Information and Communication Technology (ICT) in Construction

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Information and communication technology (ICT) is one of the important factors that support construction project performance.

information and communication technology | ICT | ICT infrastructure | ICT utilization | construction management

1. Introduction

The construction sector is considered as one of the biggest investment-draining sectors worldwide, with extremely high influence and contribution to economic development [1][2][3][4]. However, this sector faces considerable barriers and challenges, such as low performance, frequent construction delays, quality issues and cost overruns [4]. Therefore, finding solutions to improve construction project performance and make the project management knowledge more efficient is the main challenge for organizations to achieve client requirements [4][5]. One of these solutions is to apply new technologies and implement effective information and communication technology (ICT) applications in construction projects [4][6].

ICT can be described as technologies involved in the collection, transport, retrieval, storage, access, presentation, and transformation of all forms of information [7]. ICT can also be defined as applying information and communication technology tools, including software and computer hardware [8][9]. On the other hand, ICT infrastructure can be defined as the necessary components to manage and operate enterprise IT environments [10][11]. An organization can deploy its IT infrastructure in a cloud computing environment or computer facilities. These components include hardware and software, as well as networking and operating systems (OS), which are all used to provide IT services and solutions [11].

ICT utilization is crucial in the support of project operations, and the organizational ICT infrastructure supports the performance of ICT implementation from the project level to the organization level [12][13]. Moreover, many construction companies have turned to ICT utilization to quickly respond to changes in the environment and owners' demands [13][14]. The creation of new and innovative processes for projects is one major way ICT can add value to an organization's performance. In addition, if there is a strong ICT infrastructure within an organization, IT can enhance coordination, communication, cooperation, and collaboration among team members [15]. Although some research has suggested a positive correlation between ICT implementation and organizational performance,

little empirical research has concentrated on the alignment between the ICT organizational infrastructure and the ICT utilization [12][15]. These studies focus on the impact of IT infrastructure on projects and capital facilities or infrastructure performance [13][15]. To date, there are only limited studies on the adoption of ICT by construction organizations, and fewer studies regarding the effects of strong alignment of the ICT infrastructures and ICT utilization on organization performance. This is considering the relatively long period of time that computer integration has been advocated in construction literature [16].

Based on the available information there is a lack of evidence about the business value of ICT utilization in the construction industry. This scarcity of evidence could be why ICT usage, especially for project processes, seems limited [16][17]. Therefore, it is important to know how this ICT usage impacts project team–owner relationships, general organization outcomes, and the success of construction projects. However, ITC utilization alone is not the perfect solution with a utilization strategy. Accordingly, the ICT infrastructure alignment is crucial to the overall organization's performance [3][12][18].

2. Construction ICT Utilization

A significant number of studies have been conducted on ICT adoption in the construction industry and its relation to construction project performance [19][20][21][22]. These studies generally cover ICT utilization and factors that influence its implementation as part of the construction management process. It also discusses the expected benefits of using ICT in project management and construction [20][21][22][23]. Considering the type of ICT usage, Rahimian et al. (2020) examined the extent to which ICT, in general, is being used in the execution of construction industry projects. On the other hand, Elghaish et al. (2020) investigated the potential of a specific ICT, the 4D BIM technology, as a productive tool in project management. Sharma et al. (2020) provided a valuation model that measures the utility of electronic networking technologies as a type of ICT in construction project activities' progress. Alsafouri et al. (2018) also addressed the crucial issue of how to best utilize ICT in construction industry organizations. Ozumba et al. (2018) conducted to examine the role ICT transfer plays in innovation in medium- to small-sized construction organizations.

They are also active in identifying the factors that influence the adoption and use of ICT [24][25][26]. J. Li et al. (2020) looked at the relationship between construction equipment ICT and construction management progress. They ended up with three factors that mainly determine the impact of equipment ICT benefits, which are ICT implementation control, ICT implementation acceptance, and the project condition [27]. Daniotti et al. (2020) suggested that a lack of information about ICT and its benefits and an unclear competitive advantage may have caused a construction management team to resent adopting new technologies. Osunsanmi et al. (2020) concluded that the ICT adoption process is mainly linked to client relationship management. According to Adafin et al. (2021), New Zealand's construction sector has increasingly utilized ICT in the design and the project operational phase, resulting in unstructured and discrete utilization strategies. Conversely, the construction management and onsite construction execution phases had the lowest ICT utilization levels in New Zealand's construction industry. Moreover, in the New Zealand construction industry, ICT utilization was most widespread in the second phase (design phase) and less widespread during the fourth phase (project management phase) [2][28][29].

It was believed that ICT can provide significant benefits and contribute to construction project performance. However, it depends on the implementation methods [3][30][31][32]. There is limited on the construction industry that has konwn the impact of ICT on the performance of the construction organization, and the existing focus is on the project, as opposed to organization, performance [33]. Adriaanse et al. (2010), Hosseini et al. (2012), and Ozumba et al. (2018) are just a few examples. On the other hand, Hong et al. (2019) and Peansupap et al. (2005) are two other examples of studies that examined the current state of ICT use at the organization level. The work of Henderson et al. (2010) was one of the most comprehensive of these studies. They evaluated ICT's utilization on an organization's specified projects using the organization data. Henderson et al. (2010) used their evaluation to determine the impact of ICT usage on the cost of a project and its schedule success within the organizational processes and context. Boton et al. (2015) carried out to show the feasibility of using technologies such as 4D BIM on a construction project considering the organization information. To identify potential problems, the research team examined the master critical path schedule method CPSM [34]. Afzal et al. (2021) claim that it was demonstrated the value of 4D models for visualizing and understanding construction methodology, schedule sequencing, communicating special constraints to a project, and formalizing design information. They also argue that 4D models can be used to anticipate safety hazards and the assignment and allocation of project resources and construction-related machinery to the worksite, as well as for constructability reviews [35]. Alaloul et al. (2020) found that this visualization allows stakeholders of the construction projects to understand the construction schedule better than traditional construction management tools.

Howard et al. (2008) assessed ICT usage across design and construction organizations using the ICT barometer structured survey from the Finnish construction industry. Most organizations were mainly using computers for internal administrative and management tasks, including archiving. In contrast, fewer organizations use ICT tools to manage construction projects during delivery, or for document sharing and cloud usage [36]. Lu et al. (2019) conducted an analysis on construction industry and found similar results. They also reported widespread usage of basic ICT tools such as spreadsheets, accounting, word processing, and emailing. While a small number of organizations used advanced tools like 3D and 4D technology, according to Lu et al. (2019), larger organizations were using more of the most recent ICT tools compared with the medium- to small-sized organizations [37][38].

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