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ABSTRACT

The swift advancement of digital technology has brought about significant transformations in various industries, including the construction sector. To maintain competitiveness and overcome innovation lags, the construction sector, a key economic driver for the nation, must transition to more sustainable practices. This article underscores the importance of applying "human-centred" technology to drive innovation, sustainability, and efficiency in the construction industry. Among the key technologies driving this shift are BIM, IoT, AI & Big Data, and Blockchain, which offer opportunities for enhancing sustainability and smart cities.

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UNLOCKING FUTURE OPPORTUNITIES IN THE CONSTRUCTION SECTOR THROUGH DIGITAL TRANSFORMATION

by **Ahmad Farhan Roslan**

Introduction

The rapid evolution of digital technology over the past few years has altered how people work in many sectors. "Disruptive technology" has significantly changed traditional practices. Although the word “digitalisation” sounds hardly intuitive in the context of a sector like construction, the shift to digitalisation has been increasingly demanded. The pressure to digitally transform the construction sector has intensified-due to the increasing complexity of construction projects, which necessitates higher safety standards and creative solutions to boost productivity and efficiency.

The impact of the COVID-19 pandemic has accelerated digital transformation at an unprecedented rate, with 80% of respondents in a McKinsey Global Survey on businesses stating their commitment towards digital transformation[1]. However, sustaining the digital transformation process for the coming years will become challenging as the push factors motivating people to embrace digital transformation during the pandemic may not be as strong in the post-pandemic era. In addition, the steep learning curve associated with implementing new technologies and digital tools may cause resistance or reluctance to embrace the required changes.

On one hand, the COVID-19 pandemic has taught us that the decision to adopt and implement technology was influenced by a every particular social situation namely a global health and economic crisis, highlighting the need to understand society’s unique concern areas first before adopting technology at the scale we have seen. On the other hand, it is also critical for businesses to recognise the long-term benefits of technology

implementation and continue to adapt to stay competitive in the digital age. Therefore, ensuring that any digital transformation adds potential value to society and business sectors is crucial.

As such, this article aims to firstly highlight the factors that will shape the future of the construction industry, with a focus on human-centred and ESG-driven approaches. Next, it will include five essential technologies that are spearheading the industry's agenda for digital transformation. Finally, it seeks to educate stakeholders on the steps necessary to effectively transition the sector to its new, digitally-enabled future.

The case for a digital transformation

The construction sector encompasses multiple disciplines and activities in designing, constructing, and managing built environments, including buildings and infrastructure[2]. With resilient and smart cities at the forefront of city and urban planners' agenda, the desire for more sustainable and more efficient buildings and infrastructure in rapidly urbanising areas will necessitate incorporating emerging technologies into construction projects. In addition, the recent push to provide affordable housing, social services, transportation, energy, building or facilities, and other infrastructure projects is likely to raise demand for innovative and cost-effective construction practices. The construction sector can contribute to a more equitable and sustainable outcome by implementing appropriate technology to address societal issues such as rising costs, inadequate housing conditions, livelihood, climate and disaster risk, and other sustainability issues.

From an economic perspective, the construction sector contributes significantly to the nation's wealth creation and economic growth through its two-time multiplier effect on 120 other sectors that rely on construction for progress and sustainability[3–5]. The Global Financial Crisis of 2008-2009 revealed that many countries rely on construction spending to stimulate the economy and create jobs[6]. The construction sector represents a unique form of stimulus due to its high and wide-ranging multiplier effect, generating significant economic spillovers through job creations. However, future investments in building and infrastructure projects will face challenges from the need to consider green and sustainable approaches, apart from digitalisation[7]. Therefore, the future of the construction sector will require a significant shift towards more sustainable practices, which can be driven and assisted by digitalisation.

Despite being crucial to the country's economic and physical development, the construction industry has been identified as a laggard in terms of speed of adoption of innovation or technology, compared to other sectors[8]. Hence, it is imperative that the construction industry accelerates its adoption of technology in order to maintain its competitiveness and enhance quality, productivity, and efficiency. Several Malaysian construction companies and firms (e.g., architecture and engineering firms) that have adopted technology have penetrated the international market and expanded their global reach. This demonstrates how adopting technology allows local players to diversify their businesses and enter larger markets. New global construction market opportunities will only be accessible to industry players who are ready to adopt technology and innovative solutions to overcome key future risks, such as extreme weather events, infectious diseases, an ageing population, limited resources, and urbanisation, among the top threats[9]. Moreover, the urgent need to better equip construction players to meet Environmental, Social, and Governance (ESG) commitments will significantly impact their ability to compete in the global market for capital. Failing to comply with ESG requirements may result in missed opportunities for financing support. In addition, effective use of ESG data could be pivotal to drive business value for construction firms and provide insights into decision-making in achieving net zero[10].

Meanwhile, achieving "net zero" targets in construction requires the industry to adopt a whole lifecycle approach to carbon reduction that addresses emissions from operational (energy used in buildings or infrastructure) to embodied carbon (which comes from building materials and the construction or renovation process). To illustrate, Figure 1 explains carbon emissions associated with the whole project lifecycle of a building or infrastructure. Given that nearly 70 countries have committed to achieving net zero carbon

emissions by 2050 through the World Green Building Council[11], the industry must be ready to incorporate multiple strategies in designing and constructing sustainable buildings and infrastructure.

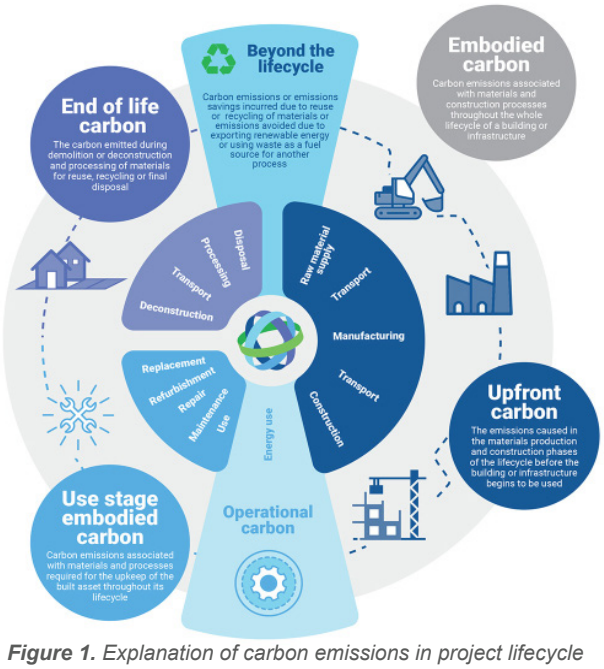

Figure 1. *Explanation of carbon emissions in project lifecycle (Source: World Green Building Council)*

Acknowledging these challenges, the following segment delves into a range of digital technologies with the potential to pave the way for future advancements and opportunities.

Digital technology and opportunities for the construction sector in delivering the future agenda

By applying “human-centred” technologies, we can address specific issues in Malaysia in the context of construction, such as improving people’s well-being, promoting economic growth and social progress, and achieving climate-neutral and resilient targets. Here, the author highlights important technologies contributing to these goals by analysing 7,944 documents from the Scopus database using VOSviewer[1]. The analysis identifies Building Information Modeling (BIM), the Internet of Things (IoT), Artificial Intelligence (AI), Big Data, and Blockchain, which are among the key construction technologies that have been identified to have the potential to affect significant changes.

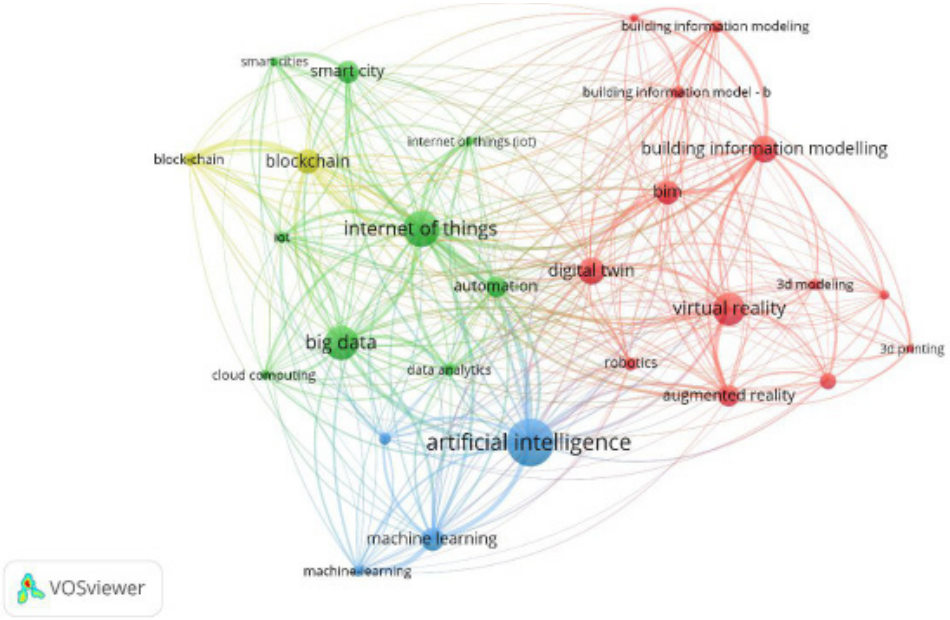

Figure 2. *Co-occurrence of digital technology trends in construction*

[1] VOSviewer is a tool for data analysis

Building Information Modelling (BIM)

Among the five key emerging digital technologies, BIM is the technology that is becoming a norm in the construction sector as it creates information-rich environments that facilitate information exchange and sharing among stakeholders. BIM provides comprehensive information throughout a project's life cycle, with the capacity to extend its benefits to sustainability analysis and asset management, traffic control, city modelling and smart cities, and facility management [12,13]. Malaysia could further explore the extension of BIM towards smart cities, aligned with the vision of the smart city framework[14].

As BIM creates information models and copies of digital models or physical assets of cities, it can support the development of Digital Twins (DTs), which are essentially virtual representations of a city (e.g., SimCity). DTs can be used to simulate and analyse various scenarios in a city, such as traffic flow, energy consumption, and disaster response. Considering the recent oft-occurring flood events in Malaysia, DTs can enable real-time monitoring and predictive analysis, allowing preventative actions to address possible difficulties or emergencies within the city. Furthermore, introducing DTs in transportation can complement its uses in the construction sector by providing real-time digital representation of physical traffic to improve traffic management and reduce congestion between and within a built environment[15].

Sensors and network communication, Internet of Things (IOT)

Data from sensors and network communication technology such as the Internet of Things (IoT) provide valuable insight to make informed decisions. Historical and real-time data produced by these sensors become critical for monitoring and predicting conditions of building performance, environment and climate trends[16–18]. For example, integrating IoT devices in buildings enables the owner to monitor energy consumption and develop strategies to enhance energy efficiency. In the real estate sector, IoT data can assist building owners in detecting technical defects and doing predictive maintenance, significantly reducing operating costs[19]. IoT applications have been identified as the next wave of technology for creating "Smart Homes" and building smart societies. With Malaysia approaching an ageing population, the implementation of Smart Homes for healthcare and well-being can assist the elderly in maintaining independence and improving their quality of life.

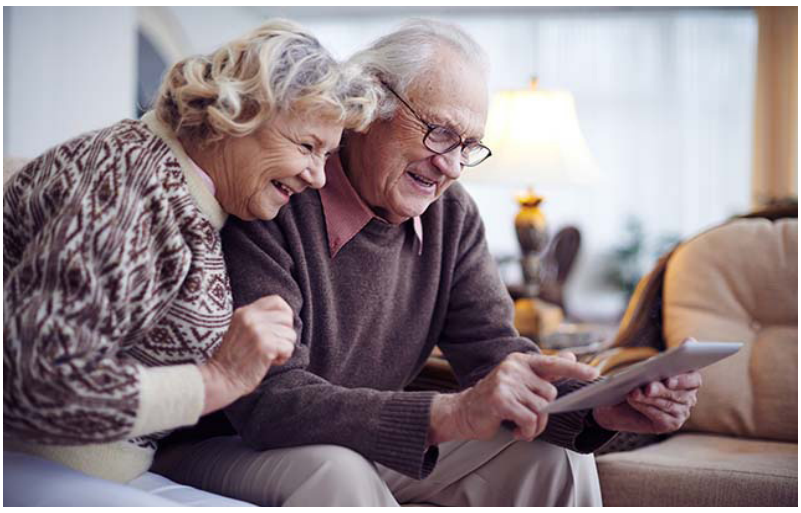

Figure 3. *Smart home for elderly (Source: Wulian Dec Smart Home)*

Artificial Intelligence (AI) and Big Data

Other than IoT, technologies such as AI and Big Data are becoming prevalent in the construction sector due to the ability to analyse large amounts of data quickly and accurately. AI assists construction stakeholders in analysing project data and providing recommendations for decision-making. Data produced by BIM contribute to big data, allowing AI to generate rapid design alternatives based on preferences and input to produce

better options, known as generative design[20]. Generative design is used in sustainable practices to access the optimal sustainable building performance and investigate a wide range of design options. The examples in **Figure 4** demonstrate how a design team can analyse maximum daylight use and available natural light in a building to help optimise energy usage and reduce the need for artificial lighting.

Figure 4. *Generative design for sustainable design (Source: Autodesk) Dec Smart Home)*

Blockchain

Blockchain technology is currently being applied in the construction industry for supply chain management, smart contracts, and BIM[17,21,22]. The construction sector is highly fragmented and diverse, with multiple stakeholders involved. The involvement of multiple stakeholders makes collaboration difficult, with trust and transparency issues limiting information sharing for making decisions. Among others, Blockchain technology among other things, can address this challenge by ensuring stakeholders are able to decide the extent to which their data is shared with others while maintaining the security and privacy of the shared data. Where open data sources are becoming critical for decision-making and accountability, the immutable nature of blockchain ensures that the integrity of open data sources is maintained, eliminating the risk of manipulation, and providing more significant construction supply chain traceability. Since blockchain is immutable, it ensures that open data sources remain intact, removing the possibility of manipulation and offering more substantial construction supply chain traceability in an environment where open data sources are becoming increasingly important for decision-making and accountability.

Conclusion: Industry Transformation is a Game of ‘Catch Up’, all stakeholders need to play their parts

The emergence of digital technology – or the Fourth Industrial Revolution in the construction sector – has generated a range of discussions and opinions among industry players, policymakers, and experts. Since the industry perceives ‘business value’ and ‘customer satisfaction’ as key decision points for investing and embracing digital technologies, prevailing lack of appreciation or awareness among customers – especially over the business value that can be derived from digitalisation – is found to be among the main reasons behind the reluctance of the construction to adopt these new technologies. Other constraints related to cost, lack of client demand, culture, expertise, and legal requirements have also hindered the widespread adoption of digital technologies in the construction sector [23,24].

While government intervention is often seen as a necessary mechanism for driving the adoption of digital technologies, it might not be sufficient or the most sustainable strategy for doing so. A collaborative effort between industry players, policymakers, academia, and society is required to shape the digital ecosystem for the construction sector to address this issue effectively. Such collaboration will provide opportunities to co-create value, innovation, and knowledge exchange.

From a policy standpoint, the ‘agile governance’[25] concept can (and should) be further explored to enable more inclusive and “human-centred” policy-making in the construction sector, by considering rapid changes in societal needs. Policy reform towards digitalisation is critical in setting the direction. Some countries, such as Japan, envisions the use of digital technology to achieve societal-level benefits by introducing “Society 5.0”[26]. In another example, the United Kingdom’s digital strategy aims at harnessing digital transformation and build a more inclusive, competitive, innovative digital economy.

Policy levers cannot be expected to be the only driver or incentivisation mechanism for adopting digital technology in construction. Businessed need to also be responsive to these policy and market incentives or adopting these new technologies. However, the effectiveness of the construction sector, especially in Malaysia, in responding to these demands remains uncertain, as we have seen in the case of the sluggish adoption of Industrialised Building Systems (IBS), widely attributable to contradicting policy incentives, such as the policy to persistently allow for the proliferation of low-cost foreign labour, while skilled labour in the construction remains limited. Furthermore, the general perception of the nature and environment of construction works as 3D (dirty, dangerous and difficult), combined with labour-intensive and low salary, is another reason for the limited participation of local, particularly skilled labour. This negative perception is exacerbated by low-skill and low-wage traps, which discourage participation by local skilled workers. Therefore, preparing the local construction workers towards highly skilled jobs is crucial while simultaneously meeting the sector's demands.

Adaptation to the changing needs of society will be the key determinant for the sector’s continued significance. For individuals, reskilling and upskilling in emerging technologies will be essential to remain competitive in the job market, even in a traditionally laborious and low-skill sector such as construction. The author believes that investing in facilities and education programs (e.g., Technical and Vocational Training Education (TVET)) by focusing on new technologies and skill sets will be critical in preparing the future workforce for the future construction sector in Malaysia.

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