Delineating the people-related features required for construction digitalisation

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Abstract

Purpose – Digitalisation, which involves the use of digital technologies in transforming an organisation's activities, transcends just the acquiring of emerging digital tools. Having the right people to drive the implementation of these technologies and attaining strategic organisational goals is essential. While most studies have focused on the use of emerging technologies in the construction industry, less attention has been given to the 'people' dimension. Therefore, this study aims to assess the people-related features needed for construction digitalisation.

Design/methodology/approach – The study adopted pragmatic thinking using a mixed-method approach. A Delphi was used to achieve the qualitative aspect of the research, while a questionnaire survey conducted among 222 construction professionals was used to achieve the quantitative aspect. The data gathered were analysed using frequency, percentage, mean item score, Kruskal–Wallis H test, exploratory factor analysis and confirmatory factor analysis.

Findings – Based on acceptable reliability, validity and model fit indices, the study found that the people-related factors needed for construction digitalisation can be grouped into technical capability of personnel, attracting and retaining digital talent and organisation's digital culture.

Practical implications – The findings offer valuable benefits to construction organisations as understanding these identified people features can help lead to better deployment of digital tools and the attainment of the digital transformation.

Originality/value – This study attempts to fill the gap in the shortage of literature exploring the people dimension of construction digitalisation. The study offers an excellent theoretical backdrop for future works on digital talent for construction digitalisation, which has gained less attention in the current construction digitalisation discourse.

Keywords Construction, Digital talent, Digitalisation, Digital technologies, Fourth Industrial Revolution

Paper type Research paper

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Introduction

Digitalisation has become synonymous with the Fourth Industrial Revolution, wherein organisations use digital technologies (DTs) to offer services in a smarter way (Dimick, 2014). To encourage the digitalisation of organisations, studies assessing the guidelines for the digital transformation in diverse fields have continued to emerge. For instance, in identifying the capabilities needed for digitalisation, Dyk and Schutte (2012), Gill *et al.* (2016) and Valdez-de-Leon (2016) all favoured the trio of people, process and technology alongside other dimensions. Sheikhshoaei *et al.* (2018) suggested technology, people and governance as key dimensions worth considering for effective digital transformation. Boström and Celik (2017), in their assessment of digital strategy, suggested technology and people as well as strategy, governance and the ecosystem. Evidently, the dimension of "people" is an integral part of the success of any organisation that will be digitally transformed.

There is no naysaying that the construction industry activities are driven by people who are bound by similar culture and structure of their organisation. Therefore, the role of these people in the digital transformation of construction organisations cannot be overlooked. Frankiewicz and Chamorro-Premuzic (2020) noted that an organisation's digital transformation is not just about having the right technology but having the right talent (people) to handle these technologies and drive the digital change required. Belfo (2012) hinted that the "people" dimension involves everything directly related to people, either employees, employers or customers. Understanding how these people-related factors influence the digitalisation of construction organisations is important to promoting digital transformation in the construction industry.

Albeit the important role of people in the digital transformation of organisations, there is a scarcity of studies focusing on this dimension in the construction industry. Much attention has been placed on how organisations use emerging DTs to solve specific industry-related problems with less emphasis on the people needed to drive these technologies. Looking at the nature of the construction industry around the world, particularly in developing countries like South Africa, where this current study was conducted, it is evident that the adoption of digital tools is slow-paced (Aghimien *et al.*, 2021a; Pärn *et al.*, 2018). This slow adoption can be attributed to the resistance from the workforce and trade unions due to fear of job loss, among other issues (Aghimien *et al.*, 2021b). Like other countries, it has been noted that several jobs are at risk of obliteration in South Africa due to advances in technologies (Mzekandaba and Pazvakav, 2018). As such, the rapid embrace of these emerging technologies will not come easily within the country's construction industry if the positive impacts of these technologies on workers' job functions and processes are not properly showcased. Therefore, through this study, organisations will be able to implement the technology changes they require in a manner that does not adversely affect their workforce. In return, the workforce will understand their role in the digital transformation journey of their respective organisations.

To this end, this study strives to contribute to the existing discourse on construction digitalisation by unearthing the significant people-related factors that will influence the digital transformation of construction organisations. The objectives were to improve the digitalisation of construction organisations and their service delivery by identifying and empirically testing the "people" sub-attributes that these organisations need to consider in their quest for digitalisation. The findings offer practical guidelines for these organisations to effectively manage their workforce for their digital transformation. Much more, the study's findings provide a good theoretical backdrop for future studies on the human dimension of construction digitalisation – an aspect that has received less attention in the current construction digitalisation discourse.

Theoretical background

Overview of construction digitalisation

Kalavendi (2017) described digitalisation as using DTs in an organisation's operations. These DTs can be in the form of software, information technology as well as communication equipment (Dimick, 2014). In construction, Aghimien *et al.* (2021b, p. 6) conceptualised digitalisation as "the innovative use of DTs in delivering tangible and intangible services within a construction organisation to gain a competitive advantage over other competitors while providing better service delivery". The concept of digitalisation is still in its infancy stage in the construction industry of most developing countries. As a result, studies have continued to explore the adoption of diverse DTs by construction organisations around the world (Bello *et al.*, 2021; Chen *et al.*, 2021; Habibi, 2021; Okpala *et al.*, 2021). In addition, other studies have assessed the inherent benefits as well as the challenges deterring the use of these technologies (Golizadeh *et al.*, 2019; Liu *et al.*, 2020; Oke *et al.*, 2018; Sompolgrunk *et al.*, 2021; Taniguchi *et al.*, 2022). The use of digital tools offers significant benefits to the construction industry. For instance, building information technology can help solve issues around cost and time on construction projects due to its ability to identify errors in design early, eradicate rework and improve collaboration (Aboushady and Elbarkouky, 2015). Poor communication among project participants can also be addressed through the use of information systems like cloud computing and the internet of things (Ammar *et al.*, 2018; Crnjac *et al.*, 2017), while big data offers the opportunity to effectively predict future events and ease decision-making through careful analysis of data from past projects (Aghimien *et al.*, 2021b; Bagheri *et al.*, 2015; Jin *et al.*, 2015). Furthermore, unmanned aerial vehicles, autonomous robots and three-dimensional (3D) printing offer reduced labour and material costs, reduced site accidents leading to fatalities and injuries and better productivity and job creation (Mohd-Tobi *et al.*, 2018; Sakin and Kiroglu, 2017).

Some challenges inherent in the construction industry have been mentioned as key culprits of the slow digital transformation of the industry. For instance, the industry, particularly in South Africa, has been noted for its skills shortage (Windapo and Cattell, 2013). This affects the availability of adequately trained personnel to handle these DTs (Oke *et al.*, 2018). More so, as a result of the cost associated with acquiring and maintaining these technologies, coupled with the cost of training personnel to operate them, it becomes difficult for construction organisations to adopt these digital tools (Dimick, 2014; Golizadeh *et al.*, 2019; Oke *et al.*, 2018). This is because the industry is littered with small and medium organisations that struggle financially. Aghimien *et al.* (2021b) noted that the construction industry in South Africa is yet to attain the required maturity needed to be digitally transformed. The understanding of the key requirements needed to attain this transformation is yet unknown, and this significantly obstructs their digitalisation. This begs the need for this study to delineate the human factors that need to be considered by construction organisations for holistic digitalisation.

People-related features for construction digitalisation

In the quest for digital transformation, several studies have been undertaken to create a roadmap for organisations. Various capabilities needed for this transformation have been presented through developed models and frameworks that have been deployed in diverse industries like manufacturing, telecommunication and education, among others. These models and frameworks have birthed many dimensions that organisations that want to be digitally transformed need to consider. Some of these dimensions include technology (Boström and Celik, 2017; Dyk and Schutte, 2012; Luftman, 2000; Newman, 2017; Valdez-de-Leon, 2016), organisation, culture and people (Dyk and Schutte, 2012; Newman, 2017; Valdez-de-Leon, 2016; Vivares *et al.*, 2018), strategy (Newman, 2017; Valdez-de-Leon, 2016), process and operations

(Dyk and Schutte, 2012; Newman, 2017), governance (Boström and Celik, 2017; Luftman, 2000; Sheikhshoaei *et al.*, 2018), ecosystem (Valdez-de-Leon, 2016), finance (Dyk and Schutte, 2012), among others. These past studies have emphasised the importance of people and their attributed factors in the digital transformation of organisations (Boström and Celik, 2017; Gill *et al.*, 2016; Sheikhshoaei *et al.*, 2018; Valdez-de-Leon, 2016).

The dimension of people in the digital transformation of organisations can be linked to the aspect of "position" in the dynamic capability theory (DCT) postulated by Teece and Pisano in 1994. The DCT, which is an extension of the resource-based view theory, was designed to provide organisations with insight into the dynamic capabilities they need to effectively use their internal and external competencies to attain improved and sustained competitive advantage (Teece and Pisano, 1994). It was noted that the environment wherein most organisations operate is not static; as such, they require dynamic capabilities to survive (Teece *et al.*, 1997). The DCT suggests that organisations require three key first-order capabilities, namely, sensing, seizing and reconfiguring. However, these capabilities must be rooted in a well-defined process, position and path (Aghimien *et al.*, 2021b; Teece, 2007). The "process", which can be managerial or organisational, involves coordinating, integrating, learning and reconfiguration activities within the organisation, while the "position" depicts the types of assets within the organisation. The "paths" are the organisation's strategic directions (Teece and Pisano, 1994). Thus, a construction organisation that will gain sustained competitive advantage in the current technology pervasive environment must have a well-defined process, a good position of its assets and a clear path. Zooming into the aspect of "position" in the DCT, it is evident that the strategic position of any organisation is shaped by the organisation's specific assets. These assets can be in the form of unique knowledge and assets complementary to them (Teece and Pisano, 1994). According to Fulmer and Ployhart (2014), humans are one of the most important assets of any organisation. This is the case in the construction industry. Thus, using this important asset towards digitally transforming construction organisations is essential.

To fully use an organisation's workforce to achieve digital transformations, past submissions have shown several factors that need to be considered. For instance, the required technical know-how is vital to the successful adoption and implementation of digital tools (Gill *et al.*, 2016; Sheikhshoaei *et al.*, 2018). Also, managing knowledge digitally is essential to the digitalisation of organisations (Peltier *et al.*, 2009; Quinton *et al.*, 2018). Gill *et al.* (2016), Newman (2017) and Sheikhshoaei *et al.* (2018) all noted the need to re-skill existing workers in the use of specific DTs. Sheikhshoaei *et al.* (2018) further stressed the importance for organisations to consider empowering their employees and, at the same time, possess the ability to attract and retain an experienced and qualified workforce. Much more, it was noted that training and motivating employees, boosting team, promoting a digital culture and proper need assessment are germane to effective digital transformation. Macchi and Fumagalli (2013) also noted the need to empower workers, while Bibby and Dehe (2018) noted that organisations should allow innovativeness, openness and continuous improvement culture among the workforce for proper digital transformation to occur.

According to Luftman (2000), the factors relating to people in the strategic alignment of business with technology include the organisation's innovativeness, entrepreneurship, *locus* of power, leadership/management style, change readiness, career crossover, education, cross-training and social, political, trusting environment. A similar observation was made by Newman (2017) in developing a digital maturity model. Boström and Celik (2017) went further to include the upgrade of digital skills through an alliance with external bodies and employee participation in creating solutions and developing awareness of change. Quinton *et al.* (2018) noted the role of top management within an organisation in the adoption of technologies. It was noted that the level of knowledge of these senior managements in technology-related issues would influence their behaviour, either supporting or opposing digital transformation in their organisation. Other factors emanating from past studies include a positive change attitude, taking risks and being proactive and readiness to innovate (Grant *et al.*, 2014; Peltier *et al.*, 2009, 2012). Based on the review conducted, Table 1 summarises the people-related features assessed in this study.

Research methodology

This study follows pragmatic philosophical thinking using a mixed-method research design. A mixed-method approach became necessary due to the absence of similar studies on the people dimension for digitalisation within construction. The variables assessed were drawn from developed models and frameworks from other fields; as such, using a single approach might not give a clear picture of the applicability of these variables in the construction domain. The combination of the qualitative and quantitative approaches in a sequential manner helped address the shortcomings inherent in the individual methods as noted in past studies (cf. Amaratunga *et al.*, 2002; Bryman, 2001; Tashakkori and Teddlie, 2003). As a result, the qualitative aspect of the mixed-method approach was achieved through a Delphi. The Delphi is a consensus-attaining process done over several iterations (rounds) to attain consensus among experts of a study (Chan *et al.*, 2001). For this study, 32 experts were invited to participate in the Delphi, out of which only 21 indicated their interest. However, only 13 of these experts met the criteria sets for determining an expert for a Delphi study as indicated in past studies (Alomari *et al.*, 2018; Chan *et al.*, 2001; Hallowell and Gambatese, 2010). These criteria include extensive years of experience, a current employee of a reputable construction organisation or a faculty member at an accredited higher institution, a member of a professional body, and an advanced degree in a construction-related field. As past studies have noted that a panel size of between 10 and 18 expert members is typical in most construction-related studies (Ameyaw *et al.*, 2016; Hallowell and Gambatese, 2010), using 13 experts for this study was considered adequate. In determining consensus, while past studies have considered single analytical approaches (Ameyaw *et al.*, 2016), there is a rising trend in combining related statistical tools to achieve robust outcomes (Aghimien *et al.*, 2021b; Ojo and Ogunsemi, 2019). This current study follows the recent trend by using the robustness of the combination of the median, interquartile deviation, Kendall's coefficient of concordance (W) and χ^2 to determine consensus among experts.

Measurement variables	Authors
Attracting digital talent	Sheikhshoaei *et al.* (2018)
Continuous learning of personnel	Gill *et al.* (2016), Luftman (2000); Quinton *et al.* (2018), Sheikhshoaei *et al.* (2018)
Digital culture within an organisation	Sheikhshoaei *et al.* (2018)
Digital empowerment of personnel	Gill *et al.* (2016), Newman (2017); Sheikhshoaei *et al.* (2018)
Digital knowledge management by the organisation	Peltier *et al.* (2009), Quinton *et al.* (2018)
Digital technical know-how of personnel	Gill *et al.* (2016), Luftman (2000); Sheikhshoaei *et al.* (2018)
Organisation's positive change attitude	Luftman (2000), Peltier *et al.* (2012); Quinton *et al.* (2018)
Personnel's innovativeness	Luftman (2000); Jones *et al.* (2013)
Re-skilling of workforce	Gill *et al.* (2016), Newman (2017); Sheikhshoaei *et al.* (2018)
Retaining digital talent	Sheikhshoaei *et al.* (2018)
Top management support	Gill *et al.* (2016), Quinton *et al.* (2018)

Table 1. Summary of people-related variables for construction digitalisation

The findings from the Delphi informed the questionnaire used for the quantitative aspect of the research. This questionnaire was designed in two sections, with the first geared towards identifying the background characteristics of the respondents. Section 2 assessed the influence of the variables (identified from the literature and confirmed through Delphi) on the digital transformation of construction organisations in South Africa. A five-point Likert scale ranging from five (very large extent) to one (no extent at all) was adopted for this Section 2. The target population for the quantitative aspect of the research were core construction professionals (architects, engineers, construction and project managers, quantity surveyors) with at least five years of working experience in the South African construction industry and actively involved in a construction project in the country. The survey of the available annual reports of the respective professional bodies of these construction professionals revealed a total population of 40,188 members. This includes 10,638 architects, 17,226 engineers, 7,785 construction and project managers and 4,539 quantity surveyors (Engineering Council of South Africa, 2019; South African Council for the Architectural Profession, 2019; South African Council for Project and Construction Management Profession, 2018; South African Council for the Quantity Surveying Profession, 2018). As this entire population is large and reaching all of them is unrealistic, Cochran's sample size calculation with a 90% confidence level, a ±7% margin of error and a 0.5 estimated proportion of the population was used to reduce the population to a manageable sample size of 546. Snowball sampling was then adopted as it was difficult to determine the exact number of professionals in good standing with their profession and who have the set years of experience and practice at the time of the research. The snowball approach, which is referral based (Heckathorn, 2011), assisted in reaching a significant number of professionals around the country. This sampling method has gained significant attention in recent construction-related studies (Aghimien *et al.*, 2020; Aliu and Aigbavboa, 2021; Chan and Aghimien, 2022; Chan *et al.*, 2017; Rahman, 2014). At the end of the survey, responses were retrieved from 222 construction professionals representing a response rate of 40.5% of the designed sample size. Past studies have noted that due to the difficulty involved in garnering large samples in surveys, a response rate of 20 to 30% is adequate for a logical conclusion to be drawn (Moser and Kalton, 1999).

Based on the data gathered, analysis was done using various statistical tools. The data on the background of the respondents were analysed using frequency (f) and percentage (%), while the variables were ranked based on the derived mean item score ($\overline{X}$) in descending order. Since the data were gathered from professionals from contracting, consulting and government organisations, understanding the significant difference in the view of these groups of respondents in rating these variables was considered necessary. Kruskal–Wallis H test (K-W) which gives a χ^2 and significant p-value that should be less than 0.05 for a significant difference across the different groups was adopted. In addition, exploratory factor analysis (EFA) was also used to regroup the identified variables. In conducting EFA, the factorability of the data was tested using Kaiser–Meyer–Olkin (KMO) set at a threshold of 0.6 and Bartlett test of sphericity (BTs), which is expected to be significant at a p-value less than 0.05 (Pallant, 2011; Tabachnick and Fidell, 2013). Having met these factorability thresholds, EFA was conducted using principal component analysis (PCA) with varimax rotation due to the ability of PCA to easily identify and reduce a significant number of variables into small coherent subscales (Hair *et al.*, 2019; Tabachnick and Fidell, 2013). Based on the extraction from the EFA, confirmatory factor analysis (CFA) was conducted to confirm the validity and significance of the variables grouped by EFA. This analysis was conducted using EQAtion (EQS) software version 6.4.

Results and discussions

The result from the Delphi

The Delphi experts comprised six construction managers, three engineers, three quantity surveyors and one architect, the majority (nine) of whom are located in the Gauteng province of the country. Eight of these experts are members of their respective professional bodies. Seven of them have a doctorate and are members of staff of higher institutions in the country. The remaining six were from diverse construction organisations, with four having a bachelor's degree and the remaining two having master's degrees. Two of these experts have between five and ten years of experience, while the remaining 11 have above ten years. In the first round of the Delphi, the expert panel was presented with 11 people-related factors to rank using a ten-point significance scale. They were also given the option to add any new factor they deemed necessary but not included in the survey. The feedback from this first round showed no new addition to the stated factors, and the responses were analysed. The derived median was included in the second-round questionnaire with the response of each expert and was sent back for them to either stick to their initial position or select the median as noted by other experts. Evidently, there was no consensus in the first round. Table 2 shows the result from the second round of the Delphi. At this round, a high median of between 8 and 10 was derived, and the IQD derived showed a strong consensus of between 0.00 to 1.00. Also, Kendall's W value of 0.686 derived is close to 1.0, while the computed χ^2 value of 89.167 derived was higher than the critical χ^2 value of 18.307 obtainable in statistical tables. These results imply that significant consensus was attained at this stage, and the variables are applicable to the construction domain and can be used for further assessment in the study.

The result from the survey

Background information of the respondents. The result derived from the respondents' background information is presented in Table 3. The table shows that the respondents for the study were drawn from eight out of the nine provinces in South Africa. More responses were gathered from Gauteng, as this province has been noted to have the highest number of construction organisations, professionals and output in the entire country [Construction Industry Development Board (CIDB) 2021]. The highest response was from quantity surveyors (32%) and engineers (26.6%). The majority of these professionals have bachelor's

People-related factors	Median	IQD	Mann–Whitney Z	Sig.
Top management support	10	0.00	−0.114	0.909
Continuous learning of personnel	10	0.00	−0.488	0.626
Re-skilling of workforce	10	0.00	−1.363	0.173
Digital technical know-how of personnel	10	0.00	−0.227	0.820
Digital culture within an organisation	9	1.00	−0.762	0.446
Organisation's positive change attitude	9	1.00	−1.152	0.249
Digital empowerment of personnel	9	1.00	−0.459	0.647
Personnel's innovativeness	9	0.00	−0.078	0.938
Retaining the right digital talent	8	1.00	−0.082	0.935
Attracting the right digital talent	8	0.00	−0.880	0.379
Digital knowledge management by the organisation	8	0.00	−0.581	0.561
Kendall's W	0.686			
Calculated χ^2	86.167			
Critical χ^2 from stat table @ p-value = 0.05	18.307			
Df	10			
p-value	0.000			

Table 2. Delphi result on the people-related factors for construction digitalisation

Category	Classification	*f*	(%)
Profession	Architect	34	15.3
	Engineer	59	26.6
	Construction manager	32	14.4
	Construction project manager	26	11.7
	Quantity surveyors	71	32.0
	Total	222	100.0
Highest academic qualification	Diploma	38	17.1
	Bachelor's/honours degree	115	51.8
	Master's degree	61	27.5
	Doctorate	8	3.6
	Total	222	100
Type of organisation	Government	49	22.1
	Consultancy	65	29.3
	Contracting	108	48.6
	Total	222	100.0
Years of experience	5 years	70	31.5
	6–10 years	67	30.2
	11–15 years	53	23.9
	16–20 years	18	8.1
	Above 20 years	14	6.3
	Total	222	100.0
	Average	9.2 years	
Current working location (province)	Eastern Cape	2	0.9
	Free State	13	5.9
	Gauteng	166	74.8
	KwaZulu-Natal	2	0.9
	Limpopo	12	5.4
	Mpumalanga	23	10.4
	North West	1	0.5
	Northern Cape	3	2.3
	Western Cape	0	0.0
	Total	222	100.0

Table 3. Background information characteristics

degrees (51.8%). This is followed by a master's degree (27.5%), diploma (17.1%) and doctorate (3.6%). The professionals were drawn from contracting (48.6%), consulting (29.3%) and government organisations (22.1%). In terms of years of working experience, while 31.5% have gathered up to five years working within the construction industry, 69.5% have over five years. These results imply that the study's target respondents (core construction professionals) were adequately represented. They have a reasonable level of academic background to understand the research questions. These questions were answered based on the wealth of experience they have accumulated during their years working within the industry.

People-related features required for construction digitalisation. The result from the K-W test, as shown in Table 4, reveals that four out of the 11 assessed factors have a considerable disparity in their rating by the different construction professionals. These variables are top management support (p-value = 0.016), digital empowerment of personnel (p-value = 0.009), personnel's innovativeness (p-value = 0.010) and attracting the right digital talent (p-value = 0.003). The disparity in rating these variables is also evident in how the respondents viewed the overall dimension as χ^2 value of 6.331 at a df of 2, and a significant p-value of 0.042 was derived from the overall K-W test conducted. This disparity in the view of the different

People-related factors	Govt. $\overline{X}$	Govt. RK	Consult. $\overline{X}$	Consult. RK	Contract. $\overline{X}$	Contract. RK	Overall $\overline{X}$	Overall RK	K-W χ^2	K-W p-value
Top management support (PC5)	4.96	1	4.72	9	4.94	1	4.88	1	8.327	0.016**
Digital culture within an organisation (PC6)	4.80	3	4.85	4	4.89	2	4.86	2	1.116	0.572
Continuous learning of personnel (PC4)	4.84	2	4.75	7	4.83	3	4.81	3	0.868	0.648
Organisation's positive change attitude (PC7)	4.59	6	4.88	2	4.76	5	4.76	4	5.409	0.067
Re-skilling of workforce (PC3)	4.63	5	4.75	7	4.81	4	4.76	4	2.607	0.272
Digital empowerment of personnel (PC8)	4.51	8	4.91	1	4.72	6	4.73	6	9.425	0.009**
Retaining the right digital talent (PC11)	4.65	4	4.85	4	4.61	9	4.69	7	3.574	0.167
Digital technical know-how of personnel (PC1)	4.55	7	4.66	10	4.68	7	4.64	8	1.535	0.464
Personnel's innovativeness (PC9)	4.37	9	4.82	6	4.65	8	4.64	8	9.210	0.010**
Digital knowledge management (PC2)	4.39	10	4.88	2	4.59	10	4.63	10	11.440	0.003**
Attracting the right digital talent (PC10)	4.18	11	4.60	11	4.41	11	4.41	11	5.231	0.073
Overall *K-W* test										
χ^2					6.331					
Df					2					
Asymp. Sig					0.042					

Notes: ** Significant at $p < 0.05$; Govt. = government, Consult. = consulting firm, Contract. = contracting firm, X = mean item score, Rk = rank, K-W = Kruskal–Wallis H-test, χ^2 = chi-square

Table 4. Mean rank and K-W result of people dimension

groups of respondents can be attributed to the notion that the concept of digitalisation is fairly new within the South African construction industry, as earlier stated. The understanding of construction digitalisation and the influence of the identified human factors is still piecemeal within the country's construction industry. The overall mean revealed that all the assessed variables could influence digital transformation as they all had a $\overline{X}$ value of above-average of 3.0. Highest among these variables are top management support (PC5, $\overline{X}$ = 4.88), the digital culture within an organisation (PC6, $\overline{X}$ = 4.86), continuous learning of personnel (PC4, $\overline{X}$ = 4.81), organisation's positive change attitude (PC7, $\overline{X}$ = 4.76) and re-skilling of the workforce (PC3, $\overline{X}$ = 4.76).

Table 5 revealed that a KMO value of 0.705 was derived, and the BTs gave χ^2 value of 989.309 and a significant p-value of 0.000, thus confirming the factorability of the data gathered. The communalities of all the assessed variables are well above the 0.5 cut-offs set for an acceptable fit (Pallant, 2011), aside from continuous learning of personnel with a value of 0.090. The EFA was conducted using PCA with varimax rotation, and the result in Table 5 reveals three principal components with eigenvalues greater than one. Combining these three principal components accounts for 63.8% of the total variance extracted, which is above the 50% limit required for an acceptable extraction (Stern, 2010).

The result in Table 5 shows that the first principal component has six factors (PC1, PC2, PC3, PC7, PC8 and PC9) loading on it, accounting for 35.8% of the total variance explained. Based on the similarities of these variables, this component was named "technical capabilities of personnel". This naming is guided by the suggestions of Williams *et al.* (2010)

People-related factors	Component 1	2	3	Communalities Extraction
Component 1 – technical capability of personnel (35.8%)				
Digital technical know-how of personnel (PC1)	0.796			0.765
Digital knowledge management by the organisation (PC2)	0.772			0.624
Re-skilling of workforce (PC3)	0.750			0.572
Organisation's positive change attitude (PC7)	0.716			0.649
Digital empowerment of personnel (PC8)	0.694			0.562
Personnel's innovativeness (PC9)	0.680			0.736
Component 2 – attracting and retaining digital talents (14.3%)				
Retaining the right digital talent (PC11)		0.907		0.842
Attracting the right digital talent (PC10)		0.732		0.741
Component 3 – organisation' digital culture (13.7%)				
Top management support (PC5)			0.852	0.774
Digital culture within an organisation (PC6)			0.785	0.649
Continuous learning of personnel (PC4)			0.416	0.090
KMO		0.705		
BTs	χ^2	986.31		
	Df	55		
	p-value	0.000		

Table 5. EFA principal extractions

that the naming of factors must be theoretical, subjective and inductive, following the researchers' judgements in line with the literature. The second principal component has just two factors (PC10 and PC11) loading on it, accounting for 14.3% of the total extracted variance. This component was named "attracting and retaining digital talents" based on the extracted variables. The last extracted component accounts for 13.68% and has three factors (PC4, PC5, and PC6) loading on it. This component was subsequently named "organisation's digital culture".

To confirm the validity and significance of the three grouped factors from EFA, CFA in EQS software was used using the robust maximum likelihood estimation. The reliability of the variables was tested using both Cronbach α and rho alpha (ρA) as their combination gives a more robust reliability value (Hair *et al.*, 2019). These analyses gave an α value of 0.812 and ρA coefficient of 0.886, which exceeded the 0.7 cut-offs that were set for both tests (Bagozzi and Yi, 2012; Hair *et al.*, 2019). In determining the validity of these variables, Figure 1 presents the standardised coefficient (λ) derived. According to past submissions, careful elimination of variables with low λ is necessary to get a reliable output and fit indices (Anderson and Gerbing, 1988). There has been no consensus in past studies on the ideal threshold for a λ, with most favouring a cut-off of 0.7. However, Hulland (1999) noted that λ as low as 0.4 can be adopted as long as the reliability and model fitness are not adversely affected (Hulland, 1999). For this study, variables with λ less than 0.4 were eliminated, with careful consideration given to their influence on the overall fitness of the model. Based on this set threshold, continuous learning of personnel (PC4) was eliminated as it gave a low λ of 0.166. This same variable gave a very low communality, as earlier indicated in the EFA. As seen in Table 6 and Figure 1, the retained variables show a λ ranging from 0.564 to 1.000. This result implies a good construct validity. Furthermore, the significance of these variables to influence the digitalisation of construction organisations can be seen in the *Z*-statistics derived in Table 6. This result revealed *Z*-values of well above 1.96 at 95% confidence level ($p < 0.05$). The rotated groups from EFA also gave *Z*-values of above 1.96, thus affirming that the groups are significant.

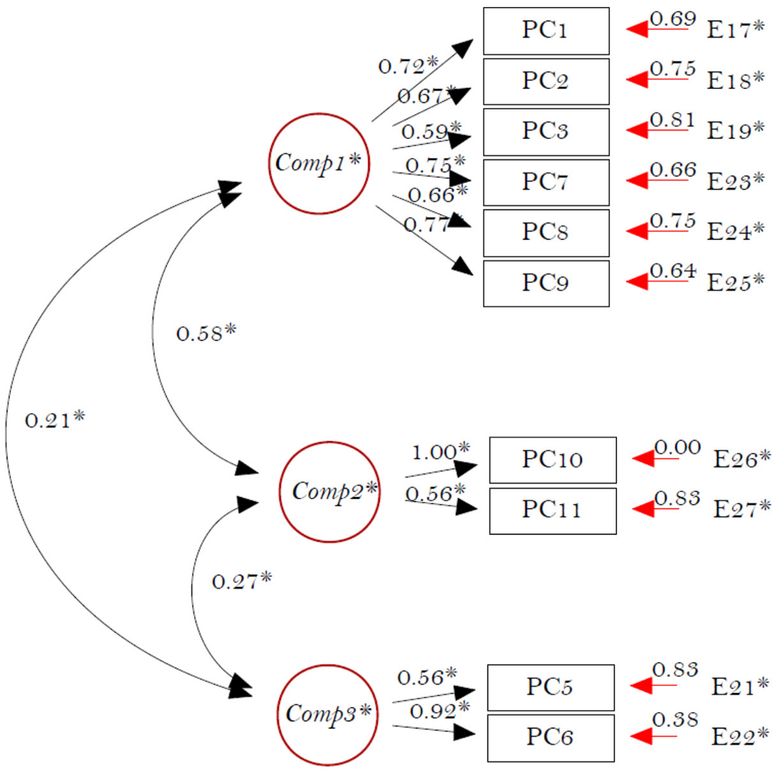

Figure 1.
CFA of the principal factors

Table 6.
CFA output

Groups	Variables	λ	Z	p-value	Group Z	R^2
Component 1 – technical capability of personnel	PC1	0.724	9.154	**	5.256	0.524
	PC2	0.665	9.490	**		0.443
	PC3	0.593	7.728	**		0.352
	PC7	0.749	9.404	**		0.561
	PC8	0.665	8.529	**		0.442
	PC9	0.770	9.610	**		0.593
Component 2 – attracting and retaining digital talents	PC10	1.000	11.491	**	7.490	1.000
	PC11	0.564	7.613	**		0.319
Component 3 – organisation' digital culture	PC5	0.564	3.740	**	7.800	0.319
	PC6	0.925	4.235	**		0.856

Note: ** = significant at 95% confidence level

The coefficient of determination (R^2) was used to test the predictive accuracy of the variables retained. Although most studies have advocated high R^2 for perfect predictive accuracy, particularly in pure science, a low R^2 does not imply an unfit or bad model (Frost, 2020). According to Hair *et al.* (2019), studies in the social sciences allow for R^2 below 50% due to the changes and difficulty in predicting human behaviour. Based on this knowledge, the cut-off for R^2 in this study was set at 0.67, 0.33 and 0.19 for substantial, moderate and weak, respectively, as suggested by Chin (1998). A look at the R^2 column in Table 6 shows that all the variables had substantial predictive accuracy aside from PC5 and PC11, which gave a moderate predictive accuracy of 0.319 each.

To determine this model's fitness, the standardised root-mean-square residual (SRMR) and root-mean-square error of approximation (RMSEA) were evaluated along with other supplemental fit indices, as suggested by Hu and Bentler (1999). SRMR gave a weak value of 0.105, while RMSEA augmented this weakness by giving a good fit of 0.054, which is below the 0.08 threshold (Hu and Bentler, 1999). In addition, the normed chi-square ($S\text{-}B\chi^2$/df) gave a good fit of 1.65, which is below the 3.0 threshold (Eisen *et al.*, 1999). The goodness of fit index (GFI) gave a good fit of 0.805, which is closer to 1. Furthermore, the comparative fit index (CFI), non-normed fit index (NNFI) and Bollen's incremental fit index (IFI) all gave good fit indices of 0.953, 0.926 and 0.954, respectively. These results imply that the variables assessed under their grouped components are fit to be adopted as the significant people-related factors that will influence the digitalisation of construction organisations in South Africa.

Discussion

From the descriptive statistics, the disparity in the view of the grouped respondents shows that a holistic understanding of the concept of digitalisation and its associated influencing factors is yet to be achieved within the South African construction industry. This further buttress the need for this study. While there is a disparity in the rating of the extent of influence of the different people-related features required for the digitalisation of construction organisations, the overall rating shows that these factors will have a considerably strong influence and, as such, should be given adequate attention. EFA grouped these factors into three clusters, namely, technical capabilities of personnel, attracting and retaining digital talents and organisation's digital culture, as seen in Figure 2. Following the attainment of acceptable validity and reliability values and several fit indices from CFA, it is evident that construction organisations seeking to be digitally transformed need to focus on factors relating to these three groups, as they were deemed significant.

Technical capabilities of personnel

One of the greatest issues facing the digitalisation of construction organisations, particularly in developing countries like South Africa, is the lack of technical know-how (Chan, 2018; Oke *et al.*, 2018; Sacks and Barak, 2010). The shortage of personnel with the right technical capability to handle DTs has been noted in past construction studies (Li and Liu, 2019; Oke *et al.*, 2018; Wright, 2015). Without these required technical personnel, adopting and effectively using digital tools will be almost impossible (Hwang *et al.*, 2016). In the same vein, this finding aligns with the submissions of Bennis (2013), Boström and Celik (2017) and Kane *et al.* (2015) on the need to upgrade digital skills within organisations. This can be achieved through an awareness of a positive change attitude in the organisations. Thus, while seeking workers with the right skill to operate emerging technologies, organisations must also be ready to upskill their available workforce and also re-skill them in DT usage. Only through this approach can the true notion of digitalisation enhancing skills rather than replacing them (Aghimien *et al.*, 2021a) be achieved. This can be done by training and developing the new and existing workforce. Valdez-de-Leon (2016) also emphasised the need for the training of the workforce within an organisation in a quest to attain digital transformation. By re-skilling these workforces, some sort of employee empowerment is being created, and this has been considered crucial to digitalisation by Gill

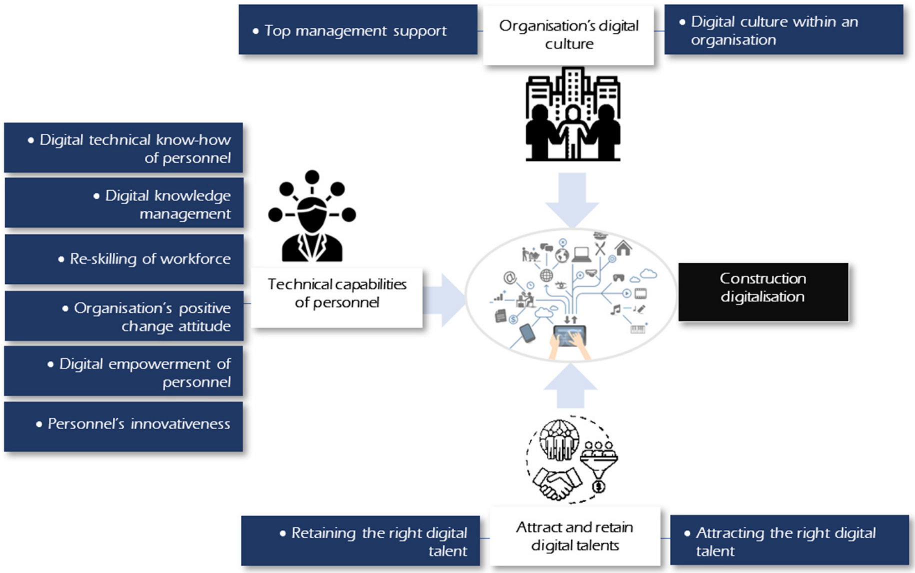

Figure 2. Summary of the people-related factors for construction digitalisation

et al. (2016), Macchi and Fumagalli (2013) and Newman (2017). The finding of this current study is also in line with Valdez-de-Leon (2016), which observed the importance of knowledge management in the quest for digitalisation. A similar observation was made by Peltier *et al.* (2009) and Quinton *et al.* (2018).

Attracting and retaining digital talents

Sheikhshoaei *et al.* (2018) have earlier noted the importance of organisations being able to attract the required digital talents while retaining the existing ones in the organisation. As such, construction organisations that can master the art of attracting the right technical expertise and retaining existing talent to handle the adopted DTs stand a better chance of digital transformation. Molis (2019) noted that organisations must be ready to build an employee-focused culture and include existing employees in the recruitment process to attract the required talents. By creating a culture where employees are considered and treated right, existing employees will be happy and willing to bring in other similar talents to the organisation. Furthermore, Wright (2015), in outlining the strategies for organisations in attracting and retaining digital talents, noted that a well-defined organisational goal with respect to DT usage and a clear description of what is expected from the digital staff is needed. This can be done through interviews of identified top digital talent and a clear explanation of what the organisation expects. Building a positive culture of innovation within the organisation by allowing existing talent to contribute to organisational processes will go a long way in retaining existing talents. This employee involvement in the strategic organisational process has been noted to impact workers' motivation and commitment to their organisations (Holt *et al.*, 2000).

Organisation's digital culture

This last key component comprises two major factors (i.e. top management support and digital culture within the organisation) that have been deemed important in past studies.

The importance of management support in successful technology adoption has been reiterated in past studies (Gill *et al.*, 2016; Oliveira and Martins, 2011). According to Quinton *et al.* (2018), the support from top management within an organisation is important as their level of knowledge in technology-related issues will influence their desire to either support or oppose digital transformation in their organisation. In construction, Aghimien *et al.* (2021b) noted that adopting any innovation or idea within construction organisations is mostly dependent on the support of the organisation's management. The support from this senior management will go a long way in determining the digital culture within the organisation. Molis (2019) noted that having the right culture of innovativeness is essential for workers to function and for digital transformation to occur within such an organisation. Sheikhshoaei *et al.* (2018) also affirmed the importance of having the right digital culture for an organisation's digital transformation. White (2018) has noted that while digital transformation is pervasive in today's competitive landscape, organisations must redefine their corporate culture and reshape their traditions before thinking of transformation.

Implication of findings

The findings of this study offer practical guidelines for construction organisations seeking to attain digital transformation. It is evident from the findings that having the right technical personnel to handle these DTs is important. As such, construction organisations must be ready to invest in training and re-training their workforce in the use of emerging technologies. This they can achieve through reshaping their organisational policies surrounding employee development. Much more, having a good partnership with other organisations, particularly those with the right digital resources, can help improve the technical capability of personnel within these construction organisations. In addition, the promotion of industry–academic collaboration through the use of industrial training of undergraduate students can help construction organisations identify digital talents at the early stage of their careers of these talents. These sets of digital talents can then be employed within the organisation upon completing their academic programme. As they already understand the organisation's goals with respect to digital transformation, it will be easier for them to fit in and deliver the company's expectations. Also, the upskilling and re-skilling of employees within the construction industry can be promoted by professional bodies through organised seminars and workshops on the use of new technologies by their members. Attaching continuous personal development (CPD) points to these workshops will go a long way in ensuring participation. In addition, construction organisations must embrace approaches that will encourage existing workers to stay and attract new employees. An organisational culture that promotes innovativeness through DTs will go a long way to encourage both existing and new employees and alienate the fear of job loss to technology among these workforces. To achieve this, top management within construction must support the digital transformation. These senior management need to create a clear goal that the organisation need to achieve using digital tools. They also need to keep themselves abreast of the emerging technologies and the benefits their organisations stand to gain from implementing these technologies. Only then will they be able to fully support their organisations' digital transformation.

Conclusion

Based on a critical evaluation, this study concludes that the technical capability of personnel, attracting and retaining digital talents and the organisation's digital culture are the three main groups of people-related features required for the digitalisation of constructions. Obviously, with the current era of the Fourth Industrial Revolution, the question is not whether construction organisations should be digitalised but how this digitalisation should occur. The findings of this current study offer guidelines as to how construction organisations can attain this digital transformation from the people dimension. Theoretically, the study's findings provide a good theoretical backdrop for future studies on the people dimension of construction digitalisation. Building upon the findings of this current study will help give a wider perspective of the people-related factors required for the digitalisation of construction organisations, particularly in countries where such studies do not exist.

It is important to note the limitation of this current study to make suggestions for future works and guide the adoption of its findings. Firstly, while the sample size used for the study met all required criteria for analyses and for drawing logical conclusions, the retrieved responses compared to the target population was low. More so, responses gotten from some provinces were lower than others, with no response at all from one of the provinces. This makes it difficult to generalise the study's findings to the entire country. Therefore, future works in this area can target provinces with inadequate responses to get a much larger response and a broader perspective. Secondly, while the developed variables can be explored in the construction industry of other countries, care must be taken in generalising the findings as the study was conducted in South Africa alone, and the factors peculiar to the country's construction industry might shape the outcome of the study. Future works can be conducted in other countries where such a study has not been explored to compare the findings. Future studies can also be conducted to empirically test the impact of the identified factors from this study on the actual adoption level of DTs in South Africa and other countries.

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