Information and Communication Technology

Subjects: Automation & Control Systems

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Information and Communication Technology (ICT) is seen as a way to enhance knowledge collection in the construction sector. Although the theoretical benefits of ICT implementation have been clarified, realizing such benefits is insufficient. This paper attempted a systematic analysis of the literature using ATLAS.ti 9 software to save, identify, and analyze this study's data. A total of 102 articles were actively reviewed, including 82 Scopus journals and 20 conference papers published from 2003 to 2020. In this article, from a construction industry point of view, the ICT adoption process is considered as an interaction between technology, task, and an individual from a construction industry perspective. While ICT is acknowledged as a source of aggressive gain by both practitioners and scholars, ICT's sole presence would definitely not guarantee achievement in the industry's ICT approval. Companies cannot grasp the full benefits of ICT, except that users are able to adopt the technology. Hence, the issues related to ICT adoption need to be examined.

Keywords: information technology (IT) ; information and communication technology (ICT) ; sustainability ; construction industry (CI)

1. Introduction

Information and Communication Technology (ICT) is an extended term that is usually employed in place of Information Technology (IT) [1]. It describes an extensive industrial spectrum of services concerning information technology, information systems, computer science, e-business, and software engineering. It embraces both soft and hard skills in programming development and systems, together with interpersonal communication skills [2][3]. It is a sector that comprises the distribution of information technology, telecommunication products, manufacturing of information technology, maintenance, and communication system installation.

In the ICT sector, the opportunities that favored the de novo entry were the rapid technological advancements that started in the early 1980s [4]. Over the last few decades, these advancements have gradually spread across many countries, reflecting the ICT components' increasing export rate in the 1990s. Consequently, this growth accounted for a considerable proportion of the total trade in ICT products, including telecom equipment, semiconductors, office machines, and IT products. Currently, it is commonly seen that the use of ICT enhances the competitiveness of organizational enterprises [5].

2. Types of ICT to Be Adopted

The current literature comprises a description of ICTs that are active in the CI. As is stated in the introduction, this research mainly focuses on three types of ICT—electronic data interchange/electronic data management method (EDI and EDMS), web-based management method, and building information modeling (BIM)—because the company-wide information system will have a more substantial influence on organization culture and people's behavior regarding stand-alone technology.

2.1. Web-Based Management System

From the very beginning of ICT use for the project, the benefit of web technologies in construction companies can be calculated. The web-based management framework is also used as an instrument for linking and obtaining multiple knowledge sets. There are different types of systems, such as a web-based decision support system, a web-based project management system, a shared online arrangement update, a web-based knowledge management system, and a management framework [6][7]. Web-based management systems are expected as remedial solutions to enhance communications in construction projects while improving the productivity, efficiency, and quality of products. The method requires the transferring and processing of the project correlated data and dispersed project members to be linked in electronic bases with the project members [8]. The use of web technology is proposed to have the benefits of bringing efficient collaboration, coordination, and communication, and decision-making methods [9][7]. Stewart and Mohamed [10]

suggested that a web-based project management system could be evaluated from five perspectives, including improvement to operational processes, obtaining profits on construction projects, achieving planned goals, increasing satisfaction with the IT portfolio, and meeting the needs of the user [11].

Academics and practitioners anticipate that web-based project management systems could enhance and revolutionize the way in which construction-related organizations conduct business. However, the absence of a sufficient understanding of how to implement web-based project management systems resulted in widespread adoption, and effective use of the system failed to meet expectations. Dossick and Sakagami [12] recommend three critical strategies for successfully implementing a web-based project management system, including assigning a leader for the project, enforcing utilization with contract specifications, and training personnel by showing the benefits of usage of the web-based project management system.

Usually, the management of a building project involves a balance between the conflicting project constraints, including, but not limited to, scope, efficiency, scheduling, expenditure, capital, and risk [11]. In real estate development building projects, a project's work scope is typically specified during the planning phase. After the tendering period, the project duration, expense, and quality criteria are specified in the contract papers. The project managers of both the contractor and the developer must accomplish the built facilities to ensure the performance of project delivery in order to be appropriate to the specified standard, within the timeframe and the budgeted costs. Different services, including supplies, tools, and financial support and, in particular, personnel and skills, have to be given during the building period. Benefits management and contingency management are also relevant during the whole process.

2.2. Electronic Data Interchange (EDI) and Electronic Data Management System (EDMS)

Electronic data interchange (EDI) or electronic data management system (EDMS) is a unified tool for data exchange between various computer networks or computer systems [7]. EDI and EDMS are built to facilitate improved collaboration and communication in the CI. The core functionalities of electronic EDMS include record control, modify management, submittals, transmittals, and demands for information [13]. Agdas et al. [14] claim that EDI and EDMS solutions can add strategic advantages to a firm through automation, streamlined communication, and waste reduction, thus improving its competitiveness. The use of EDI and EDMS as instruments in building indispensable and responsive supply chains will reduce administrative efforts, accelerate data processing time, reduce error data, and eliminate data keying [9][15][16]. Figure 4 shows the benefits of electronic data interchange.

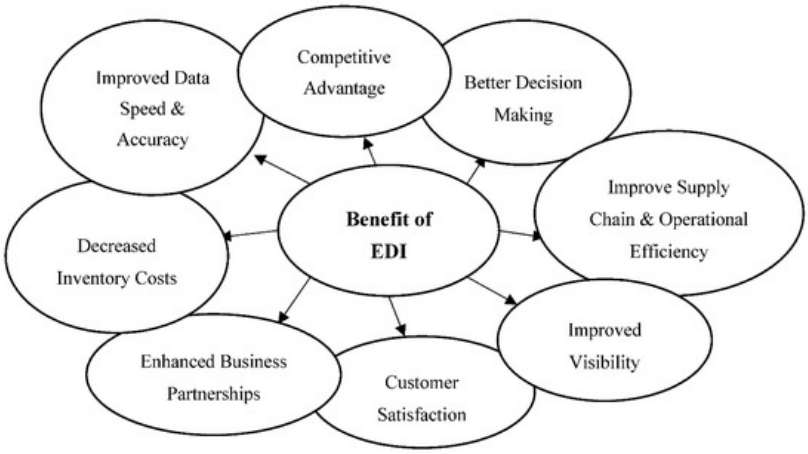

Figure 4. The benefits of electronic data interchange.

EDI studies propose that standardization is a major barrier to the successful adoption and diffusion of EDI systems in AEC (Architecture, Engineering and Construction) organizations [14]. The EDMS system usage is found to be lower than expected according to the planned system structure. Kähkönen and Rannisto [13] find that many folders in EDMS are seldom used or totally unused. In addition to this, some users have created extra folders to meet their own needs, which makes an EDMS more complicated and more difficult to use. Therefore, they suggest that flexibility should be improved, and smart features need to be added for an EDMS system to achieve better ease of use.

Shared access to information, standardized ways to scan for data, version control, the ability to read and use content without access to the program used to construct it, etc., are among the benefits of such programs. In other words, the structures provide a forum to keep all the document-based knowledge that is communicated in a building project in good order. This provides a tremendous opportunity to make the overall process more effective. One of the building industry's problems is its information-intensive project format, with new partner constellations for each new project. In the building industry, there have been very few earlier reports of the implementation of EDM. Agdas et al. [14] discussed the fact that in

a project, the participants of a device should not be viewed as one single group but rather as consisting of multiple groups with various attitudes and abilities. The problem with an EDM system is that efficient usage allows both of them to implement the framework concurrently. A variety of factors influencing the effectiveness or failure of such schemes have been defined by Kähkönen and Rannisto [13]. In broad and complicated building projects, Hjelt and Björk [17] examined the implementation and use of a common method and, in particular, shifts in the behaviors of various groups of users after they began using the method.

2.3. Building Information Model

The building information model, or BIM, has attracted growing interest from both academics and practitioners as one of the most advanced innovations of recent years. There is, however, no consensus on BIM's interpretation. Aranda-Mena et al. [18] argue that, for some, BIM is a software application; for others, it is a mechanism for the design and analysis of building information; for others, it is a wholly novel method to the discipline and development of the profession that includes the introduction of new strategies, contracts, and partnerships between project stakeholders. Succar and Kassem [19] describe BIM as a collection of interacting structures, procedures, and technologies, creating a framework during the building's life cycle to handle the critical building design and project data in digital format. BIM functions as a shared network of information for a project and plays a supporting role in decision-making during its life cycle. Different stakeholders can have varying views on BIM roles. For example, architects tend to use BIM to improve productivity, coordination, and business transactions, while contractors are more likely to schedule, estimate, and carry out processing [9][20]. Figure 5 shows the benefits of the building information model.

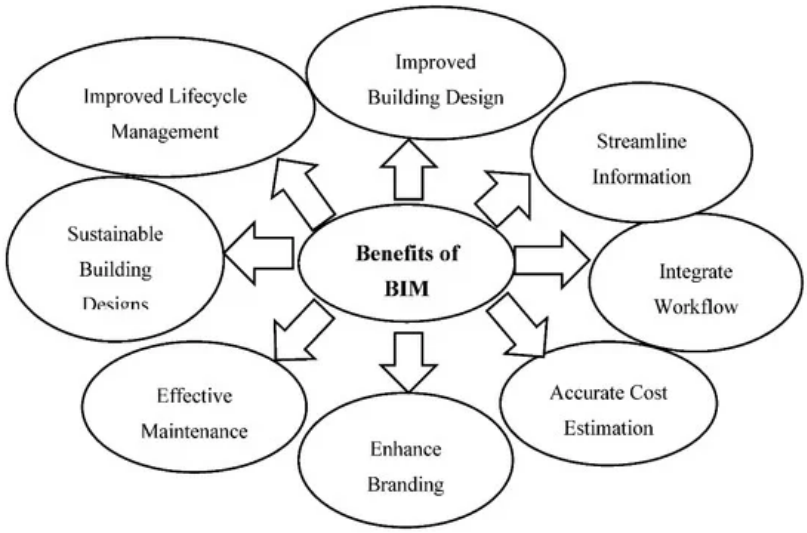

Figure 5. The benefits of the building information model.

The introduction of building information modeling (BIM) has demonstrated a great deal of promise for building planning, construction, and maintenance to increase performance. BIM was described by Yan and Damian [21] as a powerful range of design management tools that have considerable advantages over the entire life cycle of the building, particularly in planning, construction, and facility management. It is a forum that enables cooperation and enhancement of project performance between project stakeholders. Over the years, the BIM problem has acquired universal attention among all building industry stakeholders worldwide. By maintaining good coordination and cooperation between all project stakeholders from the beginning to the end of construction projects, BIM is seen as a catalyst for the building industry to increase its competitiveness. Succar and Kassem [19] found that many architecture and development organizations in numerous parts of the world are heading toward BIM adoption in their activities. Arayici et al. [21] reported that several pilot and live projects in Finland, Sweden, Norway, Germany, France, Singapore, the United Kingdom, and Australia have been completed and registered in the recent past, showing the potential to use BIM in the construction phase. Yan and Damian [21] concluded that not all industries are involved in its implementation, but with growing initiatives by researchers and market leaders, the future of BIM technology in the industry still looks promising. BIM's advocates have proposed that some advantages include improving and changing the design and development process, combining building designs, parts, graphics, and descriptions in ways that are not feasible in 2D CAD, providing parallel knowledge on efficiency and economic aspects of development, among others. This new technology has now demonstrated its ability to sanitize the building industry with increased efficiencies and teamwork capabilities from its conventional and fractured ways of functioning [21].

By using BIM in the preconstruction phase, it could increase design effectiveness by executing clash discovery and clash analysis; for scheduling, it could enable the project manager and contractor to track progress against logistics and timelines established while making the work sequence, equipment, and materials observable; also, it could allow generation of takeoffs, counts, and measurements by forming a three-dimensional project model and making specific estimation possible [22][9]. Furthermore, in the construction phase, BIM enables the presentation of the construction method, comprising entrance and exit roads, traffic issues, site materials, and types of machinery; it enhances cost regulation by providing more accurate tracking of cash flow; and it enables real-time work tracking, quicker resource movement, and more useful site supervision. Researchers point out that it is beneficial to adopt BIM at the early stage of the project.

3. Conclusions

ICT—typically, the use of Internet-based online transactions, is fast replacing the conventional approach in carrying out operations amidst mortal and brick businesses. The Internet offers many beneficial features covering broad connectivity, speed, moderate cost, and user-friendliness. With a digital network economy, e-commerce and the Internet are quickly spreading internationally, bringing several countries in the world together. Because of the Internet's power, several industries depend on adopting ICT, particularly the building industry. Naim and Lenka [23] reported that Internet usage might be a severe issue in improving a firm's operational efficiency and market reach. Many studies concluded that the investment and adequate utilization of ICT in the CI are the main techniques for enhancing productivity within the sectors.

Additionally, the government has devoted the maximum attention to improving the environment and infrastructure of ICTs adoption in the construction sector to ensure the country's rapid growth in this information era. Moreover, a report has shown that ICT is poised to become one of the key means of arousing economic growth by becoming an important sector due to its responsibility in enhancing the development of other establishments in the nation. The adoption of ICT in all divisions, particularly in the CI, will facilitate a national economic extension.

Moreover, competition in the global market is becoming more demanding and multifarious, especially for a developing nation. Hence, to compete not only includes economic liberation but also the extent to which ICT is being utilized in a nation. For example, the use of ICT (advancement in the communication) has drastically reduced both transaction and information costs. Thus, there is a need for broader dissemination to guarantee national development. For this reason, it has become pertinent for developing countries to ensure widespread ICT in the economy to enjoy the optimum benefit from it. Therefore, instead of building production capabilities in relative isolation, decisive policies must be set up to address the failures in attaining global competitiveness. This implies that the necessary resources available in the country should be properly channeled into the worldwide market to benefit maximally from the payoffs of ICT investment.

The study identified project and site managers and quantity surveyors as the main ICT users in the Nigerian CI for the range of ICT resources. This study's functional implications would enhance the understanding of ICT in construction management practices by front-line managers and could potentially encourage the complete deployment of ICT in the industry, particularly in Nigeria, where many ICT potentials have yet to be exploited. This study also identified the antecedents of ICT use's productivity impacts as the most significant overall driver and the most critical issue contributing to the complete construction project progress. The research has significant practical ramifications, which suggest that productivity as a critical factor in building project success in satisfying stakeholders is a key instigator of expanded ICT usage.

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