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Digital Technologies for Effective Value Management in the Construction Industry

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Abstract

This study presents the result of an assessment of the drivers of digital technology diffusion in the value management (VM) process in the construction industry. This was done with a view to improving the use of digital technologies in the quest to create value for construction clients. The study adopted a quantitative research design which informed the use of a structured questionnaire administered to construction professionals that have participated in VM exercises within the South African construction industry. The data gathered were analysed using mean item score, standard deviation, Kruskal-Wallis H-test, and exploratory factor analysis. The study found that the use of digital tools to improve VM process is driven by three major components viz: (1) VM process requirement, (2) digital culture of the construction industry, (3) knowledge and understanding of the need for digital tools. The use of relevant technologies will help improve the speculation and creative phase of a VM workshop, the evaluation phase, the presentation of best value alternatives, the gathering of preliminary information and the overall success of the VM workshop. This study provides a theoretical backdrop for future studies exploring the use of digital technologies for VM practices – an aspect that has not gained significant attention in VM discourse in the construction industry.

Keywords Construction industry, Digital technology, Value for money, Value management

1. Introduction

The pervasive nature of technology advancement, particularly with the fourth industrial revolution, is bringing significant changes to diverse industries, including construction (Aghimien *et al.*, 2021). Studies have shown that the use of diverse digital technologies in the construction industry is rapidly transforming how projects are being delivered as well as the quality and pace of delivering construction services (Adzroe and Ingirige, 2014; Aghimien *et al.*, 2018; Berger, 2016; Rüßmann *et al.*, 2015). As a result of the benefits inherent in digital technologies, several studies have continued to explore their usage in the management of constructions projects (Abedi *et al.*, 2013; Haung *et al.*, 2020; Irizarry and Costa 2016; Zhou *et al.*, 2018). However, there is a paucity of studies exploring digital tools to improve value management (VM) practices within the construction industry. Herein lies the gap in literature that this current study strives to fill.

VM has been described as the process of achieving value for money for construction clients through the delivery of quality products at a reasonable cost (McGeorge and Palmer, 1997). Male and Kellye (1998) described VM as a proactive, creative, problem-solving or problem-seeking service that maximises the functional value by managing its development from concept to use. According to Odeyinka (2006), VM maximises functional value by managing the project's development from planning to the delivery and use of the project through proper audit of all decisions against a value system outlined by the client. Thus, VM has been described as a process that offers construction clients value for money through the analysis functions of projects from inception to completion and use of the project and elimination of non-value-adding elements (Oke and Aghimien, 2018). Unfortunately, the VM process in most developing countries has been challenged by several issues, including the problem of poor communication relevant stakeholders/VM members and technological advancement in employing the electronic VM approach (Chhabra and Tripathi, 2014; Coetzee, 2009; Jaapar *et al.*, 2009).

With the current availability of ubiquitous technologies which are shaping the way projects are being delivered, there is no doubt that the use of some of these technologies can help improve VM practices. For instance, the use of cloud computing and the internet of things on projects have been noted to improve communication and team collaboration among project participants (Oke *et al.*, 2021). More so, through big data analytics, the project team can collect, store, and analyse a large amount of data and make informed decisions necessary to ensure successful project delivery (Bilal *et al.*, 2016; Ganesan *et al.*, 2020). Furthermore, building information modelling (BIM) also creates a platform for project teams to collaborate and share ideas. This creates an opportunity for clashes in designs to be noticed early in the project, and the remedial actions can be taken immediately to correct these issues and avoid unnecessary cost, time and material wastage during construction (Aboushady and Elbarkouky 2015). Based on the foregoing, this research was designed to unearth the significant drivers that influence the use of digital technologies to improve the VM process. Also, the study strives to determine the VM practices that the use of digital tools will impact the most. This was done to improve the use of digital technologies in the quest to create value for construction clients and improve the value delivery performance of the construction industry as a whole.

2. Review of Literature

The concept of VM was first proposed in the United States of America by Miles at the General Electric in the late 1940s. The system, which was initially referred to as value engineering, was developed after the second world war, which brought about the shortage of components needed for essential production. The search for alternative components to meet production demand proved futile due to the adverse effect of the war. Therefore, to ensure continuous production, rather than searching for alternative components, new means of fulfilling the function of those scarce components were sorted. Using alternative approaches was adopted in place of replacing component unavailable components. This method was observed the deliver low-cost products with the same required quality. Owing to the significant benefit of this approach, after the war, the method was retained as a means of removing unwarranted expenses incurred in product delivery and as a way to improve product design through the analysis of functions (Oke and Aghimien, 2018; Palmer *et al.*, 1996).

It has been noted that the VM process can be used to complement the cost planning of construction projects, especially at the inception of the project (Seeley, 1997). As a result, it has been suggested that the implementation of VM must be done early in the projects in order to improve the opportunity to improve on project design before the project commences (Ellis *et al.*, 2003). While the use of the VM process in project delivery can help reduce cost (Kelly *et al.*, 2004), Oke and Aigbavboa (2017) warn that VM is not designed to cut cost but to deliver value through careful assessment of the functions of various elements in a project. The VM process involves conveying a VM workshop at several project stages (Clifford, 2013). The purpose of these workshops is to bring together project stakeholders to brainstorm on the different approaches towards which value can be achieved on the project (Ellis *et al.*, 2003). The workshop follows several phases, which are mostly sequential in nature. First functional analysis is conducted, then comes the creative, evaluation, development and presentation phases (Society of American Value Engineers, 2008). Tanko *et al.* (2017) identified twenty VM activities that were regrouped into the information phase, functional analysis phase and creativity, evaluation development and presentation phase.

To make the VM workshop a success, several factors need to be considered. This is important as several studies have emanated on the hindrances to the success of VM practices in countries around the world. These hindrances include but are not limited to the absence of qualified VM experts, lack of training and management support, difficulties in bringing all relevant stakeholders together, obstruction from the VM team, poor technological advancement and knowledge of the use of electronic VM system as well as poor communication among VM team (Chhabra and Tripathi, 2014; Coetzee, 2009; Hayatu, 2015; Jaapar *et al.*, 2009; Kissi *et al.*, 2016). The use of digital technologies can significantly impact the VM process and help address some of these identified issues. These emerging digital technologies can be in the form of software; methods; hardware network and networking systems for data processing, storage and presentation; repository and databases; and intelligent systems that promote communication, collaboration, and teamwork (Ibem and Laryea, 2014). The use of these technologies can be driven by the need to improve team communication, the gathering of information, and decision making. Digital technology can offer a VM team communication medium that allows for increased flexibility. As such, the long days associated with the VM workshop can be reduced, and contact can be done via online platforms. More so, with the advent of the COVID-19 pandemic and the work-from-home protocol that most organisations have adopted (including construction organisations), using online digital platforms for VM workshops can prove useful and ensure effective communication while maintaining a safe space (Aigbavboa *et al.*, 2022). Coetzee (2009) also noted that the use of video conferencing could help create a new VM delivery process that is more effective than the traditional physical VM workshop practice. Technologies such as BIM, internet of things, cloud computing and big data analytics can all prove effective in ensuring effective communication and understanding of the project requirement, team collaboration as well as faster informed decision making by the VM project team (Aboushady and Elbarkouky 2015; Bilal *et al.*, 2016; Ganesan *et al.*, 2020; Oke *et al.*, 2021). Drawing from general drivers to the use of digital tools and VM, proper understanding of the need for the use of digital technologies, the request from clients, the need for quick VM output and cost-effectiveness of the VM process are some of the drivers assessed in this current study (Aghimien *et al.*, 2021; Eadie *et al.*, 2013). More so, the availability of the required technologies and the availability of training and education can prove useful for the use of digital technologies in the VM process (Becerik, 2004; Kelly *et al.*, 2002; Oke *et al.*, 2018).

3. Research Method

The study is quantitative and the instrument for data collection was a structured questionnaire. The target population for the study were construction professionals that have been involved in VM workshop/practice within the South African construction industry. This set of individuals is few as the VM practice is not common within the industry (Oke and Aghimien, 2018; Oke and Aigbavboa, 2017). As a result, snowball approach was adopted to gather participants that have been involved in VM practices in the country. The snowball approach has become popular among construction researches where the exact number of the target population is unknown from the initial stage of the research (Chan and Aghimien, 2022). Using this approach, the study gathered data from 80 professionals that have been involved in VM practices in the past. The questionnaire used to harness information from these respondents was designed using three sections. The first section sought answers to some background information on the respondents, while the second section assessed the drivers of the use of digital tools for VM practice. The last section unearths the impact of digital tools on VM exercise. These second and third sections were assessed using a five-point agreement scale with five being strongly agreed and one being strongly disagree.

The data gathered on the background information were analysed using frequency and percentage. The data from the second and third sections were first tested for their reliability using the Cronbach alpha test (α). The set cut-off for this test was ≥ 0.7 (Hair *et al.*, 2019). The data from these two sections were analysed using mean item score ($\bar{X}$) to rank the different identified drivers and impacts. The premise for ranking these variables was that variables with the highest mean are ranked first, and others follow in descending order. Where two variables have the same $\bar{X}$ the one with the lowest standard deviation (SD) is ranked first, as suggested by Field (2009). Furthermore, since the respondents were drawn from different organisation types (contracting, consulting and government), Kruskal-Wallis H-Test (*K-W*) was employed to test the disparity in the rating of the variables by the different groups. The *K-W* test gives a chi-square (χ^2) and a *p*-value that shows the significant relationship in the response of respondents from the different groups. Also, exploratory factor analysis (EFA) was conducted to further cluster the different drivers to the use of digital tools in VM practice into a more manageable subscale. While past studies have noted the need for large samples for EFA to be conducted, studies have shown that as long as the communalities derived are adequate (i.e., > 0.5), then less emphasis should be placed on the samples (Preacher and MacCallum, 2002; Zhao, 2008). As a result, construction-related studies with samples of less than 100 have continued to emerge with reasonable outputs (Aghimien *et al.*, 2020). The communalities derived from this study were all higher than 0.5. More so, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (BTS) were used to ascertain the suitability of the data for EFA. Both tests gave acceptable values, which merited the use of EFA for further analysis.

4. Findings and Discussion

Background information of respondents

The respondents for this study comprised 62% construction and project managers, 12% architects, 12% engineers, and 14% quantity surveyors. About 49% of these respondents work for contracting organisations, while the remaining 26% and 25% work in government and consulting organisations. The majority (55%) of these respondents have a bachelor's degree, while 27% have national diplomas and 18% have master's degrees. For the years of experience, most of the respondents (65.1%) have been in the South African construction industry for more than five years, with 16.3% having above 20 years of experience in the industry. Only 18.8% have below five years of working experience in the industry. Following these results, it can be said that the respondents for the study have a considerable understanding of happenings within the South African construction industry, and their response is based on their experience in VM shaped by their years of working experience in the industry.

Drivers of the use of digital technologies in Value Management Practices

In assessing the critical drivers that will propel the use of digital tools to improve the VM practice, the respondents were presented with eight drivers to rank based on their level of agreement. These drivers revealed an α-value of 0.810, which is above the set cut-off of 0.7, thus implying that the questions asked were reliable and the variables had significant internal consistency. The *K-W* test revealed that the respondents from the contracting, consulting and government organisations all had a unified view regarding the key drivers, as seen in Table 1. A *p*-value above the conventional threshold of 0.05 was derived for all the assessed drivers. The result derived from the SD also confirmed that there is no disparity in the rating of these drivers by the respondents as SD-values of below 1.0 was derived for all the assessed drivers. As such, the result can be adopted as a true reflection of the drivers needed to promote the use of digital technologies for effective VM practice in the South African construction industry. The respondents agreed that only when there is a proper understanding of the need for digital tools in the VM practice can digital technologies be effectively used to improve VM exercise. This driver was ranked first with a $\bar{X}$value 4.45. This is followed by the client's request for digital technologies to be used on their project ($\bar{X}$= 4.41, *p*-value = 0.135), the need for faster VM process ($\bar{X}$= 4.28, *p*-value = 0.059), and a positive digital culture in the construction industry ($\bar{X}$= 4.01, *p*-value = 0.171). The least ranked drivers are the need to reduce costs associated with the VM workshop ($\bar{X}$= 3.76, *p*-value = 0.263) and the need to improve communication in the VM process $\bar{X}$= 3.28, *p*-value = 0.777). While these drivers might be considered as the least critical, they have $\bar{X}$values above the average of 3.0. This means when saving cost associated with physical VM meetings is essential and communication is a problem, VM team may result to the use of appropriate digital tools.

Table 1. Drivers of the use of digital technologies for VM practices

Drivers	$\bar{X}$	SD	Rank	*K-W* χ^2	*K-W* *p*-value
Proper understanding of the needed digital technologies for VM exercise	4.45	0.525	1	4.002	0.135
Client's request	4.41	0.544	2	6.003	0.059
The need for a faster VM process	4.28	0.927	3	3.530	0.171
Positive digital culture in the construction industry	4.01	0.112	4	2.810	0.245
Training and education on VM and digital technologies	3.94	0.401	5	0.709	0.702
Availability of needed digital technologies	3.90	0.704	6	2.698	0.259
The need to reduce cost associated with VM workshop	3.76	0.750	7	2.673	0.263
Need to improve communication	3.28	0.779	8	0.504	0.777

Preliminary analysis of the data gathered on the drivers gave a KMO value of 0.823 which is above the 0.6 thresholds (Pallant, 2011) and a significant BTS output of 0.000. The result in Table 2 gave a communality of between 0.629 to 0.968. These preliminary results show that the use of EFA for the data gathered was adequate. EFA was conducted using principal component analysis (PCA) due to its ability to adequately regroup variables into more manageable clusters (Pallant, 2011). The result in Table 2 shows that at four iterations, three principal components were derived with eigenvalues of above 1.0, and they all account for 84.1% of the total variance extracted. The first principal components account for 44.8% of the variance explained and has four drivers loading on it. These drivers are the need for a faster VM process (97.3%), the need to reduce the cost associated with VM workshops (85%), the availability of needed digital technologies (84.9%), and the need to improve communication (72.8%). This component was renamed as 'VM process requirement'. The second extracted component account for 24.4% of the total variance explained and has two drivers loading on it, viz: client's request (92.9%) and positive digital culture in the construction industry (91.5%). This component was subsequently named 'digital culture of the construction industry due to the latent similarity in the variables. The last component accounts for 14.9% of the total extracted variance and also has two drivers loading on it. These drivers are proper understanding of the needed digital technologies for VM exercise (80.7%) and training and education on VM and digital technologies (78.1%) and was subsequently named 'knowledge and understanding.'

Table 2. EFA of the drivers of the use of digital technologies for VM practices

	Component	Communalities

Drivers	1	2	3	Extractions
Component 1 – VM process requirement (44.8%)				
The need for a faster VM process	0.973			0.968
The need to reduce cost associated with VM workshop	0.850			0.844
Availability of needed digital technologies	0.849			0.857
Need to improve communication	0.738			0.964
Component 2 – Digital culture of the construction industry (24.4%)				
Client's request		0.929		0.866
Positive digital culture in the construction industry		0.915		0.895
Component 3 – Knowledge and understanding (14.9%)				
Proper understanding of the needed digital technologies for VM exercise			0.807	0.703
Training and education on VM and digital technologies			0.781	0.629

Impact of digital technologies on the VM practices

Table 3 present the result of the assessment of the various VM practices that the use of digital tools will impact significantly. The *K-W* test conducted shows that the respondents all have a unified view as a *p*-value of above 0.05 was derived for all the assessed VM practices. More so, the result derived from the SD affirms that there is no disparity in the rating of the impact of digital tools on these practices as SD-values of below 1.0 was derived for all the assessed practices. Therefore, it can be deduced that the result can be adopted as a true reflection of the impact of the use of digital technologies on VM practices within the South African construction industry. From the overall $\bar{X}$values, it is evident that the use of digital technologies will impact the different VM practices assessed as they all have a $\bar{X}$of the above-average of 3.0. More specifically, the use of digital tools will impact the speculation and creative phase of a VM workshop ($\bar{X}$= 3.99, p-value = 0.486) as well as the evaluation or judgment phase ($\bar{X}$= 3.99, *p*-value = 0.266). Also, digital tools can be used to help improve the overall success of the VM workshop ($\bar{X}$= 3.98, *p*-value = 0.649), presentation of best value alternatives ($\bar{X}$= 3.91, *p*-value = 0.452), and in gathering of preliminary information on the project ($\bar{X}$= 3.78, *p*-value = 0.303).

Table 3. Impact of digital technologies on VM practices

				K-W	
Impact	$\bar{X}$	**SD**	**Rank**	χ^2	***p*-value**
Speculation and creative phase of VM workshop	3.99	0.464	1	1.441	0.486
Evaluation or judgment phase	3.99	0.490	2	2.645	0.266
Overall success of VM workshop	3.98	0.503	3	0.866	0.649
Presentation of best value alternatives	3.91	0.455	4	1.588	0.452
Gathering preliminary information on the project	3.78	0.795	5	2.386	0.303
Communication among VM Team	3.55	0.673	6	1.381	0.501
Conducting functional analysis	3.54	0.635	7	1.436	0.488
Management of group by VM facilitator	3.51	0.636	8	1.868	0.393
Development of alternatives	3.35	0.658	9	5.930	0.052

5. Discussion

The findings of this study shows that the use of digital technologies in the VM process can be driven by three main factors (1) VM process requirement, (2) digital culture of the construction industry, (3) knowledge and understanding. In terms of VM process requirements, past studies have shown that the fear of the cost and time associated with the VM process can be a severe problem to the implementation of VM in construction projects (Abidin, 2005; Daddow and Skitmore, 2005; Kissi *et al.*, 2016). As a result, the ability of digital technologies to save cost and improve service delivery to time (Hashim *et al.*, 2013; Berger, 2016) can be a major driver for their implementation in the VM process. More so, when these digital technologies are readily available, adopting them for VM practices becomes easier. Kagermann (2014) have noted that the use of digital technologies will be significantly dependent on the availability of the technologies, among other factors. Furthermore, where communication is an issue, as observed in past studies (Coetzee, 2009; Chhabra and Tripathi, 20014; Jaapar *et al.*, 2009), implementing relevant digital tools becomes necessary.

Regarding the digital culture of the construction industry as a driver for technology adoption in VM, past studies have noted that the construction industry has a poor digital culture (Aghimien *et al.*, 2018; Pärn and Edward, 2019).

However, the improvement in the embrace of technological advancement within the industry will drive the use of digital tools in VM practices. More so, this will lead to clients requesting the use of digital technologies in the delivery of their projects – an act that is currently deterring the use of digital tools within the construction industry (Oke *et al.*, 2018; Yahya *et al.*, 2019). Past studies have affirmed that the demand by clients for the use of digital technologies on their project is a crucial driver to technology adoption (Aghimien *et al.*, 2021; Eadie *et al.*, 2003).

Finally, in terms of knowledge and understanding, evidently, without a proper understanding of the need for digital tools, adopting them to improve the VM process will be difficult. As such, creating medium to enlighten, train and educate participants of VM practice on the need to adopt digital means of attaining the objectives of the VM process is necessary. Becerik (2004) as well as Oke *et al.* (2018) have noted that the availability of proper training can drive the use of digital technologies.

In terms of the diverse VM practices that the use of digital technologies will impact, the findings revealed that the use of digital tools will help improve diverse aspects particularly in the aspects of speculation and creative phase of a VM workshop wherein diverse ideas are postulated for deliberation by the VM team (Oke and Aghimien, 2018). The impact can also be felt in the evaluation or judgment phase where the ideas from the creative phase are adjudged for their merit and applicability (Oke and Aghimien, 2018; Society of American Value Engineers, 2008); the presentation of best-value alternatives to the client; the gathering of preliminary information on the project; as well as the overall success of the VM workshop.

6. Conclusion

The study assessed the drivers of the use of digital technologies to improve VM and the diverse VM practices that will be impacted upon through the use of digital tools. Based on the results, the study found that the requirement of the VM process, such as the need to save cost and time associated with the VM exercise, the digital culture of the construction industry, as well as the knowledge and understanding of VM participants of the need for digital tools are the main drivers of the use of diverse digital tools in VM processes within the construction industry in South Africa. Furthermore, the study found that the use of relevant technologies will improve the speculation and creative phase of a VM workshop, the evaluation phase, the presentation of best value alternatives, gathering of preliminary information as well as the overall success of the VM workshop. Based on the findings of the result, it is therefore concluded that digital technologies can help improve the VM process in the construction industry and, in the process, ensure clients get the required value for money. However, for this to be achieved, there must be a positive digital culture in the construction industry that will promote the use of digital tools by both professionals and clients. More so, there is the need for adequate training, education and enlightening of construction stakeholders on the VM process and how the use of digital tools can be beneficial to the entire VM exercise. The findings of this study provide a good theoretical backdrop for future studies seeking to explore the use of digital technologies for VM practices – an aspect that has not gained significant attention in VM discourse in the construction industry. The study also provides directions for future research based on its inherent limitations. For instance, the study adopted a smaller sample due to the slow adoption of VM practice in the country and the rareness of VM participants. Future works can explore a larger sample and include other project participants to get a wider view of the topic. Also, the current study adopted a quantitative approach. Future works can be conducted using other methods such as qualitative or mixed-method. The findings of the study cannot be generalised for the construction industry in other countries. Thus, other studies can be conducted in the construction industry of countries where such evaluation has not been conducted with a view to compare the findings.

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