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Barriers Impeding the Adoption of Information and Communication Technology (ICT) in Construction Project Management

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Abstract: In today's world, Information and Communication Technology (ICT) adoption is one of the most critical factors influencing project stakeholders' ability to effectively coordinate and collaborate construction activities. The construction industry and its stakeholders are often confronted with a large volume of data and serious communication. Unlike other sectors, the building industry's use of ICT has not been extensively studied. Consequently, it adds to a range of obstacles to completely using ICT. As a result, the study aimed to investigate the barriers of ICT in managing construction project. The objectives for this study were to identify the current state of ICT use in the construction industry and to investigate the barriers to ICT use in construction project management. The data for this analysis was gathered using both secondary and primary data collection methods. Secondary data was gathered using a literature review of previous studies and documents on ICT for construction project management. The study used a quantitative research design that included a questionnaire survey. To explain the respondents, a non-probability sampling approach was used. A total of 40 people responded to the questionnaire survey, which included members of different project teams. Statistical Program for Social Sciences applications was used to complete the data analysis (IBM SPSS). The results were produced using critical and descriptive analysis. Computers and email were found to be among the most widely used ICT methods for managing construction projects, according to the findings. One barrier to ICT implementation in construction project management was resistance to reform and the high cost of ICT adoption. Resistance to change and the high cost of ICT adoption were among the challenges to ICT implementation in construction project management.

Keywords: Information, communication, technology, ICT, construction, project management

1. Introduction

The construction industry is repeatedly criticised for being inefficient and slow to innovate [1]. Creative approaches to improve construction efficiency are required in the construction industry, which is proving for expected changes in the near future. Currently, conventional contact methods such as face-to-face meetings and the exchange of papers are still used in the majority of construction projects. In completed developments, the potential uses of ICT can be overwhelming and challenging, due to design and construction are information intensive activities involving a great number of people collaborating to produce complex, one-off developments. In Addition, the combination of project

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planning, design criteria, material selection, budget limitations, project deadline, and the availability of specialised skills, each construction project is completely unique.

The construction industry is also recognized for its fragmented and competitive climate. As a result, it is possible to enhance communication, increase client satisfaction, minimise construction planning mistakes, increase project participant comprehension, reduce ambiguities and inconsistencies in documentation, and increase overall awareness and recognition of issues and requirements by all project participants. Hence, ICT adoption by the project team is crucial in the construction industry for design, construction, and operation processes.

1.1 ICT in Construction

ICT development and investment has been a major contributor to global economic and productivity growth in recent years. However, the adoption of ICT by the construction industry has not been as significant as in other sectors [1]. According to [2], many construction projects suffer from time delays and cost overruns due to productivity issues. Employment of unskilled workers and slow adoption of ICT are found to be the major reasons for such low productivity [3].

Although recent advances in ICT in the form of mobile technologies have changed the way communication and information sharing take place in many industries [4], there are certain characteristics that differentiate the construction industry from others.

Mobile ICT such as smartphones and tablets, mobile applications, wireless network, and cloud storage can offer an effective way to overcome the problems of collaboration in construction projects [2]. However, unlike the other industries, its use within the construction industry has not been explored in sufficient depth [2].

ICT in the construction industry is defined as "the application of decision support tools, which uses electronic machines and pro-grams for processing, storage, analysis, control, transfer and pre-sensation of construction information during the whole life cycle of a construction project" [5].

In operational terms, ICT refers to the technologies engaged in collecting, transportation, retrieval, storage, presentation, visualization and conversion of information from various forms [6]. ICT can bring about a wide range of enhancements on different areas of construction projects [7]. These include supporting management functions, enhancing the quality of decision-making, optimization of resources and improving workers' efficiency [8]–[12]. Use of ICT improves coordination, communication and cooperation among project team members and assists on-site personnel with access to well conveyed data and information [6], [11].

Information, together with communication, are the very lifeblood of project management [13]. From conception to completion of a construction project, as a means of record and communication, a large number of documents are generated and exchanged [14]. However, the manual approaches to dealing with information often result in wasted time and increased cost in construction projects [15], [16].

The construction team need to be expert with the software that can improved the work performance for their team by supporting the sharing and flow of information [17]. Understanding dispersion requirements could help development firms oversee enhance their ICT dissemination forms by concentrating on conceivable ICT usage dispersion boundaries and finding approaches to relieve them [18].

Samuelson & Björk indicate that adoption of ICT in construction has continued [19]. Nevertheless, it is arguable from older and recent literature, that barriers still plague the uptake of ICT in construction [19].

2. Literature Review

In project developments, the potential of ICT can be overwhelming, especially for the development of very complex and intensive demands type of projects. Use of ICT improves coordination, communication and cooperation among project team members and assists on-site personnel with access to well conveyed data and information [11]. For instance, mobile ICT has the potential to significantly improve field work, on- site information management, and productivity in projects because its users can access computing and communication functionalities seamlessly, regardless of space and time [20], [21]. Despite such great potential, construction projects still lag in fully embracing ICT [11], [22], [23].

Various communication issues such as misunderstanding between worker and superintendents, lack of clarity of instructions and technical specifications, low level of coordination among construction parties, delay in responding to requests for information, and slow decision making have continued to impede productivity in both developed and developing countries [3], [24], [25].

2.1 Immature of ICT

Absence of creativity mindfulness can also obstruct ICT venture opportunities. This is due to the fact that knowledge about a construction process (such as assessing or cost control) could be limited to traditional/conventional methods rather than how ICT might be used to effectively re-design these procedures.

Aside from people and construction culture obstacles, the perplexing production process necessitates a diverse variety of supply chain partners of varying authoritative size and progression. Immature innovation can lead to

fragmented ICT capabilities, so mechanical advantages that do not meet the needs of the organisation have a negative impact [18].

2.2 Lack of Skill and Knowledge

ICT is a method that requires not only technical skills but also a broad understanding of the hardware and software to be used. This may occur when senior managers are not interested in ICT appropriation when introducing ICT applications into an organisation, as well as when there is a lack of confidence in ICT execution strategies and client resistance, giving the appearance of being linked [18].Giving only basic preparation allows for a basic understanding of ICT concepts, benefits, and knowledge. This can lead to ICT coaches focusing solely on the specialised setting (for example, menus, capacities, and interfaces), enabling clients to find out how to apply ICT advancements to their work types [18]. Some of experienced project managers are accustomed to the conventional approach, making it difficult for them to adapt to and comprehend the technology. Most experienced project managers have limited their ICT learning if their knowledge was gained before ICT became essential to current administration hone [18]. ICT implementation needs users to learn how to operate new IT tools. Therefore, learning should be part of intraorganizational ICT implementation diffusion [26].

2.3 Lack of Support System

Training is a primary organisational ICT diffusion factor because it helps users understand how to best use and adopt ICT applications. Likewise, many construction case studies found that lack of training is a key barrier to adopting and using IT/ICT applications [27]–[29].

In addition, [30] found that compatibility has a positive influence on organisational ICT adoption and implementation. For example, ICT that was designed to replicate manual or paperwork is easy for users to accept because they feel familiar with the work patterns. Therefore, the higher the compatibility with users' existing work, the more likely it is that the users become familiar with a system.

The ICT diffusion process can be seen as a process of change within an organization [31], [32], so it need commitment from both users' and the organisation [33].

2.4 Resist to Change

The construction industry has a wide variety of phases, stages, and parts, which contributes to the resistance. Construction is a divided amassing industry where the work is done in a few autonomous stages (feasibility studying, master planning, permission management, technical design, construction, and operating the facility). Different stages are in truth characterized in various industry segments, for instance, from outline and counselling and additionally offices administration, to proficient, logical and specialized administrations. The work breakdown is regularly connected in the extraordinary, so little possess, and subcontractors are playing out the real work in situ [34].

A basic requirements of ICT adoption is the need to directly or indirectly persuade users to commit and involve themselves with using ICT. An organisation's top management also needs to be committed to support and allocate adequate resources for ICT technology investment. Numerous examples of lack of organisational commitment have been shown to lead to IT project failure [35], [36]. Without individual commitment, ICT implementation success could not be achieved.

2.5 Financial Constraints

Other technology attributes are speed, reliability and accessibility. Speed makes users feel that they are gaining a real benefit and improving their productivity by using ICT technology compared with previously used systems. Thompson, Higgins & Howell argue, resource allocation is a key factor in ICT use. If users feel that applications lack speed and reliability or if users are not provided with necessary access to use an ICT application (due to resource limitations such as money for high-speed links, current technology or compatible equipment/software) then they may not be willing to use them [36].

2.6 Summary

The literature review identifies a variety of fascinating new perspectives on ICT implementation. It establishes a structure for gaining a comprehensive understanding of the obstacles that impede ICT implementation during the implementation process. This structure comprises five key barriers as stated in Table 1.

Table 1 - Barriers of implementing ICT applications in managing construction projects

Key Barriers	Sub-Barriers
Immature of ICT	The immature of ICT application for construction industry
	Security of information
	Regulations (i.e. electronic signature is not acceptable in most of official documents).
Lack of knowledge and skills	Lack of skills and knowledge of ICT
	Drastic changes of the new technology used
	Varying professional competencies
Lack of support systems	Time constrains in learning total skills of ICT application
	ICT infrastructure (low bandwidth, low internet speed)
	Lack of common standard for ICT adoption among firms
Resist to change	Resist to change
	Lack of interest to use ICT
	Cultural matters (i.e. paper-based systems)
Financial constraints	Require high cost for ICT adoption
	Company's financial issues
	Lack of incentives and support

3. Methodology

This study was derived by secondary data collection and questionnaire survey. The methodology that has three main stages starts with the initial information gathering, involving literature review in the second stage. It is followed by the second stage of main data collection by using a questionnaire. The survey data is later analysed in the next stage by adopting the statistical approach of the Statistical Package for the Social Sciences (SPSS).

To accomplish the objectives, first method adopted was the secondary data collection. The search was all about the ICT in construction, specifically focusing the barriers of ICT in managing construction projects. Data collected for literature review was used as inputs to the questionnaire survey in establishing the variables for barriers of ICT in managing construction projects. Other than that, to obtain the current data of the research, the primary data collection was conducted which was the questionnaire survey. The survey was conducted among key players in construction with different roles such as project manager, engineer, and others.

In order to investigate the barriers of ICT utilization in managing construction project, quantitative method was adopted to fulfil the aim and objectives of the study. This study uses quantitative method as the past research for this study mostly conducted the similar method in order to fulfill the aim and objectives [37]. Table 2 shows the study were conducted using three distinct stages.

Table 2 - Research flow of the study

Stage	Description	Methods
Stage 1	Problem identification	In depth reading for previous research
	Objectives establishment	By referring to the problem and issue of the study
	Limitation identification	Narrow down the area of study and respondent according to the aim and objective of study
Stage 2	Literature review	Critical analysis on secondary data (journal, article, etc.)
	Primary data collection: Questionnaire survey	Questionnaire design. Identify population and sampling
Stage 3	Data analysis	By using SPSS to analyse frequency, percentage and descriptive statistical analysis
	Result interpretation	Interpreting the data
	Conclusion and recommendation	By using the findings to meet the aim and objectives of study

The convenience sampling approach was chosen in this study. Convenience sampling is a non-probability sampling technique in which samples are selected from the population only because they are conveniently available to the researcher. Because of its speed, cost-effectiveness, and simplicity of availability of the sample, convenience sampling is the most used non-probability sampling approach. Non-probability sampling, on the other hand, was utilised in this study since a sample can be chosen based on specified criteria or suitability. As a result, this study concentrates on construction industry participants, and it analyses the topic as a preliminary investigation to fit the convenience sampling technique. There are around 20 construction projects ranging from medium to large size in the selected area. Due to a propensity for substantial project costs, only medium and large construction projects were chosen. Furthermore, these projects tended to use ICT applications at a moderate to high level in their projects.

4. Findings and Discussion

According to the demographic background, there were more than 5 positions responded to the questionnaire. This is not including 'others' which mostly were the site supervisors. Table 3 indicated that 30% of the respondent led by quantity surveyor while others were 10% (i.e. site supervisors). 80% of respondent's organization were from contractors. Figure 1 shows the respondent skills for ICT. Most of the respondent ranging from moderate level.

Table 3 - Key profile of respondents

Attributes	Classification	Number of respondents	Percent
Role	Interior Designer	3	7.5
	Quantity Surveyor	12	30.0
	C&S Engineer	11	27.5
	M&E Engineer	1	2.5
	Project manager	9	22.5
	Others	4	10.0
Organization / Sector	QS consultant firm	2	5.0
	M&E consultant firm	1	2.5
	Architect firm	2	5.0
	Contractor firm	32	80.0
	Developer firm	3	7.5

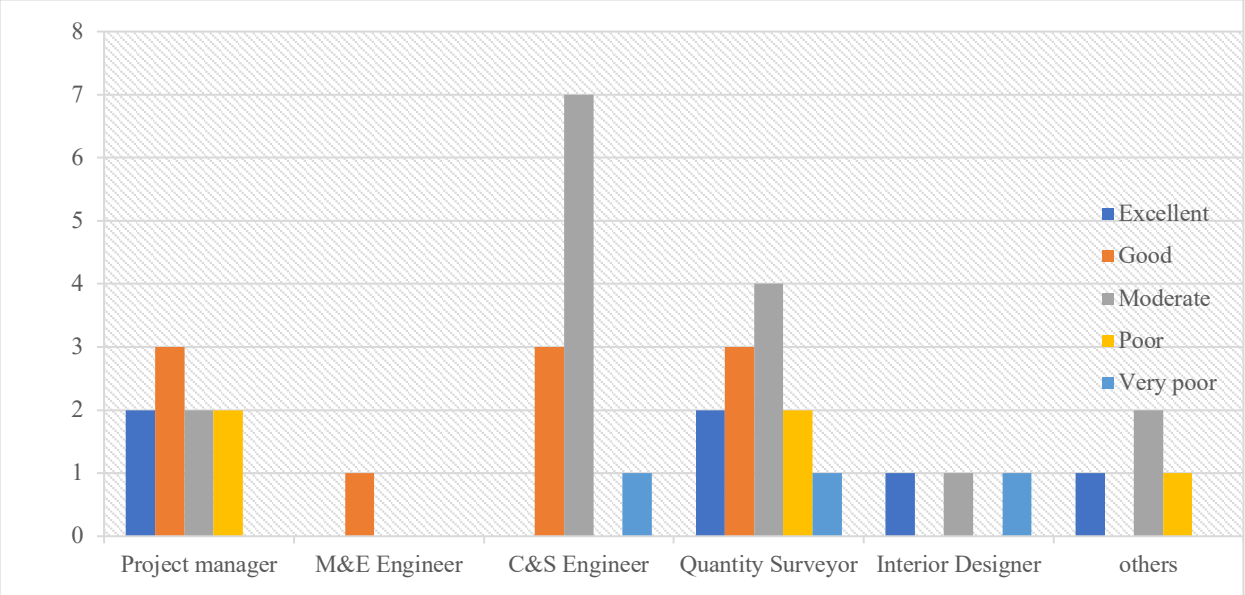

Fig. 1 - Respondents' ICT skills in relation to their respective positions

Table 4 illustrates that infrastructure projects employ the most ICT for project management, followed by commercial projects. It also indicates the percentage of ICT adoption in each projects, ranging from 20% to 100%. Despite the fact that participation from healthcare and recreational projects was low, the percentage of ICT application in these projects demonstrates a good trend of ICT in project management.

Table 4 - Percentage of ICT applications based on types of project

Types of project	Percent of ICT adoption					
	100%	80%	60%	40%	20%	10% and below
Commercial	2	11	1	0	1	0
Residential	3	9	1	1	1	1
Infrastructure	3	11	6	1	2	0
Healthcare	0	4	0	0	0	0
Recreational	0	1	0	0	0	0

In keeping with the Table 5, the most common mode of communication among the project team was messaging apps such as WhatsApp, Telegram, and others, which were used by 65 percent of the respondents. According to [38], mobile devices allow users to perform tasks more effectively with greater precision and fewer management inefficiencies, thus improving connectivity and collaboration.

Table 5 - Preference method of communication among project team

	Frequency	Percent
meet personally	7	17.5
via social media	2	5.0
via messenger application	26	65.0
via email	5	12.5
Total	**40**	**100.0**

Reliability scale analysis is a method to check the validation of the question using Cronbach's alpha numbering. The Cronbach alpha coefficient of a scale should be above .7 (DeVellis 2003). Table 6 shows the reliability scale analysis for the barriers in implementing ICT. Rule of thumb by George & Mallery (2003), where ≥.9 is excellent, ≥.8 is good, ≥.7 is acceptable, ≥.6 is questionable, ≥.5 is poor and ≤.5 is unacceptable. Barriers have a Cronbach's alpha of 0.802 in the table. This indicates that the items were both reliable and valid.

Table 6 - Cronbach's value for barriers impeding ICT applications

Section	Cronbach's alpha	Reliability	No of items
Barriers in implementing ICT	0.802	Good	15

Table 7 depicts the barriers in implementing ICT application in construction project. Resisting reform, high costs, and a lack of a common standard for ICT implementation are the major obstacles that prohibit the respondent or organisation from adopting ICT. The top three obstacles, as measured by the mean, are labeled in the table. However, according to [2], many construction projects suffer from time delays and cost overruns due to productivity issues. This is due to employment of unskilled workers and slow adoption of ICT were found to be the major reasons for such low productivity [2]. As a result, it can be seen ICT in construction is plagued by two terms: sluggish acceptance and resistance to change. The drastic change of the new technology was ranked 15th as the least significant obstacle to ICT adoption in construction. This demonstrates that the dramatic change has little impact on the respondent's decision not to use the ICT application.

Table 7 - Analysis of barriers of implementing ICT applications in managing construction projects

Sub-barriers	Mean	Std. Deviation	Rank
Resist to change	3.80	0.79097	1
Require high cost for ICT adoption	3.80	0.88289	2
Lack of common standard for ICT adoption among firms	3.75	0.89872	3
Security of information	3.675	0.88831	4
ICT infrastructure (low bandwidth, low internet speed)	3.675	0.94428	5
Company's financial issues	3.65	0.94868	6
Cultural matters (i.e. paper-based systems)	3.575	0.9306	7
Lack of skills and knowledge of ICT	3.55	0.74936	8
Varying professional competencies	3.55	0.95943	9
Time constrains in learning total skills of ICT application	3.475	0.84694	10
Lack of incentives and support	3.425	0.87376	11
Regulations (i.e. electronic signature is not acceptable in most of official documents)	3.40	1.0328	12
Lack of interest to use ICT	3.375	0.97895	13
The immature of ICT application for construction industry	3.35	0.94868	14
Drastic changes of the new technology used	3.15	1.21	15

5. Conclusion

ICT has had a major effect on people's everyday lives. Every social, economic, and legal field has seen progressive changes as a result of it. The construction industry is no exception. Resistance to change and high costs are two major factors that lead to the obstacles to ICT implementation in construction project management. Strengthened ICT technology research or education, as well as offering training, tend to be viable options for overcoming ICT obstacles in construction project management. The construction industry's traditional reluctance to embrace innovation is slowly being overcome in this area by the rapid emergence of technology and by the introduction of policies such as the government requirement for fully collaborative 3D BIM.

Design and construction are information-intensive tasks that require a large number of people to work together to create sophisticated, one-of-a-kind developments. While information was previously managed and communicated through paper-based systems and verbal instructions, the integration of the supply chain, the introduction of computer aided design (CAD) and building information modelling (BIM), and the development of mobile computing (MC) means that ICT is becoming an integral part of not only the design office, but also the construction process. There is also increasing potential for automation of construction processes using ICTA, (Information and Communications Technology and Automation), off-site manufacturing, prefabrication and the use of technologies such as 3D printing.

At the moment, 2D/3D CAD is the most widely used design tool. Large contractors, in particular, make extensive use of ICT for administrative purposes. Information transit between participants and across stages of a project is inefficient, resulting in the creation of redundant data. Information is frequently transferred manually. The construction industry is rather slowly adopting ICT technology. Presently, mobile internet is regarded as the most promising technology for the construction business. There is a need for creative approaches to improve ICT in construction project management, which is proving to be true now and for soon projected improvements.

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