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**HOW TO CITE:**  
Windapo AO. The construction industry transformation and the digital divide: Bridging the gap. *S Afr J Sci.* 2021;117(7/8), Art. #10990. <https://doi.org/10.17159/sajs.2021/10990>

**ARTICLE INCLUDES:**  
 Peer review  
 Supplementary material

**KEYWORDS:**  
digital innovation, construction industry, gender equity, digital technologies

**PUBLISHED:**  
29 July 2021

# The construction industry transformation and the digital divide: Bridging the gap

Professor Abimbola Olukemi Windapo is the recipient of the 2019/2020 NSTF-South32 Engineering Research Capacity Development Award for her research of construction business and management that confronts the problems of poor project and organisation performance from a practice perspective.

Numerous digital technologies aim to improve both the productivity and performance of construction professionals, projects and companies. However, they have not been completely adopted, and low productivity is evident. Maintaining technological skill levels in line with industry progress also presents a challenge to women, because crucial skill development in emerging technologies tends to be achieved by aspirational labour. Previous research suggests a possible transformation of the construction industry using digital technologies. However, a digital divide exists.

## Introduction

The construction industry has not achieved the best possible performance, which is largely due to low productivity on construction sites.<sup>1,2</sup> This most often leads to time and budget overruns, which create a high-cost escalation for the projects.<sup>3</sup> The issue of low productivity is a problem worldwide, not just in developing countries; even developed countries suffer from a decline in productivity.<sup>4</sup> This is a major issue across the construction industry, and if the current trend continues, there will be a major negative effect on its health and viability.<sup>1</sup>

Howell and Higgins<sup>5</sup> hold a theory that organisations in the construction industry must be leaders in the identification, evaluation, and adoption of the latest technological innovations if they are to remain relevant and competitive. However, many companies do not fully adopt these innovative technologies.<sup>6</sup> The numerous innovative construction technologies available on the market aim to complement job functions and improve the performance of construction companies. However, in line with the Diffusion of Innovation theory, these technologies have not been adopted in the construction sector of many developing economies, such as Nigeria, and low productivity continues to affect them.<sup>5</sup>

Although previous research suggests that there are opportunities for the digital environment to transform the construction industry and make it more productive, scholars such as Oke et al.<sup>7</sup> note several barriers to adopting digital technologies. There is limited knowledge of how they could improve the productivity of projects and transform the construction industry. Here I examine construction's digital future and whether it can be proactively reconstructed, promoting gender equity in the construction industry, rather than creating a barrier, and how to bridge the digital divide. Recommendations are made to help professional builders, especially women in the construction industry, to take advantage of this digital environment to increase their effectiveness in technically dominated and male-dominated workplaces.

## Overview of digital innovation

According to Barrett<sup>8</sup>, Construction 4.0 could potentially offer opportunities to resolve issues of gender equity in the industry. Barrett<sup>8</sup>, however, notes that Construction 4.0 itself is a gendered concept that leans towards male professionals, because there has been no strategy offered to ensure that both women and men can fill anticipated skills shortages. This exacerbates the situation in which higher rates of men are attracted to and enter a digitally transformed construction industry, and in doing so, enable the bridging of the digital divide. Digital innovative technologies which may offer new opportunities to resolve issues of poor productivity and performance in the construction industry include 3D scanning, building information modelling/management, 3D printing, augmented/virtual reality, drone technology, the Internet of Things, big data analytics, machine learning and blockchain technology. These are explained in the following paragraphs.

The process of 3D scanning analyses a real-world object to collect data on its shape, and possibly its appearance. This type of scanner is used to model and build the structure. Laser scanning is used to create quick and accurate 3D models of existing buildings, to support the subsequent process of 3D scanning.

Building information modelling relies upon various tools, technologies, and contracts involving the generation and management of digital representations of buildings, and of the infrastructure's physical and functional characteristics.

Integrated building information modelling and 3D scanning involves converting laser scans into a Building Information Model. It thus collects and documents valuable information in a consistent building database that serves as an accurate source for engineering, design and construction.

3D printing is an automated, additive manufacturing process for producing three-dimensional solid objects from a digital model.

Augmented reality is an interactive experience of a real-world environment, where the objects in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including the following senses: visual, auditory, haptic, somato-sensory and olfactory.

Virtual reality is the use of computer technology to create a simulated environment. Unlike traditional user interfaces, virtual reality places the user inside an experience. Instead of viewing a screen in front of them, users experience themselves as immersed in, and interacting with 3D worlds.

Drone technology provides construction teams with an overhead view of job sites, materials, machinery and people. Contractors use autonomous flying machines to record videos that help optimise everything from grading plans and operations to identifying differences between as-designed and as-built site plans.

The Internet of Things is a system of interrelated computing devices, mechanical and digital machines, objects, animals, or people provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. Internet devices can monitor and control the mechanical, electrical and electronic systems used in infrastructure and buildings in home automation and building automation systems.

Big Data Analytics is the process of collecting, organising and analysing large sets of data (called 'big data') obtained from text, audio, video, and images to discover patterns and other information. Analysts working with big data typically want the knowledge from analysing the data. Organisations in charge of assets analyse big data to find consumer patterns and trends, to make investment decisions.

Machine learning is an application of artificial intelligence that provides systems with the ability to learn from experience automatically, without being explicitly programmed. Machine learning focuses on developing computer programs that can access data and use it to learn for themselves. This iterative aspect is important; when models are exposed to new data, they can independently adapt, and produce reliable results.

Blockchain technology stores transactional records of the public, also known as the 'block', in several databases, known as the 'chain', in a network. This storage is referred to as a 'digital ledger'. Together with building information modelling, blockchain can create a single source of truth for all aspects of a construction project (see Figure 1). Such a model can become the trusted digital twin of an asset, supporting its design and construction and its operation and maintenance, through the life cycle.

### Using innovative digital technologies

Low productivity on construction sites can lead to time overruns and excessive cost on a project.<sup>3</sup> Karim et al.<sup>9</sup> showed that the use of technology could improve both productivity and project performance. These results show that it is a priority to find effective innovative technology.

Traditional career structures are becoming less attractive and no longer the norm in the emerging digital environment.<sup>8,10</sup> Furthermore, the labour-intensive nature of construction is increasingly lessened by digitisation; automation and robotics increasingly perform physical tasks previously identified as only within men's ability. The new digital environments remove the physical visibility of distinctions between women and men, which reduces the likelihood of gender discrimination.

The use of innovative technologies has also been shown to positively impact companies' performance.<sup>11</sup> Pelsler<sup>12</sup> found that innovation had a positive correlation with the company's performance, showing that when companies made positive use of the technologies, they could boost their competitiveness. Molenaar et al.<sup>13</sup> indicated that innovative technologies provided more collaboration and cohesiveness across the project team, which positively benefited cost, schedule, and quality performance measurements.



Figure 1: Smart contracts using blockchain technology.

The digital network has supported women to connect and network more flexibly with colleagues and clients. Previously, networking in the construction industry has seemed to exclude women and impose a barrier to career progression. The construction industry's digital access will widen participation in professional learning, enabling more opportunities for women in digital learning and networking.

## Overview of barriers to the adoption of digital technologies

Mtya<sup>14</sup> found that digital technologies such as building information modelling are not widely adopted in the construction industry; although firms possess capabilities to use the technology, some barriers prevent them from using those capabilities and digitising. These barriers are outlined below:

### **Resistance by the consultant team**

According to Oke et al.<sup>7</sup>, the lack of cooperation within the professional team creates the most significant barrier to innovation. The strict standards across industries, and the unwillingness of professional councils to change, are a barrier to industry change.<sup>15</sup>

### **Training and upskilling of employees**

The lack of structured training is another critical barrier to adopting innovative technology on projects.<sup>16</sup> Dupwa<sup>17</sup> states that significant investment in industry professionals' education in the use of innovative technologies is imperative to their successful adoption. The construction industry is extremely competitive, and a shift towards the use of innovative technologies has meant that company executives continually need to improve their staff's proficiency to improve overall performance.<sup>18</sup> A construction company's ability to adapt to new technology faster than its competitors is vital to a competitive advantage.<sup>19</sup> To meet the growing industry requirements for further adoption of innovative technologies on projects, firms are required to be more proficient in their use.<sup>20</sup>

### **Costs incurred when adopting innovative technology**

The high cost of training employees<sup>7</sup> combined with the high initial cost of implementing the technology<sup>21</sup> discourages companies from adopting the technology<sup>22</sup>.

### **Current legislation**

Mostafa et al.<sup>23</sup> identify the main barrier within developing countries as the current legislation – for example, legislation about drone technology. Many companies have not fully adopted innovative technologies on projects.<sup>23,24</sup> Additionally, data security, protection, and control of information are all barriers to adoption.<sup>7</sup>

### **Clients' lack of knowledge**

Clients and governments lack an understanding of the positive impact that new technology can have on performance. This is a significant barrier to the implementation of innovative technology on construction projects.<sup>24,25</sup>

## The way forward – bridging the digital and empowerment divides

Can construction's digital future be proactively reconstructed as an opportunity for change, promoting professional gender equity, rather than creating a barrier to it? In my appraisal of different types of innovative digital technology, the barriers to, and benefits of using it, several advantages of using innovative digital technology emerged, including high productivity, and project and company performance. These technologies have the added benefit of eliminating the necessity of women's physical visibility and allowing them to network easily. Digital technologies will empower women to overcome disadvantage and participate equally in the construction industry.<sup>8</sup> Therefore, the industry can be transformed to become more productive and representative, by using innovative digital technologies.

However, there are barriers to using innovative technologies in construction, which must be addressed to enable this transformation: resistance by the consultant team, the training and skills required, costs involved when adopting innovative technologies on projects, current legislation, and clients' lack of knowledge.

To bridge the digital divide and transform the construction industry, it is recommended that the project consultant team should develop relationships promoting the use of innovative technology; also that clients should be more exposed to the benefits of digital technology, despite the cost. Legislation should be updated regularly and should not lag behind industry regulations.

To meet these goals, the government and the construction sector must provide targeted investment in education and training. This should support individuals, especially women and girls, considering or beginning digital construction careers. Barrett<sup>8</sup> identifies a strategy of supporting businesses and organisations to remove the barriers that hinder women's career progression, by closing gender pay gaps and neutralising traditionally masculine cultures. The digital transformation should be paralleled by a cultural revolution, to fully embrace gender equity opportunities. Barrett<sup>8</sup> posits that this cultural shift should allow women to manage their diverse and fluctuating out-of-office commitments. It should also define alternative career and reward structures to encourage professionals to deliver their best work.

The construction industry can be transformed; and the digital divide can be closed if the government makes targeted investments in training and upskilling, and regularly updates legislation in step with new construction knowledge.

## Acknowledgements

This paper was first presented at the investiture of the Association of Professional Women Builders of Nigeria on 25 February 2021. This work is supported by the National Research Foundation (NRF) of South Africa (grant no. 120843). Opinions and conclusions are those of the author and are not necessarily attributable to the NRF.

## References

1. Hassan T, Carter C, Carter C. Collaboration in construction: Legal and contractual Issues in ICT applications. Weimar: Bauhaus-Universität Weimar; 2004.
2. Hassan S. Factors influencing labour productivity and the impacts on construction industry. *Caspian J Appl Sci Res.* 2013;2:349–354.
3. Ameh OJ, Osegbo EE. Study of relationship between the time overrun and productivity on construction sites. *Int J Constr Supply Chain Manag.* 2011;1:56–67. <https://doi.org/10.14424/ijscm101011-56-67>
4. Hiyassat MA, Hiyari MA, Sweis GJ. Factors affecting construction labour productivity: A case study of Jordan. *Int J Constr Manag.* 2016;16(2):138–149. <https://doi.org/10.1080/15623599.2016.1142266>
5. Howell JM, Higgins CA. Champions of technological innovation. *Admin Sci Q.* 1990;35(2):317–341. <https://doi.org/10.2307/2393393>
6. Aghimien D, Aigbavboa C, Matabane K. Impediments of the fourth industrial revolution in the South African construction industry. In: *Collaboration and integration in construction, engineering, management and technology.* Cham: Springer; 2021. p. 223–227. [https://doi.org/10.1007/978-3-030-48465-1\\_37](https://doi.org/10.1007/978-3-030-48465-1_37)
7. Oke A, Aghimien D, Aigbavboa C, Koloko N. Challenges of digital collaboration in the South African construction industry. Paper presented at: Proceedings of the International Conference on industrial engineering and operations management; 2018 March 6–8; Bandung, Indonesia.
8. Barrett J. Choose your future: A feminist perspective on Construction 4.0 as techno-utopia or digital dystopia. *Proceedings of the Institution of Civil Engineers – Management, procurement and law.* 2020;173(4):153–157. <https://doi.org/10.1680/jmapl.20.00003>
9. Karim NA, Hassan S, Yunus JN, Hashim MZ. Factors influencing labour productivity and the impacts on construction industry. *Caspian J Appl Sci Res.* 2013;2:349–354.



10. Caven V. Constructing a career: Women architects at work. *Career Develop Int.* 2004;9(4/5):519–531. <https://doi.org/10.1108/13620430410550763>
11. Bach TM, Dalazen LL, Da Silva WV, Ferraresi AA, Da Veiga CP. Relationship between innovation and performance in private companies: Systematic literature review. *SAGE Open.* 2019;9(2):1–17. <https://doi.org/10.1177/2158244019855847>
12. Pelser T. The effect of innovation strategies and their connection to company performance. *Mediterr J Soc Sci.* 2014;5:60–68.
13. Molenaar K, Leicht R, Messner J, Franz B, Esmaeili B. Examining the role of integration in the success of building construction projects. Research report 2014. <https://doi.org/10.13140/RG.2.1.5165.2648>
14. Mtya A. Evaluation of building information modelling (BIM) adoption, capability and maturity within South African consulting and construction firms [master's thesis]. Cape Town: University of Cape Town; 2019.
15. Gambatese JA, Hallowell M. Enabling and measuring innovation in the construction industry. *Constr Manag Econ.* 2011;29(6):553–567. <https://doi.org/10.1080/01446193.2011.570357>
16. Peansupap V, Walker D. Factors enabling information and communication technology diffusion and actual implementation in construction organisations. *Elect J Inform Technol Constr.* 2005;10(14):193–218.
17. Dupwa RP. Investigation of the utilisation of modular construction in South Africa [master's thesis]. Johannesburg: University of the Witwatersrand; 2017.
18. Hany Abd Elshakour MA, Al-Sulaihi IA, Al-Gahtani KS. Indicators for measuring performance of building construction companies in Saudi Arabia. *Journal of King Saud University – Engineering Sciences.* 2013;25(2):125–134. <https://doi.org/10.1016/j.jksues.2012.03.002>
19. Jashapara A. Cognition, culture and competition: An empirical test of the learning organisation. *The Learning Organization.* 2003;10(1):31–50. <https://doi.org/10.1108/09696470310457487>
20. Succar B, Sher W, Williams A. An integrated approach to BIM competence assessment, acquisition and application. *Automat Constr.* 2013;35:174–189. <https://doi.org/10.1016/j.autcon.2013.05.016>
21. Tam VVY, Tam CM, Zeng SX, Ng WCY. Towards adoption of prefabrication in construction. *Build Environ.* 2007;42(10):3642–3654. <https://doi.org/10.1016/j.buildenv.2006.10.003>
22. Hossain MK, Munns A, Rahman MM. Enhancing team integration in building information modelling (BIM) projects. *ARCOM Doctoral Workshop - BIM Management and Interoperability.* 2013: 78-92.
23. Mostafa S, Dumrak J, Chileshe N, Zuo J. Offsite manufacturing in developing countries: Current situation and opportunities. Paper presented at: The 5th International Conference on Engineering, Project and Production Management; 2014 November 26–28; Port Elizabeth, South Africa. <https://doi.org/10.32738/CEPPM.201411.0007>
24. Bikitsha L, Haupt T. Impact of prefabrication on construction site health and safety: Perceptions of designers and contractors. *ASOCSA Conference Proceedings.* 2011:196–208.
25. Vernikos V, Goodier C, Broyd T, Robery P, Gibb A. Building information modelling and its effect on offsite in civil engineering. *Proceedings of the Institution of Civil Engineers: Management, procurement and law.* 2014;167:152–159. <https://doi.org/10.1680/mpal.13.00031>