adopting and implementing technology in construction management. Technology presents several potential advantages, including augmented collaboration, data-informed decision-making, and increased project oversight, challenges such as cost, complexity, and resistance to change may hinder widespread adoption (Magaba *et al.*, 2014). The optimization of technology integration is crucial, including identifying best practices and strategies for selecting and implementing the most suitable technologies for specific project requirements, overcoming barriers to adoption, and ensuring successful utilization (Arayici *et al.*, 2011; Bin Alam *et al.*, 2023). Consequently, this research aim to bridge this knowledge gap by examining the impact of technology integration on construction management efficiently in project delivery.

LITERATURE REVIEW

Impact of technology in construction

The integration of technology in construction can have a profound impact on project delivery timelines, cost management, and quality control. Technology integration improves the efficiency, accuracy, and predictability, enabling better planning, resource allocation, and real-time monitoring. This leads to reduced delays, optimized budgets, and higher construction quality, significantly improving project outcomes (Azhar *et al.*, 2011; Oesterreich &Teuteberg, 2016).

Project Delivery Timelines

The integration of technology in construction has significantly optimized project delivery timelines by improving planning, monitoring, resource allocation, and collaboration. Advanced software tools, such as BIM and Gantt chart-based project management platforms, enhance project planning by offering clear visual timelines, enabling more accurate scheduling, and ensuring that all stakeholders are aligned (Azhar *et al*., 2011).

Real-time progress monitoring using IoT sensors and project management software enables project managers to receive up-to-date information on construction status, allowing for swift intervention when delays occur (Zhou & Ding, 2017). Automated scheduling tools driven by Artificial Intelligence (AI) can dynamically adjust timelines based on changes in resource availability and project conditions, improving responsiveness and reducing downtime (Oesterreich & Teuteberg, 2016). Digital platforms facilitate efficient communication and collaboration among project stakeholders, streamlining decision-making and reducing the delays caused by miscommunication. Furthermore, automated approval processes and document management tools help speed up the approval of changes, avoiding bottlenecks that could extend project timelines (Shen *et al*., 2020). Technologies like predictive analytics utilize historical data to forecast potential schedule risks, allowing for proactive planning to mitigate delays. Prefabrication and modular construction techniques, supported by technological advancements, enable simultaneous off-site fabrication and on-site preparation, significantly reducing assembly time and ensuring quicker project delivery (Huang *et al*., 2022). Resource allocation is also optimized through the use of data analytics, which ensures that labour and materials are available when needed, minimizing idle time. Additionally, automated reporting tools provide real-time insights into project performance, keeping all stakeholders informed and enabling timely adjustments to the schedule (Zhou & Ding, 2017).

VR and AR technologies further reduce project delays by enabling early design reviews and clash detection before construction begins, minimizing the need for rework during the project (Azhar *et al*., 2011). While technology implementation requires upfront investment, the resulting improvements in efficiency, coordination, and timeline management lead to faster project completion and enhanced client satisfaction.

Cost Management

The integration of technology in construction significantly enhances cost management, resulting in improved budgeting, resource utilization, and overall cost savings. One of the key advancements is the use of Building Information Modelling (BIM) and cost management software, which enhances cost estimation accuracy. These tools provide precise predictions of material and labour costs, thereby reducing the risk of budget overruns (Azhar *et al*., 2011).

Real-time cost monitoring through cloud-based platforms enables project managers to track expenses as they occur, facilitating immediate adjustments and preventing cost overruns (Oesterreich & Teuteberg, 2016). Predictive analytics powered by AI tools can forecast potential cost escalations due to variables such as material price fluctuations or project delays, allowing for proactive budget adjustments to mitigate financial risks (Zhou & Ding, 2017).

Technological advancements also reduce material waste through methods like 3D printing and prefabrication, leading to lower procurement costs by minimizing excess materials (Huang *et al*., 2022). Automated procurement management streamlines purchasing processes, enhancing supply chain efficiency and achieving cost-effectiveness through competitive pricing (Akinsulire *et al*., 2024). Also, labour costs are significantly impacted by automation technologies, such as robotics, which reduce reliance on manual labour (Faheem *et al*., 2024). This not only lowers labour costs but also increases efficiency on site. Early defect detection technologies help minimize rework, leading to significant cost savings associated with rectifying mistakes (Shen *et al*., 2020).

IoT and data analytics play crucial roles in optimizing resource allocation, ensuring efficient use of materials and labour, which minimizes idle time and wastage (Sallam *et al*., 2023). This contributes to overall cost savings. Moreover, real-time data supports timely budget adjustments based on evolving project conditions, maintaining financial control throughout the project lifecycle (Oesterreich & Teuteberg, 2016). While upfront investments in technology and staff training may pose initial challenges, the long-term savings achieved through enhanced efficiency and lower operational costs justify the expenses (Agenda, 2016). Overall, the integration of technology in construction cost management leads to improved project outcomes, better financial performance, and increased client satisfaction.

Quality Control

Technology has revolutionized quality control in construction by significantly enhancing precision, defect detection, and data-driven decision-making. Advanced tools like BIM, laser scanning, and drones improve accuracy in design and construction processes through real-time monitoring and measurement, ensuring adherence to specifications (Azhar *et al*., 2011). According to Puri & Turkan (2017) and Chen & Luo (2014), BIM facilitates detailed inspections by simulating design elements and detecting potential clashes before they occur on-site, thereby preventing errors that could compromise quality.

Automation technologies, such as robotic inspection systems and drones, further improve defect detection and inconsistencies. Drones efficiently survey large sites and capture detailed images, enabling project managers to identify quality issues early (Agnisarman *et al.,* 2019; Huang *et al*., 2022). Robotic systems perform repetitive quality checks with greater accuracy than human inspectors, minimizing the risk of human error (Proia *et al*., 2021). Additionally, IoT sensors and AI-driven analytics provide real-time data on material performance and workmanship quality. This data enables the identification of trends, predictive analysis of potential issues, and optimization of quality assurance processes (Zhou & Ding, 2017). The integration of wearable technology enhances worker safety, which indirectly supports quality by ensuring that work is executed correctly and safely.

Moreover, effective communication facilitated by digital platforms ensures alignment among stakeholders regarding quality expectations, reducing misunderstandings. While the implementation of these technologies offers significant benefits, challenges such as upfront investment and the need for training can hinder widespread adoption (Oesterreich & Teuteberg, 2016). Ultimately, the integration of technology in quality control not only improves project outcomes and reduces rework but also enhances client satisfaction, thereby bolstering the reputation of construction firms (Love *et al*., 2023; Akintoye *et al*., 2012).

METHODS

The study investigated the influence of technology adoption on construction project delivery, exploring its impacts and implications. This study employed deductive reasoning, leveraging positivist principles to derive specific conclusions from established theories (Babbie, 2013). Given positivism's emphasis on objective, observable facts, a quantitative approach was utilized to collect verifiable data.

The study's population consisted of practicing professionals within the construction industry, encompassing architects, builders, engineers, and quantity surveyors. Sampling involves selecting a representative subset from a larger population, enabling data collection from a manageable group that accurately reflects the entire population (Welman *et al*., 2005). This study adopted purposive sampling, a deliberate non-probability sampling technique, to identify and select participants possessing specialized knowledge or experience on technology integration in construction for project delivery.

Therefore, to gather quantitative data, an online questionnaire survey was administered, necessitated by the widespread geographical distribution of construction companies involved in the study (Saunders *et al*., 2009). Prior to the survey, a comprehensive list of construction professionals along with their contact information was obtained within Lagos State which is the study area. Lagos state was chosen as one of Nigeria's major urban centers, and hosts a substantial population of built environment experts and witnesses significant building construction activity.

Despite the challenge of low response rates associated with online surveys (Archer, 2008), the benefits of web-based data collection outweigh the drawbacks. Online surveys offer numerous advantages, including enhanced questionnaire administration, increased accessibility, cost-effectiveness, and user-friendly data cleaning features (Boyer *et al*., 2010). This study utilized survey monkey (www.surveymonkey.com) to collect data for the study. The survey targeted 256 active construction professionals in Lagos State which include quantity surveyors, engineers, builders, and architects. The survey was open from 20 April 2024 through 30 August 2024. At the end, a total of 195 responded, achieving a high response rate of 76%, which is considered statistically sufficient. The questionnaire was organized into two sections: the first collected demographic data, while the second investigated the impacts of technology integration on construction processes. The impact of technology section of the questionnaire was captured on a 5-point Likert scale where 1= strongly disagree, 2 = disagree, 3 = neutral 4 = agree and 5 = strongly agree. Before data gathering, the research questionnaire underwent a rigorous review process, with senior industry experts providing valuable feedback that informed subsequent revisions, ultimately enhancing the questionnaire's validity and reliability. Descriptive statistical measures, comprising mean item scores (MIS) and standard deviations (SD), were used to interpret responses, providing insights into the impacts of technology integration in construction for project delivery.

ANALYSIS AND DISCUSSION

Profile of respondent

Analysis of respondent demographics revealed a significant gender disparity, with males comprising 86% and females 14%, reflecting the male-dominated nature of the construction industry in Nigeria. The professional composition of the respondent pool was diverse, with Quantity Surveyors (27%), Builders (26%), Engineers (25%), and Architects (22%) represented. The educational profile of respondents was also examined, revealing that the majority (58%) held a first degree, while a smaller percentage (6%) held a PhD.

Table 1: ***Profile of respondent***

		Frequency	Percentage (%)
Genger			
	Male	168	86%
	Female	27	14%
Educational Qualification			
	National Diploma	28	14%
	Bachelor's Degree	113	58%
	Master's Degree	43	22%
	Doctorate	11	6%
Professional Discipline			
	Architects	43	22%
	Builders	50	26%
	Engineers	49	25%

	Quantity Surveyor	53	27%
Years of Experience			
	1 – 5years	15	8%
	6- 10 years	66	34%
	11 – 15 years	55	28%
	16 years and above	59	30%

Impacts of technology integration in construction

Table 2 shows the analysis of the impact of technology on project which reveals significant improvements across all areas.

With regard to project delivery timelines, Improved Project Planning ranked highest (mean score: 4.55), indicating that technologies such as BIM and PMIS are particularly effective in ensuring well-structured, efficient project schedules. These tools allow for early detection of issues and provide real-time feedback, which is critical for keeping projects on track. Similarly, Enhanced Communication and Collaboration (4.42) is recognized as a key factor in improving timelines, as it ensures all stakeholders are aligned and aware of project developments. Automated Scheduling (4.40) and Real-time Progress Monitoring (mean score: 4.38) follow closely. These technologies enable project managers to track every aspect of the project in real time, allowing for timely adjustments and minimizing delays.

In terms of cost management, Improved Cost Estimation Accuracy (mean score: 4.19) and Real-time Cost Monitoring (4.17) were ranked highly. These findings suggest that technologies that provide accurate financial tracking and forecasting are particularly valued for their role in preventing cost overruns. However, Predictive Analytics for Cost Risks ranked slightly lower (mean score: 3.45), suggesting that while predictive technologies are valuable, they may still be underutilized or not fully trusted in this context.

In the area of quality control, Enhanced quality of project documentation (mean score: 3.75), Improved Defect Detection and Prevention (mean score: 3.70) and others variables were ranked closely. These tools help maintain high standards and reduce rework, a significant cost and time factor in construction projects.

Table 2: Impacts of technology integration in construction

s/n	Impacts of technology in construction	MIS	SD
	Project Delivery Timelines		
1	Improved project planning	4.55	0.53
2	Real-time progress monitoring	4.38	0.58
3	Automated scheduling	4.40	0.59
4	Enhanced communication and collaboration	4.42	0.58
5	Efficient resource allocation	4.25	0.71
6	Streamlined approval process	4.23	0.69
7	Predictive analytics for timeline risks	4.13	0.73
8	Virtual and Augmented reality for design reviews	3.48	0.80
	Cost Management		
9	Improved cost estimation accuracy	4.19	0.69
10	Real-time cost monitoring	4.17	0.71
11	Predictive analytics for cost risks	3.45	0.77
12	Reduced material waste	4.13	0.74
13	Automated procurement management	3.98	0.72
14	Reduced labour cost through automation	4.01	0.75
15	Cost savings from reduced rework	3.93	0.79
16	Optimized resource allocation	3.95	0.79
17	Automated financial reporting	3.90	0.75
18	Efficient budget adjustments	3.85	0.77
19	Streamlined contract and documentation	3.80	0.70
	Quality Control		
20	Enhanced quality of project documentation	3.75	0.72
21	Improved defect detection and prevention	3.70	0.74
22	Integration of sustainable practices	3.65	0.76
23	Precision in construction	3.60	0.70
24	Improved compliance with design specifications	3.55	0.73
25	**Enhanced worker safety and compliance**	**3.50**	**0.78**

DISCUSSION OF FINDINGS

The findings from the survey indicate that technology has a substantial impact on project delivery timelines, cost management, and quality control.

Key technologies, such as Building Information Modelling (BIM), automated scheduling tools, and real-time progress monitoring systems, are recognized for their ability to streamline processes and improve project outcomes.

Project delivery timelines benefit significantly from technologies that enhance project planning and collaboration. Improved project planning, supports the idea that technologies like BIM and Project Management Information Systems (PMIS) provide construction teams with better visibility into project timelines and allow for real-time adjustments when necessary. This study's findings are in agreement with previous research by Darko *et al*. (2020) & Reja *et al.* (2024), which shows that the technologies integration enhance project planning and collaboration, such as BIM and PMIS, significantly optimizes project delivery timelines by facilitating real-time adjustments. These tools reduce delays by improving coordination between different stakeholders and optimizing the use of resources.

On cost management, the integration of technology specifically, real-time cost monitoring and predictive analytics has improved the accuracy of cost estimates and helped identify financial risks early in the project lifecycle. The respondents confirmed that these tools allow for more precise budgeting and effective resource allocation, reducing the likelihood of cost overruns. However, the survey also highlights a concern shared by many in the industry: the high upfront costs of adopting advanced technology. This aligns with the study of Adebayo *et al*. (2024), which underscores the tension between the long-term benefits of technology and the short-term investment required for implementation.

For quality control, the use of technologies like automated defect tracking and digital checklists has enhanced the accuracy of inspections and compliance with design specifications. These tools help identify defects early, preventing costly rework and maintaining high standards of construction quality. Drone surveillance and IoT sensors have also emerged as effective tools for monitoring construction sites in real-time, ensuring safety compliance and environmental monitoring, which are critical for maintaining both worker safety and quality outcomes. Similarly, AlRushood *et al*. (2023) & Abdullah *et al*. (2023) also found that the efficacy of innovative tools in detecting defects early, preventing costly rework, and maintaining high construction quality standards. Furthermore, drone surveillance and IoT sensors facilitate real-time site monitoring, ensuring safety and environmental compliance.

CONCLUSION ANDRECOMMENDATIONS

From the findings of this research, it is evident that technology integration plays a critical role in improving construction management efficiency. BIM, PMIS, and automated scheduling tools have emerged as key technologies for enhancing project delivery timelines, cost management, and quality control. These technologies enable construction professionals to plan more accurately, collaborate more effectively, and make informed decisions that improve project outcomes. The integration of technology in the construction industry significantly enhances project delivery by improving timelines, cost management, and quality control. By leveraging advanced tools and systems, construction professionals can achieve greater efficiency, accuracy, and collaboration, ultimately leading to better project outcomes and increased client satisfaction.

The ability to make real-time adjustments to schedules based on updated information helps prevent bottlenecks, improve resource allocation, and enhance communication between various stakeholders, thus ensuring more efficient project execution. Therefore, it is recommended that construction companies continue to invest in these technologies and integrate them into their project planning workflows to further streamline project delivery and mitigate the risk of delays. The construction firms consider phased adoption of these technologies or seek partnerships with tech providers to reduce the initial financial burden. Furthermore, companies should conduct thorough cost-benefit analyses to justify the long-term return on investment. More so, to optimize quality control, it is recommended that construction firms expand the use of automated defect detection tools and real-time site monitoring technologies. Thus, this research contributes meaningfully to the expanding knowledge base in this area of study.

REFERENCES

Abdullah, Z., Çelik, T., & Celik, T. (2023). Digital Quality Management System for Construction: The Role of Smart Cameras. In *International Conference on Advances in Civil Engineering* Singapore: Springer Nature Singapore, pp. 85-94.

Adebayo, Y. A., Ikevuje, A. H., Kwakye, J. M., & Esiri, A. E. (2024). Balancing stakeholder interests in sustainable project management: A circular economy approach. *GSC Advanced Research and Reviews*, 20(3), 286-297.

Agenda, I. (2016). Shaping the future of construction a breakthrough in mindset and technology. In *World Economic Forum*, 11-16.

Agnisarman, S., Lopes, S., Madathil, K. C., Piratla, K., & Gramopadhye, A. (2019). A survey of automation-enabled human-in-the-loop systems for infrastructure visual inspection. *Automation in Construction*, *97*, 52-76.

Akinsulire, A. A., Idemudia, C., Okwandu, A. C., & Iwuanyanwu, O. (2024). Supply chain management and operational efficiency in affordable housing: An integrated review. *Magna Scientia Advanced Research and Reviews*, *11*(2), 105-118.

Akintoye, A., Goulding, J. S., & Zawdie, G. (2012). Construction innovation and process improvement. *Construction innovation and process improvement*, 1-17.

Albert, I., Shakantu, W., & Ibrahim, S. (2021). The effect of poor materials management in the construction industry: A case study of Abuja, Nigeria. *Acta Structilia*, *28*(1), 142-167.

AlRushood, M. A., Rahbar, F., Selim, S. Z., & Dweiri, F. (2023). Accelerating Use of Drones and Robotics in Post-Pandemic Project Supply Chain. *Drones*, *7*(5), 313.

Arayici, Y., Coates, P., Koskela, L., Kagioglou, M., Usher, C., & O'Reilly, K. (2011). Technology adoption in the BIM implementation for lean architectural practice. *Automation in construction*, *20*(2), 189-195.

Archer, T M (2008) Response rates to expect from Web-based surveys and what to do about it, Journal of Extension, 46(3), 3RIB3.

Azhar, S., Hein, M., & Sketo, B. (2011). Building Information Modeling (BIM): Benefits, risks and challenges. *Automation in Construction*, 20(2), 217-224

Babbie, E. (2013). The Practice of Social Research, 13th ed., Thomson Wadsworth, Belmont, CA.

Bin Alam, M.F., Hosen, I., Mridha, J.H., Chowdhury, S.E., & Rahman, A. (2023). Assessing the Barriers of Integrating Technological I*nnovations in Textiles Sector: Implications towards Sustainable Production*, 1(3), 100039

Boyer, C N, Adams, D C and Lucero, J (2010). Rural coverage bias in online surveys: Evidence from Oklahoma water managers, *Journal of Extension*, 48(3), 3TOT5.

Chen, L., & Luo, H. (2014). A BIM-based construction quality management model and its applications. *Automation in construction*, *46*, 64-73.

Chen, X., Chang-Richard, A., Pelosi, A., & Jia, Y. (2021). Implementation of Technologies in the Construction Industry: A Systematic Review. *Engineering Construction and Architectural Management*, 10.1108/ECAM 02-2021-0172

Darko, A., Chan, A. P., Yang, Y., & Tetteh, M. O. (2020). Building information modeling (BIM)-based modular integrated construction risk management–Critical survey and future needs. *Computers in Industry*, *123*, 103327.

Faheem, M. A., Zafar, N., Kumar, P., Melon, M. M. H., Prince, N. U., & Al Mamun, M. A. (2024). AI and robotic: about the transformation of construction industry automation as well as labour productivity. *Remittances Review*, *9*(S3 (July 2024)), 871-888.

Famiyeh, S., Amoatey, C. T., Adaku, E., & Agbenohevi, C. S. (2017). Major causes of construction time and cost overruns: A case of selected educational sector projects in Ghana. *Journal of Engineering, Design and Technology*, *15*(2), 181-198.

Huang, W., Liu, H., & Zhang, Y. (2022). Robotics in construction: Progress and prospects. *Journal of Robotics and Automation*, 28(1), 32-45.

Johnson, R. M., & Babu, R. I. I. (2020). Time and cost overruns in the UAE construction industry: a critical analysis. *International Journal of Construction Management*, *20*(5), 402-411.

Love, P. E., Matthews, J., Ika, L. A., Teo, P., Fang, W., & Morrison, J. (2023). From Quality-I to Quality-II: cultivating an error culture to support lean thinking and rework mitigation in infrastructure projects. *Production Planning & Control*, *34*(9), 812-829.

Magaba, M., Cowden, R., & Karodia, M.A. (2014). The Impact of Technological Changes on Project Management at a Company Operating in the Construction Industry, 2(9),113-148

Oesterreich, T. D., & Teuteberg, F. (2016). Understanding the implications of digitization and automation in the construction industry. *Computers in Industry*, 83, 121-139.

Oluwaseun, A.S., & Oluwatobi, A.A. (2020). Adoption of Building Information Modelling (BIM) in Nigeria Construction Industry: Prospects and Challenges. *Journal of Engineering, Project, and Production Management*, 10(1), 34-46.

Oyedele, L.O., Akinade, O.O., Bilal, M., Ajayi, S.O., Alaka, H.A., & Owolabi, H.A. (2018). Mobile Technology Adoption in Construction Project Management in Nigeria. *Journal of Construction Engineering and Management*, 144(4), 04018005.

Proia, S., Carli, R., Cavone, G., & Dotoli, M. (2021). Control techniques for safe, ergonomic, and efficient human-robot collaboration in the digital industry: A survey. *IEEE Transactions on Automation Science and Engineering*, *19*(3), 1798-1819.

Puri, N., & Turkan, Y. (2017). Toward automated dimensional quality control of precast concrete elements using design BIM. *WIT Transactions on The Built Environment*, *169*, 203-210.

Reja, V. K., Sindhu Pradeep, M., & Varghese, K. (2024). Digital Twins for Construction Project Management (DT-CPM): Applications and Future Research Directions. *Journal of the Institution of Engineers (India): Series A*, 1-15.

Sallam, K., Mohamed, M., & Mohamed, A. W. (2023). Internet of Things (IoT) in supply chain management: challenges, opportunities, and best practices. *Sustainable Machine Intelligence Journal*, *2*, 3-1.

Sauders, M, Lewis, P and Thornhill, A (2009) Research methods for Business Students, 5th Edition, Hallow: Pearson Education Limited.

Shen, L., Tam, V. W. Y., Gan, X., & Ye, K. (2020). Critical success factors for managing risks in construction projects. *Journal of Construction Engineering and Management*, 146(8), 04020085.

Welman, C., Kruger, S.J. and Mitchell, B. (2005), Research Methodology, 3rd ed., Oxford University Press, Oxford

Zhou, W., & Ding, L. (2017). Smart construction technologies: IoT and cloud computing. *Automation in Construction*, 84, 103-112