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A Delphi Exploration of Construction Digitalisation in South Africa

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Abstract

The current technological advancement has rapidly transformed how industries worldwide deliver their products, and the construction industry is not immune to this transformation. However, while the industry in developed countries is gradually picking up with the use of digital technologies in attaining digital transformation, the construction industry in developing countries like South Africa is still lagging in its adoption. Therefore, to promote construction digitalisation within the South African construction industry, this study, through a Delphi approach, unearths the major risks construction organisations will face in their quest for digital transformation. The study also explored the potential of the country's construction industry to be fully digitalised and the demerits of the industry not being digitally transformed. Using appropriate statistical tools, the study found that while the South African construction industry has a high potential to be digitalised, this digital transformation can take a long time to be achieved. Data insecurity and information overload are among the critical risks that organisations seeking digital transformation might have to face. However, should these organisations fail to implement digital strategies in the delivery of their projects, they risk having a lack of competitiveness in the global market and an increase in poor project delivery.

Keywords Construction, Digitalisation, Fourth industrial revolution, South Africa

1. Introduction

In the current industrial revolution, emerging technologies are being used to improve product delivery and customer experience (Schwab, 2017). In construction, digital technologies such as Building information modelling (BIM), Internet of things (IoT), robotics, augment and virtual realities, digital twin, and blockchain technology, among others, are gradually being deployed to improve project delivery. However, the adoption rate of these ubiquitous technologies in developing countries, like South Africa, is still slow compared to the industry's counterparts in developed countries (Aghimien *et al.*, 2021). This slow adoption of beneficial technologies has been noted to be a principal problem in the poor delivery of construction projects that have characterised the construction industry in developing countries (Agarwal *et al.*, 2016). To improve project delivery, adopting digital tools has become obvious. By adopting emerging digital technologies, the construction industry can attain digitalisation and improve client satisfaction (Oke *et al.*, 2018).

Aghimien *et al.* (2019) described construction digitalisation as the adoption of digital technologies in place of human effort to deliver construction services that are satisfactory to the client and for which the organisations can attain a competitive advantage over their competitors. The array of benefits proposed by digitalisation in construction has been immensely discussed in past studies (Aghimien *et al.*, 2021; Delgado *et al.*, 2019; Oke *et al.*, 2018). However, just like every innovation, the move from a traditional approach that appears to be working to a digital approach with several unknowns, can be considered a risky venture for most construction organisations (Vass and Gustavsson, 2017). Past studies on digitalisation in construction have been piecemeal, with each focusing on how diverse digital tools can be applied to solve different problems within the industry. Less emphasis has been placed on the capability of the construction industry to be digitalised. Also, the risk inherent in the digitalisation of construction and the demerits of not being digitalised have gained less attention within the construction digitalisation discourse. Herein lies the knowledge gap.

To promote the digitalisation of the construction industry, particularly in developing countries like South Africa, this study assessed the viability of attaining digital transformation within the South African construction industry. In addition, the study assessed the risk inherent in construction digitalisation and the demerits of not digitalising the construction industry in the country. This was done with a view to preparing the construction organisations for the possible risks involved in the digitalisation process and proposing mitigating measures for addressing these risks should they occur.

2. Construction Digitalisation in South Africa

The concept of digitalisation in the South African construction industry has not been effective as would have been expected for a country with significant potential for digital transformation. A study conducted by Siemens to ascertain the digital maturity of four African countries (Ethiopia, Kenya, Nigeria and South Africa) concluded that South Africa has an established maturity level. This means that the country can be a digital leader in Africa (Dall'Omo, 2017). While the report focused on the manufacturing, energy and transport industries, its finding points to the fact that South Africa has an enabling environment for digitalisation, which can be beneficial for construction organisations. Unfortunately, this digital transformation is yet to happen. Similarly, a survey conducted by Accenture (2019) revealed that while almost all business owners admit that digital technology diffusion into their business can rapidly change their business and service delivery, only very few feel prepared enough to handle this diffusion. This is a pointer that the problem at hand might not be that of awareness but rather that of proper understanding of other factors relating to implementation.

According to Yaghoubi *et al.* (2012), most construction organisations are reluctant to invest in digital tools due to a lack of evidence of return on investment. Taylor and Smith (2000) have also mentioned that, in most cases, it is difficult for these organisations to predict the annual cash flow required for the use of required digital technologies. This implies that organisations risk not getting the expected return on investment, especially when the adopted technologies are not fully utilised. Another crucial issue in the construction digitalisation discourse is the risk of job loss. The resistance to technology adoption within the construction industry has been attributed to the fear that these technologies will replace humans and render people jobless (Mzekandaba and Pazvakav, 2018). The Price Waterhouse Coopers (PwC) reports in 2018 noted that 30% of jobs in South Africa might seize to exist with the advent of emerging technologies. However, Windapo (2016) earlier proposed that instead of pondering on the jobs to be lost, the question should be what types of jobs are these and what else could best replace these jobs. To this end, there have been studies stating that contrary to the popular opinion that technology leads to job loss, the use of pervasive digital tools will open up new markets for new skills and help human improve their skills, particularly in areas of managing these technologies for optimum production (Muro, 2017).

There is also the possibility that once digital tools are adopted, they might not meet the organisation's expectations, particularly in cases where proper needs assessment is not conducted before implementation (Stephenson and Blaza, 2001). This can lead to disappointment and a complete lack of confidence in the use of such technology. More so, it has been noted that technologies are mostly adopted in silos within the construction industry. Each profession adopts the technology better suited to them, and they are rarely willing to share information on the use of such technology (Kane *et al.*, 2015). Aside from this silos use of digital tools, the use of digital technologies poses some data insecurity if not carefully monitored and used. Rubin (2006) noted that the large amount of data produced through digital technologies is susceptible to cyber-attacks due to the interconnectedness of these technologies with the internet. Clearly, attention must be given to ensuring data security in the use of digital tools connected to the internet.

Aside from these envisaged issues, other issues that might emanate as a result of digital uptake in construction organisations include a lack of digitally skilled candidates (Oke *et al.*, 2018), the industry's resistance to technology adoption (Alaghbandrad *et al.*, 2011), fear of infringement of privacy leading to psychological issues (Tatum and Liu, 2017), loss of personal and interactive relations (Zahrandik and Jónsdóttir, 2017), information overload (Anderson and Thorpe, 2004), personnel injury as a result of machine operations (Tatum and Liu, 2017), increased industry competition, and obsolescence or system failures (Strukova and Liska, 2012).

3. Research Method

This study adopted an interpretivism philosophical view using an inductive approach wherein Delphi was used to acquire qualitative data. Delphi has been described as a consensus tool that helps forecast future situations using expert opinions, especially for complex problems (Skulmoski *et al.*, 2007). Care was taken in the selection of the experts for the study. Following past submissions, the selected experts were expected to have at least 50% overall value for some defined criteria (Alomari *et al.*, 2018). They were expected to have worked extensively within the construction industry in the country, working either as an academic in a higher education institute or practicing within the industry, be part of a professional body, and have a minimum bachelor's degree (Alomari *et al.*, 2018). Based on the set criteria, out of 32 experts invited, 13 completed the two-round Delphi process. These 13 experts were considered adequate, as past studies have noted that the number of experts used in most Delphi studies ranged from 8 to 20 (Ameyaw *et al.*, 2016)

The Delphi was conducted over two rounds using a questionnaire designed with open and closed-ended questions. In the first round, the questionnaire sought answers to the background of the experts, the potential of the South African

construction industry to be digitally transformed, and the time frame for this transformation to occur. The experts were also provided with some risk factors associated with construction digitalisation and were asked to rate them based on their criticality using a ten-point scale ranging from not critical to very critical. An option was given for the experts to add to the list. Lastly, the experts were asked to give the demerits of construction organisations failing to adopt the concept of digitalisation. The feedback from the first round was analysed using frequency (*f*), percentage (%), mean ($\bar{X}$), median (M), interquartile deviation (IQD), Kendall's coefficient of concordance (*W*), Chi-square (χ^2), as well as Mann-Whitney U-Test (*M-W*). Based on the analysis result, the second-round questionnaire was designed with the group M of all scores added for the experts to re-assess their responses. The experts were given the option to either agree with group M or retain their initial selection and give logical reasons. The feedback from the second round was also analysed, and the consensus was determined when 60% of all the variables achieved an IQD of 1 or less.

4. Findings and Discussion

4.1 Background information of the experts

The experts for the study were drawn from three provinces in the country vis; Gauteng (*f* = 9), Free state (*f* = 3), and Mpumalanga (*f* = 1). These experts cut across the core construction professionals such as construction manager *(f* = 6), engineers (*f* = 3), quantity surveyors (*f* = 3) and architect (*f* = 1). Regarding academic qualification, seven of the experts had a PhD, and are working in higher education institutions. The remaining six experts work in construction organisations. Four have bachelor's degrees, while two have master's degrees. Most of the experts (*f* = 11) had above ten years of working experience, with only 2 having between five to ten years. Collectively, the experts had above 50% of the set criteria and were considered fit for the study.

4.2 Digitalisation potential of the South African construction industry

Considering that the Delphi process can be used as a forecasting tool, particularly in areas with little or no knowledge (Agumba and Musonda, 2013), it became important to understand the future prospect of the South African construction industry with regard to its digital transformation. Based on this notion, the experts were first asked to rate the level of potential of the South African construction industry to be digitally transformed on a scale of one to five, with one being very low and five being very high. The result in figure 1 revealed that at the first round, most of the experts noted that the South African construction industry has a high potential to be digitally transformed, while only three experts noted that the potential is low. However, the number of those that noted a high level of potential in the industry increased to ten in the second round, while only two people insisted that the potential level was low, and one believed it was on average.

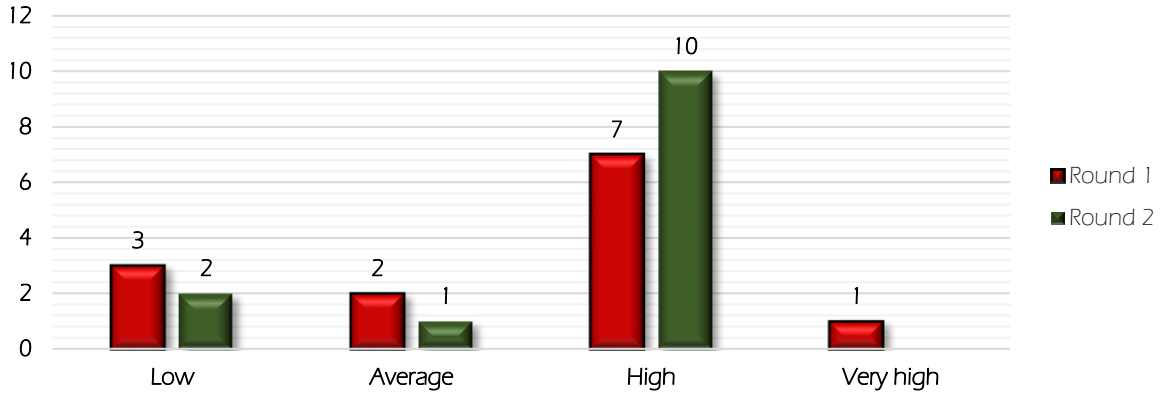

Figure 1: Digitalisation potential of the South African construction industry

Aside from understanding the potential of the South African construction industry to be digitally transformed, the envisaged timeline for this transformation to occur was also assessed. The result in figure 2 shows that at the first and second rounds, the envisaged time frame for the South African construction industry's digital transformation is between 9 to 10 years from when the study was conducted (i.e., August, 2019). Only two experts believed that this transformation was possible within a year or two from the time of conducting this study.

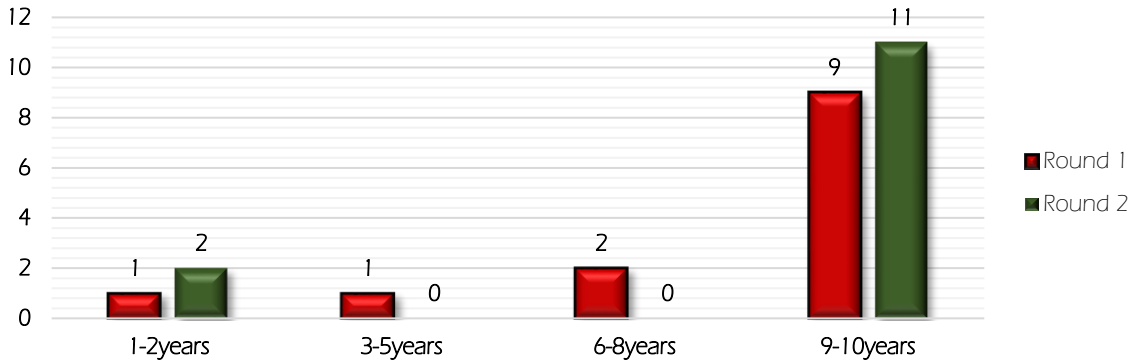

Figure 2: Timeline for the digitalisation to occur

4.3 Risks associated with the digitalisation of the South African construction industry

Delphi Round 1

The analysis of the feedback in Table 1 from the first round of the Delphi shows that only two risk factors (data insecurity and information overload) were very critical, with a group median of 10 and 9, respectively. Productivity loss was not considered a critical risk. Furthermore, the *M-W* test conducted to determine the significant difference in the rating by the experts working within higher education institutions and construction organisations revealed no disparity in how both groups of experts rated the criticality of these risk factors. This is because the *p*-value derived for all the assessed risk factors was above the 0.05 threshold. It is important to note that consensus was not achieved at the first round because the factors assessed had an IQD of above 1.

Table 1. Round 1 result of the risk associated with digitalisation

			M-W	
Risks associated with digitalisation	**M**	**IQD**	**Z**	***p*-value**
Financial investment risk	8	2.00	-1.167	0.243
Implementation and systems failure	8	2.00	-1.363	0.173
Information overload	9	3.00	-0.884	0.377
Job loss	8	2.00	-0.523	0.601
Work overload	7	2.00	-0.887	0.375
Productivity loss	4	3.00	-1.159	0.247
Overdependence on technology	7	3.00	-1.014	0.311
Data insecurity / cyber attacks	10	3.00	-2.022	0.053
Silo implementation of technologies	8	3.00	-1.774	0.076
Compliance violations with public sector practices	8	4.00	-0.872	0.383
Kendall's *W*			0.448	
χ^2			48.420	
χ^2 – Critical values from the statistical table ($p = 0.05$)			16.919	
Df			9	
Sig.			0.000	

Delphi Round 2

The consensus was achieved at the second round as all the risk factors assessed had an IQD of 1 and below. Furthermore, Kendall's *W* gave a value of 0.607, which is closer to one. Moreso, the computed χ^2 value of 65.542 was higher than the critical χ^2 value of 16.919 obtainable in statistical tables, thus implying a convergence in the rating of the variables by the expert. On individual assessment, the *M-W* test only revealed a disparity in the rating of one of the factors (job loss), as a *p*-value of 0.031 was derived. This implies that not all experts believe that job loss is a risk that construction organisations seeking to be digitalised should worry about. The ranking system was introduced using the group $\bar{X}$ to clearly present the most critical risk factors. From Table 2, security issues ($\bar{X}$ = 9.23) and information overload ($\bar{X}$ = 8.92) are the most critical risk factors. The least critical risk is productivity loss ($\bar{X}$ = 4.46). This implies that while construction organisations are taking measures to avoid risks such as implementation and systems failure, job loss, financial investment risk and others, emphasis must be placed on the security of sensitive organisation

information and managing information. Less emphasis should be placed on productivity loss as digitalisation will help optimise the production process and not reduce it.

Table 2. Round 2 result of the risk associated with digitalisation

						M-W	
Risks associated with digitalisation	**M**	$\bar{X}$	**IQD**	**SD**	**Rank**	**Z**	***p*-value**
Data insecurity / cyber attacks	10	9.23	0.00	2.204	1	-1.743	0.081
Information overload	9	8.92	1.00	1.115	2	-1.223	0.221
Implementation and systems failure	8	8.31	1.00	0.947	3	-1.483	0.138
Job loss	8	8.25	0.50	1.215	4	-2.162	0.031**
Financial investment risk	8	8.08	0.00	0.760	5	-1.923	0.054
Silo implementation of technologies	8	8.00	0.00	0.816	6	-0.492	0.623
Compliance violations	8	7.92	0.00	1.115	7	-1.919	0.055
Overdependence on technology	7	7.00	0.00	1.348	8	-1.030	0.303
Work overload	7	6.38	1.00	1.261	9	-0.625	0.532
Productivity loss	4	4.46	1.00	1.561	10	-0.148	0.883
Kendall's *W*						0.607	
χ^2						65.542	
χ^2 – Critical values from the statistical table (p = 0.05)						16.919	
Df						9	
Sig.						0.000	

4.4 Demerits of non-adoption of digitalisation in the South African construction industry

Delphi Round 1

In the first round of the Delphi, experts were given a blank space to fill in their views regarding the demerits of construction organisations failing to adopt the concept of digitalisation. This approach was adopted due to the lack of information in the existing literature. The feedback from the first round was analysed using content analyses by grouping like terms and themes together. At the end of the analysis, eight distinct demerits were identified and further assessed in the second round.

Delphi Round 2

The respondents were asked to rate the eight demerits identified in the first round, and the result is presented in Table 3. The *M-W* test revealed no disparity in the rating of each of these eight demerits as a *p*-value of above 0.05 was achieved. A consensus was reached for seven out of the eight assessed demerits. Kendall's *W* value of 0.298 was also derived with a computed χ^2 value of 18.746, which is higher than the critical χ^2 value of 14.067. Although Kendall's *W* value is low, and one of the assessed demerits had above 1.00 IQD, it was concluded that consensus was achieved since it was set that at least 60% of the assessed variables must have an IQD of less than or equal to 1. Table 3 revealed that the most significant demerits with the failure of construction organisations to be digitalised are lack of competitiveness in the global market ($\bar{X}$ = 9.64), increased poor-performing projects ($\bar{X}$ = 9.27), non-competitiveness of indigenous organisations ($\bar{X}$ = 9.27), and stagnation of the industry ($\bar{X}$ = 9.09).

Table 3. Demerits of non-digitalisation

						M-W	
Demerits of non-digitalisation	**M**	$\bar{X}$	**IQD**	**SD**	**Rank**	**Z**	***p*-value**
Lack of competitiveness in the global market	10	9.64	0.00	0.809	1	-1.361	0.174
Non-competitive nature of indigenous organisations	10	9.27	0.50	1.009	3	-0.233	0.816
Increased poor-performing projects	10	9.27	1.00	1.348	2	-0.982	0.326
Stagnation of the industry /Lack of innovativeness	10	9.09	1.00	1.375	4	-0.642	0.521
Potential loss of complementary/alternative digital employment opportunities	8	8.80	1.00	1.033	5	0.000	1.000
High cost of construction in the future	8	8.73	1.00	1.348	6	0.000	1.000
Continued unsustainable reliance on manual labour	10	8.55	1.00	2.382	7	-1.535	0.125
Low labour productivity	8	7.40	1.75	2.119	8	-0.329	0.742

Kendall's *W*	0.298
χ^2	18.746
χ^2 – Critical values from the statistical table (p = 0.05)	14.067
Df	7
Sig.	0.009

4.5 Discussion

In the expert's opinion, the South African construction industry has a high potential to be digitalised. However, this transformation can take up to ten years for it to be achieved. This result can be viewed in two folds. On the one hand, the South African construction industry has the potential to be like its counterparts in other developed and developing countries that have embraced or are embracing the concept of digitalisation. This result further confirms Dall'Omo's (2017) submission that South Africa as a country has a high digital technology readiness when compared to other African countries. However, the expected time for this transformation can be far. This result can be associated with the careless attitude of the construction industry in the country to adopt technology in the delivery of their projects, as noted by Aghimien *et al.* (2019). Thus, if the timeline for this transformation is to reduce, there is a need for an awakening in terms of digital technology adoption and improvement of construction organisations' digitalisation capabilities.

The Delphi revealed that the most likely risk factors to occur are data insecurity or cyber-attacks and information overload. With organisations switching from hardware storage of data to cloud storage, they face the possibility of hacking if proper security measures are not put in place. Similarly, with the use of the internet comes the vulnerability of organisations' information being hacked by malicious individuals. Therefore, internet service providers (ISPs) and data storage organisations have crucial roles to play in ensuring the protection of organisations' information. This result is in tandem with the submission of Hudson (2017), who noted that the adoption of digital tools would ease data storage and access and increase the chances of cyber-attacks. The finding is also in line with past submissions that have shown that the fear of cyber insecurity has been the bane of the non-adoption of most technologies (Pärn and Edwards, 2019; Rubin, 2006). Spremić and Šimunic (2018) have also earlier submitted that many organisations, including large entities, do not have effective policies to address cyber risks. This might pose a big challenge for developing countries like South Africa, whose construction industry is filled with small and medium enterprises (SMEs). Therefore, construction regulatory bodies such as the Construction Industry Development Board can take the initiative to ensure that its members prioritise cybersecurity in their quest for digital transformation.

Interestingly, information overload is considered a critical risk. This can be because approaches such as data mining allow unearthing underlying issues from the enormous data being generated (Gupta and Gupta, 2010). If not adequately handled, SMEs that saturate the South African construction industry might just be overwhelmed with the amount of information they have at their disposal. Aside from these two principal risks, construction organisations might also want to look out for issues such as potential failure of the systems, job loss, financial investment risk, silo implementation of digital technologies, and the violation of compliances. These factors have come up in past studies as either a challenge or inherent issue associated with using one form of digital technology or the other (Gaille, 2016; Strukova and Liska, 2012; Zahradnik and Johnsdottir, 2017). Mzekandaba and Pazvakav (2018) discussed a PwC report that discovered that a third of jobs (especially monotonous and repetitive jobs) in South Africa are at risk of complete obsolescence with digitalisation. This has been the fear of most developing countries, with an associated risk of industrial actions among workers in protest of the use of digital technologies. It is, therefore, the duty of the different regulatory bodies in the industry to enlighten their members and the public on the notion that digitalisation is not designed to eliminate skills but rather enhance them (Holopainen and Jokikaarre, 2016).

While the aforementioned risk of construction digitalisation abounds, construction organisations might experience a lack of competitiveness in the global market if they fail to be digitalised. This is understandable as the world has become a global village. Advancement in technology is on the increase, and the construction industry in most countries will continue to evolve through the adoption of these technologies. If construction organisations in South Africa fail to evolve, they will eventually lose out on most international projects that could have benefited both these organisations and the country. Undoubtedly, the industry stands the risk of increased poor project performance, non-competitiveness of indigenous construction organisations, and stagnation of the construction industry. Abidin *et al.* (2014) noted that the construction industry continually demands organisations to improve their service for them to be competitive. To achieve this, working 'smarter' should be the watchword for construction organisations and not working 'harder'. This can be achieved through the innovative use of digital technologies (Koch and Windsperger, 2017).

5. Conclusion

This study assessed experts' views of construction digitalisation in the South African construction industry. Using a Delphi approach, the study concludes that the construction industry in the country has the potential to be digitalised; however, this might require a long time and planning to achieve. Furthermore, construction organisations need to be aware and prepared for possible risks of data insecurity, information overload, failure of digital systems, job loss, shortage in returns in investment, silo implementation and possible violations of compliances should they decide to digitalise their organisational processes. However, sticking to the traditional construction approach without digitalising will lead to a lack of competitiveness in the global market, non-competitiveness of indigenous organisations, increased poor project delivery, stagnation, loss of alternative digital employments, and high future cost construction, and continuous unsustainable reliance on manual labour.

These findings imply a need to ensure proper cyber system security by internet service providers and other related organisations to help check the cyber insecurity risk. Similarly, there is a need for the government and relevant construction bodies to support construction organisations through soft loans and other relief media to enable them to acquire the needed technologies and keep pace with the evolving digital world. Furthermore, there is a need to enlighten construction participants and the public on the role of digitalisation in promoting and improving skills rather than replacing them. Lastly, there is also the need to revisit regulations that do not favour the use of digital technologies in construction projects' delivery. The government and construction regulation bodies need to champion the quest for digitalisation by enacting favourable policies that promote technology use in construction projects within the country.

Despite the significant contribution of the study to the discourse on construction digitalisation, care must be taken in generalising its findings. First, not all participants invited to the Delphi agreed to participate. A different outcome might have been achieved had all invited experts participated. Also, the experts in the study were from three out of the nine provinces in the country. Future studies can be done in the other provinces not represented in this current study.

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