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DIGITALISATION IN CONSTRUCTION INDUSTRY: CONSTRUCTION PROFESSIONALS PERSPECTIVE

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This study presents the result of an assessment of digitalisation within the South African construction industry from the construction professionals' perspective. The study adopted a quantitative approach through a questionnaire survey carried out among construction professionals in Gauteng Province, South Africa. Appropriate descriptive statistical tools were used in analysing the data gathered. The study revealed that the major stages of construction where digitalisation is evident are the design phase, and the feasibility phase. The major construction processes where it is mostly visible are, construction cost control, cost planning, preliminary cost estimate and building system analysis. In addition, the most significant benefits to be derived from digitalisation in the industry includes time-saving in construction projects delivery, increase productivity, increase speed of work, increase document quality, speeding up of response time, and simpler working methods. This study contributes to the body of knowledge as it reveals the happenings surrounding digitalisation within the South African construction industry; an aspect that seems to be lacking research attention.

Keywords: Digital technologies, Digital transformation, Digital tools, ICT, Technological advancement, Industry4.0.

1 INTRODUCTION

Digitalisation has become a popular concept around the world today due to its ability to create efficiency in operations, effectiveness, and provide new opportunities. Industries such as banking, manufacturing, and retailing have all come to understand the benefit of digitalisation and have keyed into the future by using it as a new approach for ensuring competitive gain and efficiency (Osunsanmi *et al.* 2018). While these other industries have adopted the use of this obviously beneficial development, the construction industry is yet to fully embrace it in the delivery of its services. This failure to harness the inherent benefit of digitalisation has significantly affected the industry, especially in developing countries, as no major transformation is evident within their construction sector (Castagnino *et al*. 2016). The case is no different with South Africa, as most construction services are still being delivered using traditional delivery methods. This has adversely affected the growth of the industry, the quality of services rendered, and the satisfaction thereof. Halim (2010) have earlier noted that there is no industry that can effectively succeed in solving its growth problems unless its goals and strategies towards achieving these goals are rooted in the realm of knowledge creation, and driven by digital technology.

Ibem and Laryea (2014) submitted that the use of digital technologies has only recently become a common idea among construction participants, because of the attention garnered over time by BIM (Building Information Modelling). Therefore, if construction services are to be delivered with less effort and higher accuracy, then digitalisation among construction participants must change from being just an "idea" to becoming a "norm". There is the need for the industry to change from just being aware and partially adopting digitalisation through BIM, to fully implementing it in all facets of its activities.

This study recognises the fact that there are different published studies that have been done on digital technology, and information and communication technology (ICT) in construction in countries around the world (El-Mashaleh 2007, Ibem and Laryea 2014, Oladapo 2007, Peansupap and Walker 2015) just to mention a few. Benefits of the use of these technological advancements have been revealed. However, there has been a paucity of information in literature as regards digitalisation within the South African construction industry. This industry just like its counterparts in every other country plays a vital role in the economic development of South Africa. Its proper functioning and alignment with current happenings within the construction world is necessary for it to stay relevant and serve its purpose in the socio-economic development of the country. It is based on this knowledge that this study examined digitalisation in the delivery of construction projects in the South African construction industry as well as its perceived benefits. The study contributes to the body of knowledge as it reveals the happenings surrounding digitalisation within the South African construction industry; an aspect that seems to be lacking research attention.

2 OVERVIEW OF DIGITALISATION

Rouse (2017) posited that digitalisation is the process of organising and transforming information into a distinct data set that is digital in nature. This transformed information becomes the binary data that is understandable and can be processed by computers and other devices with computing capacity. According to Berger (2016) digitalisation is more about working with tools and practices based on information and communication technology. Castagnino *et al*. (2016) observed that digitalisation can be crucial in the transformation of the three major life-cycle phases of construction projects; that is the design and engineering phase, construction phase and operation phase. Adopting digital technologies for the various construction processes within these different construction life-cycle phases will largely reduce uncertainty and promote satisfactory construction products. The advantages of utilising digital technologies as part of development in construction are great. In fact, Hashim *et al.* (2013) identified the benefits of using digital technology in procuring construction projects to include among others, improvement in process quality, adequate savings in construction cost, adequate clients and participants satisfaction, increased responsiveness and productivity, expansion in market, and project delivered in the most effective manner. Staub-French and Fischer (2017) noted that using digital technologies go a long way in distinguishing clashes in design, and facilitates outlines of schedule in the construction procedure. Aside from this, it was also discovered that less rework and fewer change orders are recorded when digitalisation is adopted. These rework are in most cases costly and occur due to countless encounter that is undiscovered until they are experienced in the construction phase. Above all, the adoption of digitalisation gives better cost control.

3 RESEARCH METHODOLOGY

This study adopted a survey approach and quantitative data were gathered from construction professionals in Gauteng province, South Africa, most of who have considerable years of

experience within the construction industry. These construction professionals are Architects, Construction managers, Engineers, General Contractors and Quantity Surveyors. These professionals are directly involved in the delivery of construction project, hence their selection for the study. The instrument for data collection from these professionals was a questionnaire. The questionnaire was employed because of its ease of use and its ability to cover a wide range of participants (Tan and Yeoh 2011). Sixty (60) questionnaires were conveniently distributed to the identified construction professionals, out of which 52 were retrieved and deemed fit for analysis. Data gathered were analysed using percentage for background information of the respondents. Mean Item score (MIS) was used to rank the use of digital technology in the different construction processes and stages, and its perceived benefits. Kruskal-Wallis H-Test; a non-parametric test used in ascertaining the significant difference in the perception of three or more categories of respondents, was employed in determining consistency in the opinion of the different professionals sampled. Cronbach's alpha values of 0.716, 0.735 and 0.874 were also derived for the use of digitalisation in the construction process, construction stages, and the perceived benefits of digitalisation. This result implies that the instrument used is reliable as they tend closer to 1.0

4 FINDINGS AND DISCUSSIONS

4.1 Digitalisation in the Construction Industry

In determining the state of digitalisation within the South African construction industry, different construction stages were presented to the respondent and they were asked to rate these construction stages base on the level of digital technology used in them using a Likert scale of 1 to 5. Result in Table 1 shows the ranking of these stages with their associated significant p-value derived from Kruskal-Wallis H-test conducted. From the table, it is evident that all the stages have a p-value of above 0.05. This implies that at 95% confidence level, there is a statistically significant relationship in the view of the different construction professionals as regards the adoption of digitalisation in all the construction stages. A look at the table also shows that all the assessed construction stages have a mean value of well above the average of 3.0. This implies that to a considerable extent, digital technologies are being used within the industry for the identified construction stages. Digitalisation in the South African construction industry is more evident at the design phase and the feasibility phase as mean values of 4.40 and 4.12 were derived for both stages.

Table 1. Adoption of digitalisation for different construction stages.

Construction Stages	Mean	Rank	Chi-Sq.	Sig.
Design Phase	4.40	1	5.961	0.241
Feasibility Phase	4.12	2	3.514	0.476
Maintenance Phase	3.88	3	6.326	0.176
Construction Phase	3.85	4	7.537	0.110
Operation Phase	3.79	5	1.925	0.749
Decommissioning Phase	3.71	6	1.493	0.828

Certain construction processes were also identified from the review of related literature and respondent were asked to rate these processes base on the level of digital technology used in them. Result in Table 2 shows that all the processes have a p-value of above 0.05. This implies that there is a statistically significant relationship in the view of the different construction professionals as regards the adoption of digitalisation in all the assessed construction processes.

In addition, a cursory look at the table shows that all the processes assessed have a mean value of above average of 3.0. This implies that to a considerable extent digital technologies are being used within the industry for the identified construction processes.

The key construction process where digital technology is mostly used is in construction cost control. This ranked the highest with a mean value of 4.13. Cost planning, preliminary cost estimate, and building system analysis followed this, while the least aspect is 3D/4D coordination, and maintenance schedule. This result implies that digital technologies geared towards cost reduction and controls especially during designing are mostly being adopted. Relating the earlier result, which shows that digitalisation, is common at the design and feasibility stages, with this result, it is shown that while designing using digital technology, the cost of the project is also being considered. Digital technology is used to carry out preliminary estimate at the feasibility stage so as to determine the possible cost of construction, while at the designing phase, it is used to plan and control cost alongside the design in line with the clients' budget.

Table 2. Adoption of digitalisation for different construction processes.

Construction processes	Mean	Rank	Chi-Sq.	Sig.
Cost control	4.13	1	5.913	0.206
Cost Planning	3.79	2	8.241	0.083
Preliminary cost estimating	3.77	3	4.642	0.326
Building System Analysis	3.71	4	3.688	0.450
Existing condition Modelling	3.62	5	3.400	0.493
Procurement Stages	3.60	6	3.693	0.449
Design Authoring	3.54	7	2.009	0.734
Conflict resolution	3.44	8	1.516	0.824
Structural analysis	3.44	8	3.830	0.429
3D/4D Co-ordination	3.38	10	3.876	0.423
Maintenance Schedule	3.33	11	0.707	0.950

4.3 Perceived Benefits of Digitalisation

Result in Table 3 shows the ranking of the different benefits identified from literature with their associated significant p-value. From the table, it is evident that all the benefits have a p-value of above 0.05. This implies that at 95% confidence level, there is a statistically significant relationship in the view of the different construction professionals as regards the benefits of digitalisation. A look at the table shows that all the identified benefits also have their mean value to be above the average of 3.0. This implies that to a considerable extent with the digitalisation of the industry come the identified benefits.

Table 3. Perceived benefits of digitalisation in the construction industry.

Benefits	Mean	Rank	Chi-Sq.	Sig.
Saves time	4.37	1	1.604	0.808
Increases Productivity	4.18	2	3.512	0.476
Increases speed of work	4.17	3	1.462	0.833
Increases document quality	4.15	4	2.988	0.560
Speeds up response times	4.06	5	2.110	0.716
Simpler working methods	4.06	5	1.020	0.907
More accurate documentation	3.98	7	1.490	0.828
Reduces degree of difficulty	3.96	8	1.687	0.793
Reduces construction error	3.83	9	1.903	0.754
Proportion of new work	3.81	10	1.862	0.761

The most significant benefits to be derived from the digitalisation of the industry includes time saving, increase productivity, increase speed of work, increase document quality, speeding up of response time, and simpler working methods. The least benefits of digitalisation are, reduction of construction error, and the promotion of new work. Despite the fact that these benefits were ranked the least, they have a mean value of well above the average of 3.0, which means that they can still be achieved with the adoption of digitalisation of the industry.

4.4 Discussion

Findings of the study reveal that digitalisation in the South African AEC industry is more evident at the design phase and the feasibility phase than the decommissioning phase of construction projects. The major construction processes where digitalisation is mostly visible are, construction cost control, cost planning, preliminary cost estimate and building system analysis. It is, however, less evident in the maintenance schedule. This means that more attention is given to digitalisation in the cost of construction, while the use of digitalisation in maintenance schedule requires more attention if effective maintenance of construction works is to be achieved. Contrary to Castagnino *et al.* (2016) submission that digitalisation can be crucial in the transformation of the three major life-cycle phases of construction projects, findings of the study shows that the South African construction industry has only adopted digitalisation in the early phase of construction (feasibility and design phase). This digitalisation is mostly in the cost and design aspect, which is similar to happenings in other Middle East/African countries as observed by Jung and Lee (2015). Findings of this study further confirm Jung and Lee (2015) submission that the adoption of digitalisation in maintenance schedule in most African countries is low, as this aspect of construction was rated the least area where digitalisation is being used in South Africa.

Findings also revealed that the most significant benefits to be derived from the digitalisation of the AEC industry includes time-saving in construction projects delivery, increase productivity, increase the speed of work, increase document quality, speeding up of response time, and simpler working methods. This finding further confirms Hashim *et al.* (2013) submission that some of the benefits of using digital technologies in the delivery of construction projects include, improvement in process quality, adequate savings in construction cost, adequate clients and participants' satisfaction, increased responsiveness and productivity, expansion in market, and project delivered in the most effective manner. Findings also agrees with Staub-French and Fischer (2017) submission that digitalisation goes a long way in distinguishing clashes in design, and also facilitates outlines of schedule in the construction procedure. Also, less rework and fewer change orders are recorded when digitalisation is adopted.

5 CONCLUSION

Based on the findings, the study concludes that the major stages of construction where digitalisation is evident are the design phase, and the feasibility phase. The major construction processes where digitalisation is mostly visible are, construction cost control, cost planning, preliminary cost estimate and building system analysis. It is, however, less evident in the maintenance schedule. In addition, the most significant benefits to be derived from the digitalisation in the industry includes time-saving in construction projects delivery, increase productivity, increase the speed of work, increase document quality, speeding up of response time, and simpler working methods.

The study, therefore, recommends the need for further adoption of digital technology in other aspects of construction aside feasibility and designing. This will go a long way in achieving the

holistic benefits inherent in digitalisation. Also, more focus is needed in the digitalisation of construction processes such as maintenance schedule. The findings of this study will go a long way in assisting construction professionals and stakeholders in understanding the inherent benefit in digitalisation. However, though result reveals that there is the considerable use of digital technology in some aspect of the construction processes within the South African construction industry, care must be taken in generalising the result as it is based on the perception of construction professionals. Herein lies the limitation of the study. Therefore, further study is needed to effectively determine the practical adoption of digitalisation within the industry.

References

Berger, R., *Digitization in the Construction Industry*, Think Act, 1-16, 2016.

Castagnino, S., Rothballer, C., and Gerbert, P., What's the Future of the Construction Industry? World Economic Forum, 2016. Retrieved from https://www.weforum.org/agenda/2016/04/building-in-the-fourth-industrial-revolution/ on October 2018.

El-Mashaleh, M. S., Benchmarking Information Technology Utilization in The Construction Industry in Jordan, *Journal of Information Technology in Construction*, 12(19), 279-291, 2007.

Halim, H. C., *Assessment of The Application of Information and Communication Technology in Real Estate Practice (A Case Study of Lagos Metropolis)*, MSc. Thesis, Department of Estate Management, University of Nigeria, Enugu, 2010.

Hashim, N., Said, I., and Idris, N. H., Exploring E-Procurement Value for Construction Companies in Malaysia, *Procedia Technology*, 9, 836–845, 2013.

Ibem E. O. and Laryea S., Survey of Digital Technologies in Procurement of Construction Projects', *Automation in Construction*, 46, 11-21, 2014.

Jung, W., and Lee, G., The Status of BIM Adoption on Six Continents, World Academy of Science, *Engineering and Technology International Journal of Civil and Environmental Engineering*, 9(5), 512-516, 2015.

Oladapo, A. A., An Investigation into the Use of ICT in The Nigerian Construction Industry, *Journal of Information Technology in Construction*, 12, 261-277, 2007.

Osunsanmi, T. O., Aigbavboa, C. O., and Oke, A. E., Construction 4.0: The Future of South Africa Construction Industry, World Academy of Science, *Engineering and Technology International Journal of Civil and Environmental Engineering*, 12, (3), 206-212, 2018.

Peansupap, V. and Walker D. H., Factors Enabling Information and Communication Technology Diffusion and Actual Implementation in Construction Organisations, *Journal of Information Technology in Construction*, 10(4), 193-218, 2015.

Rouse, M., *Mean of Digitalisation*, 2017. Retrieved from http://whatis.techtarget.com/definition/digitization on October 2018.

Staub-French, S., and Fischer, M., *Enabling Concurrent Engineering Through 4d Cad*, In Anumba, C. J., John M. K., and Decelle, A. F. C., Concurrent Engineering in Construction Projects, 201-217, London, New York, Taylor Francis, 2017.

Tan, C. K., and Yeoh, K. C., *A Study on the Use of Measurement Software in the Preparation of Bills of Quantities Among Malaysian Quantity Surveying Firms*. i9th International Conference on ICT and Knowledge Engineering, Bangkok, Thailand, Jan 12-13, 2011.