



## Review

## Survey of digital technologies in procurement of construction projects



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## ABSTRACT

Digital technologies are increasingly being used to support the execution of all aspects of the construction procurement process. However, there has been no systematic attempt to identify and catalogue the different digital technologies and tools available for executing construction procurement activities so as to guide those involved in procurement on the options available to support the six basic procurement activities identified in ISO 10845. The method used to identify 36 different digital technologies and tools used in construction procurement was a literature survey involving systematic identification and review of 78 articles published in 52 different sources between 1993 and 2014. The 36 digital technologies and tools identified include ten generic tools used across the procurement process. This is followed by four applications for establishing what is to be procured; four for soliciting tender offers; one for establishment of procurement strategy; two for tender evaluation, two for award of contract and thirteen for contract administration. The research shows that the majority of existing digital technologies are web-based applications that facilitate real-time communication and collaboration across construction supply chains. The effort made to map digital technologies with the ISO 10845 framework presents a useful contribution to current discourse on digital technology use in construction procurement. It seems interesting that despite the progress made in the evolution and use of digital technologies in construction, there is still no single digital technology which integrates all six construction procurement activities into a system that procurers can adopt to manage the entire construction procurement lifecycle. This should be addressed.

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## 1. Introduction

The use of digital technologies (DTs) as electronic tools for conducting business transactions, including production and marketing of products as well as procurement of goods and services, has grown significantly in different industrial sectors in the past five decades (see e.g. [1–3].) Despite

the common notion that the construction sector tends to be relatively slow in adopting DTs, when compared with other industries such as manufacturing; finance; and transportation, evidence in the literature shows an increasing use of DTs in the procurement of construction projects internationally. The following empirical studies amplify this point:

- Analysis of the use of e-Procurement in the public and private sectors of the UK construction industry Eadie et al. [4]
- Building Information Modeling (BIM) application in Malaysian construction industry Latiffi et al. [5]

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- A survey of 120 construction firms on e-Procurement value for construction companies in Malaysia by Hashim et al. [6]
- Use of information and communication technologies by 227 small and medium-sized enterprises in building construction in Turkey by Acar et al. [7] and
- Adoption patterns of advanced information technologies in 152 U.S. and 13 Korean construction firms by Williams et al. [8].

Digital technologies (DTs) generally refer to information and communication technologies (ICTs) that enable the production, storage and handling of information, and facilitate different forms of communication between human beings and electronic systems and among electronic systems in digital, binary computer language as defined by Hamelink [9] in a study on new ICTs, social development and cultural change. For the purpose of this study, DTs encompass stand-alone, integrated and web-based technologies and tools used in capturing, storing, processing, displaying and communicating data and information in the course of executing the different stages and functions of construction procurement activities.

The benefits of using DTs in construction are generally considered to be enormous. In fact, Hashim et al. [6] identified the benefits of using electronic tools in the procurement of construction projects to include among others increase in process quality, cost savings, user satisfaction, increased responsiveness and productivity, market expansion and effectiveness in project delivery. These may explain why the use of DTs and tools in the execution of construction procurement activities is increasing internationally as shown in empirical studies including the surveys of 127 respondents on the current state of e-commerce technologies' applications in the construction supply chain in Sydney Australia by Zou and Seo [10]; 70 executives in 25 construction firms on the impact of using an e-marketplace in construction supply process in Chile by Alarcon et al. [11]; 368 respondents on the impact of electronic procurement technologies on procurement practice in the U.S. by Quesada et al. [12]; and a survey of 66 architects, contractors, engineers and quantity surveyors on the state of e-Tendering in Nigeria by Oyediran and Akintola [13].

The published literature reveals that since the introduction of electronic data interchange (EDI) technology in the late 1960s for procurement related activities and subsequent adoption of computers in business transactions in the 80s; there has been phenomenal growth in the use of different kinds of DTs in the business of construction. The studies reviewed also show that DTs are produced and supplied by different vendors for different markets; and their descriptions combine technical and application domain specific terms that users may not be very familiar with. Consequently, intending users find it difficult to understand the differences and similarities between the various packages and their specific applications in the procurement of construction projects. This obviously suggests that the existing literature on DTs available for procurement activities is highly fragmented and that there has yet been no attempt to identify, classify and systematically document the available systems, packages, tools and/or applications in the market.

In the face of an increasing number of DTs and tools in construction, there is a need for a comprehensive overview of digital technologies and tools used in the procurement of construction projects for academic and practical purposes. This will provide a useful point of reference to assist practitioners in selecting the most suitable package(s) to support the execution of procurement activities. A better understanding is needed of the different DTs and tools reported in the literature and their specific applications in the procurement of construction projects. Therefore, the research aim was to systematically identify, classify and catalogue the different DTs and tools available to support the construction procurement process. The International Standard on Construction Procurement ISO 10845 [14] was adopted as the framework for breaking down construction procurement into six basic activities. The DTs identified were then mapped and cross-referenced to ISO 10845 to create a logical

approach for establishing an intersection between procurement and digital technologies.

The achievement of the research aim was guided by the following research questions:

- What are the different digital technologies and tools available to support the execution of activities involved in the construction procurement process?
- How do digital technologies and tools published in the literature relate to the six basic procurement activities outlined in ISO 10845?
- How has digital technology used in construction procurement evolved over the years?

A comprehensive approach was needed to address these questions. In the first instance, this comprised of a detailed literature survey conducted with the help of Scopus, followed by a systematic mapping exercise of the findings to the ISO 10845 framework. The remaining part of this paper has been structured to provide understanding on the research design and methods; current knowledge of construction procurement; DTs and their uses in construction procurement activities; intersection of DTs and construction procurement; and how DTs used in construction have evolved over the years. The paper ends with a discussion of study findings and some concluding remarks.

## 2. Research design and methods

This paper is part of a broader study designed to investigate the use of electronic procurement in the South African construction industry. The choice of research approach was informed by the need to address the research questions from evidence-based literature. This was important because in their paper on integrative review, Whitemore and Gray [15] made it clear that the need for research reviews to combine the advantage of evidence from multiple studies regarding a specific issue to inform practice. It is perhaps the unique advantage of using research reviews to bring together evidenced-based knowledge and practice on specific subject that led several authors, including [16–19] to adopt a similar approach in their studies.

The data presented in this paper is substantially secondary data obtained through a survey of the existing evidence-based literature on the research subject. A comprehensive search of peer-reviewed articles and conference papers were conducted between July 2013 and March 2014 using Scopus online database as the main source of literature. The choice of Scopus was based on its advantages in covering a wider range of journals, and special features in keyword searching and citation analysis as explained by Falagas et al. [20] in a comparative study of the strengths and weaknesses of PubMed, Scopus, Web of Science, and Google Scholar. Our search algorithms combined text words such as: *construction procurement*, *digital technologies in construction projects*; *e-commerce technologies in construction*; *e-procurement technologies*; and *information technologies in construction procurement*, published all year to present. Similar approach was adopted by Vaha et al. [21] in their paper on extending automation of building construction-survey on potential sensor technologies and robotic applications; and Ibrahim [19] in a review of evidence in the use of digital collaboration technologies in a major building and infrastructure projects.

Both journal articles and conference papers were included in the searches as academics and practitioners depend on journals and conference proceedings in the dissemination of research findings and acquiring information on recent and emerging developments in their different areas of interest. Also, the choice of the search criteria was informed by the need to capture relevant and current international research literature on the subject.

The searches returned a total of 999 items comprising 555 journal articles, 428 conference papers and 16 lecture notes. As would be expected, a number of items appeared in the search results of "digital technologies in construction projects" and "e-procurement technologies". In selecting the articles that were reviewed, three criteria were adopted.

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