A DEVELOPMENT OF A COST CONTROL SYSTEM FOR SMALL AND MEDIUM-SIZED CONTRACTORS

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Abstract

Construction business comprises a number of small and medium-sized contractors which form the major part of the industry. The existing research on the new ICT development is creating more and more sophisticated and complex systems which may not be applicable to the construction industry. With regard to general limitations as design criteria, this research used a collaborative approach to develop a cost control system for small and medium-sized contractors. Five suitable contractors were selected to participate in this research study. The new efficient cost control system can be developed using available ICT tools which are familiar and easy-to-learn. A collaborative approach can ensure the diffusion of technology to these companies.

Keywords: Construction SME, small and medium-sized contractor, cost control, system development, ICT application

Introduction

Construction is a very competitive business mainly by prices. This forces contractors to cut their unnecessary costs in every aspect unless they reduce the quality of the work. To maintain success, contractors have to continuously improve the efficiency of their business processes. Modern information and communication technology (ICT) holds promising advantages to improve the business processes of the construction industry particularly in the field of management. Many new system developments are being created in relation to research findings and they are getting more sophisticated with the current trend of integrating everything. It is interesting to realize how small and medium-sized companies with their limited resources and some other constraints can obtain benefits from the technology.

The National Statistical Office has conducted a nation-wide survey of IT applications in the construction industry in 2004. The reports (Industrial and Business Statistics Group, 2005) shows that the construction industry in Thailand is very fragmented. It consists of a number of small and medium-sized companies that represent about 92% of the whole industry. 95% of all construction companies have registered capitals of less than 1.5 million US dollars. The reports also show that the small and medium-sized construction companies (or construction SMEs) have developed very few of their own in-house software which is only

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1.7%. This insufficiency is partly a cause of many problems in this industry, such as lack of efficient control systems, project delays, poor quality of work, and high costs. Kaplan (1996) has argued that American Society of Civil Engineers (ASCE) through their publications is neglecting the big picture that the major components of the civil engineering community and their employers are indeed small-business entities. He requested more attention to foster small-business groups and local sections. These construction SMEs are currently using primitive business processes which rely largely on manual, paper-based data, intuition, and experience, but not ICT. The government is concerned about this issue and urges SMEs of many industries to implement new ICT applications as their competitive advantages. Many government initiatives are now encouraging them to improve their business processes and to increase their capabilities through ICT.

This situation is similar to that of many other developing countries. Jaafar *et al.* (2007) have done a survey study to confirm that construction companies regardless of their sizes have been seeing IT as their opportunity for improvement. Goh (2006) concluded from his survey study focusing on people, their IT needs, and ability to manage change. The new system must be compatible with their normal work routines and easy to use because SMEs have limited resources for training and time. Yang *et al.* (2007) found that most field managers prefer to use Excel for recording and processing cost data, notwithstanding the introduction of specialized computer applications for project management. Cumbersome workloads associated with data update in the commercial project management applications make managers hesitant to use. Thus they try to handle not only the cost but also scheduling data using Excel. Acar *et al*. (2004) studied the relationship between an organizational size and the use of ICTs within the SMEs in the building construction sector in Turkey. They concluded that the larger the firm sizes are the more intensive use of ICTs contractors do. This is not a surprising finding because the applications of ICTs come with a large amount of investment and that is a limitation of construction SMEs.

With their limited capitals, most construction SMEs are cost concerned. This paper reports the research project which aims to analyze the existing business processes of construction SMEs and identify priority area of improvement. It also aims to determine the methodology and to develop a new ICT system that can be successfully implemented on construction SMEs' business.

Recent System Developments for Construction SMEs

ICT has already been adopted on the construction industry for a while. Aouad *et al.* (1996) showed that all publications from 1990 to 1994 revealed the applications of IT in construction in 16 different fields. El-Ghandour and Al-Hussein (2004) also conducted a comparable study of publications during 1992 to 2001 and they categorized the applied IT in 9 main different fields. There are many ICT system developments available in the literature and commercial packages. Most of these systems are in the trend of data integration which prefers to combine different functions together. This aims to share information across different disciplines, platforms, and formats. This tends to make these developed systems more and more complex and difficult to comprehend and operate. Despite that, only a few of them were particularly designed for construction SMEs or have considered their limitations on implementation.

Among those available system developments that were created for construction SMEs were investigated and summarized as follows. Love and Irani (2004) confirmed the benefits of ICT to the management practices of construction SMEs. Primary motivations for IT adoption of SMEs were identified as productivity and business processes improvement, cost efficiency, competitive advantage enhancement, service quality, and profitability. Apart from good f unctions of the system, Stewart (2007) showed that companies which provided reliable IT systems that are well-supported and user-

friendly would achieve higher IT-induced performance improvement in their operational, strategic competitiveness and benefit perspectives.

Forcada *et al.* (2007) devised a tool for automatically creating an organizational document structure in order to improve both internal and external document organization and to remedy the inefficiency of document management in SMEs. Perera and Imriyas (2004) have developed an integrated management information system for project cost management using DBMS (MS Access) and time management software (MS Project). Their system is particularly designed for SMEs. Zhiliang *et al.* (2004) have developed a system for the multi-party in construction projects to collaborate on the Web using XML. The information exchanged among the multi-party was identified such as scheduling, cost control, quality assurance, and contract management. Yang *et al*. (2007) have developed a new method to maximize the practicability of progress management of multiple apartment buildings construction projects. They designed a work-packaging model based on the Cost Breakdown Structure which has the lowest level is the cost items shown on the bill of quantity.

Alshawi and Ingirige (2003) have discussed the impacts of the latest advances in technology on project management and the emerging paradigm of performing project management over the Web. Abudayyeh *et al.* (2001) have proposed an approach to implement a cost control system over the Web. Cheung *et al*. (2004) have developed a Web-based construction Project Performance Monitoring System (PPMS) that aimed to assist project managers in exercising construction project control. The project performance measure categories were identified for inclusion in the PPMS: people, cost, time, quality, safety and health, environment, client satisfaction, and communication. Chan and Leung (2004) have also developed a prototype of a metadata-based information system for data exchange among Web-based documents for construction project management using XML technology.

It can be summarized that those system developments designed for construction SMEs were kept simple and addressed on a certain problem area of the existing business process. The developments were based on the existing practices and used low-investment tools such as common office software, compact database management software, XML, and web-based technology. However, none has reported the use of a collaborative approach during the development stage.

Research Framework

This research aims to find a methodology for designing and developing a new IT system for construction SMEs and also successfully implementing it with regard to their limitations identified in the next section. To overcome these limitations a collaborative approach is created and employed. Some partner companies have been recruited for the system development process. The criteria for recruitment were the size and the positive attitude toward the IT benefits. This research has collaborated with five different construction SMEs which are representing various specializations in the industry such as local infrastructures, public buildings, commercial buildings, flats, and residential houses. The key policies for the development are as follows:

1. To enhance involvement of both the managements and the prospective users in designing the system
2. To identify and improve the business process in area of their high priority
3. To develop the system by referring to the existing routine and to be aware of any dramatic changes
4. To develop the system with the existing software that they are using and familiar with so that it will require a minimum cost and learning time

Figure 1 summarizes the research framework. The process starts with involving construction SMEs in this research program. Public announcements and invitations are made to recruit five construction SMEs. The

reason is that these five different companies can generalize the picture of the construction SMEs business and are a reasonable number of cases for this study. The companies who make contact are the ones who are interested in the program. They have to have a certain level of confidence in IT benefits and they should be ready to give support to their commitment.

Then an investigation of business processes of the five construction SMEs was conducted through several meeting sessions with their managements. Their business processes must be well understood before letting them raise problem areas in their processes that is their own priorities. These priorities will ensure that the new system is based on what they really want. The problems of all five partners are later analyzed and generalized to determine suitable solutions. Then both managements and prospective users participate in designing the system and generating system requirements. This ensures that the developed system will suit their abilities. The new system is designed with a consideration of avoiding any radical changes. Instead, it must imitate or follow the existing business processes and rather transform paper-based information system into electronic-based and database system. The system interface is designed by the prospective users to ensure their acceptance and understanding. Also, tentative procedures and functions of the system must be demonstrated before actual use to prepare the users. Finally, the new system is developed with the existing software which is being used and familiar to them.

At the implementation stage, the developed system is delivered to the companies with a demonstration and explanations. Then the companies are still assisted with facilitations and encouragement to help them successfully implement the new system. After launching the system for four months, the system is evaluated with feedback from the managements and the users.

Limitations of Construction SMEs

With regard to limited resources available for adopting IT in their businesses, Chau (1995) found in his study the factors used in the selection of software package in SMEs that SMEs rated the vendor support as the most important factor when selecting package software. This shows that SMEs have inadequate technical personnel. The ease of use / user-

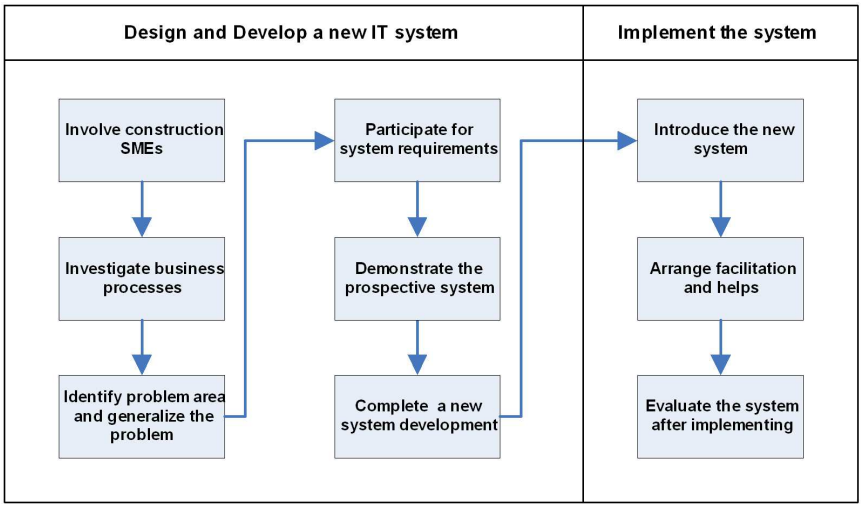

Figure 1. The research framework

friendliness of the software package were viewed as an important factor. Their common software packages are just accounting or word processing-related software. Fink (1998) provided an indication of factors important to SMEs when adopting IT. Internal factors such as IT benefits, organizational culture, in-house IT expertise and resources, IT implementation and selection were judged to be more significant than external factors which were external environment, outside support, external resources. Nitithamyong and Skibniewski (2006) have conducted a survey study to identify the success and failure factors of performance of commercial Web-based project management systems. They concluded that the two most influential groups of factors were the characteristics of the system, such as ease of use, system reliability, output quality, and the project team, such as team attitudes, support from top management, and adequate training. Peansupap and Walker (2006) have provided an organizational level framework of ICT innovation diffusion at the implementation stage of a construction project. They identified four groups of factors that influence ICT use and adoption such as management, individuals, technology, and workplace environment. Challenges are the acceptance of prospective users and the diffusion of new applications.

From the literature reviews and many interview sessions with collaborative construction SMEs, limitations of construction SMEs in implementing the new IT developments are generalized and clearly categorized into two main groups, namely physical and psychological factors. Figure 2 shows the category of generalized limitations of construction SMEs. The first group, which is physical factors, can be considered as resources comprising money and personnel. They are apparent limitations since they usually are the criteria for classifying the size of a company. Construction companies are generally underfinanced. At any point in time there is only limited capital available for investment and IT investment must compete with other demands on capital (Andresen *et al.*, 2000). Although the managements are convinced of the benefits of the new IT developments, they may not be able to afford a highly-priced fully-functioning commercial package. Also they have limited personnel in terms of both availabilities and abilities. With their small number of employees, all personnel are fully occupied with a variety of responsibilities rather than focusing on a specialized work area. They are not able to afford a high-salary job to attract

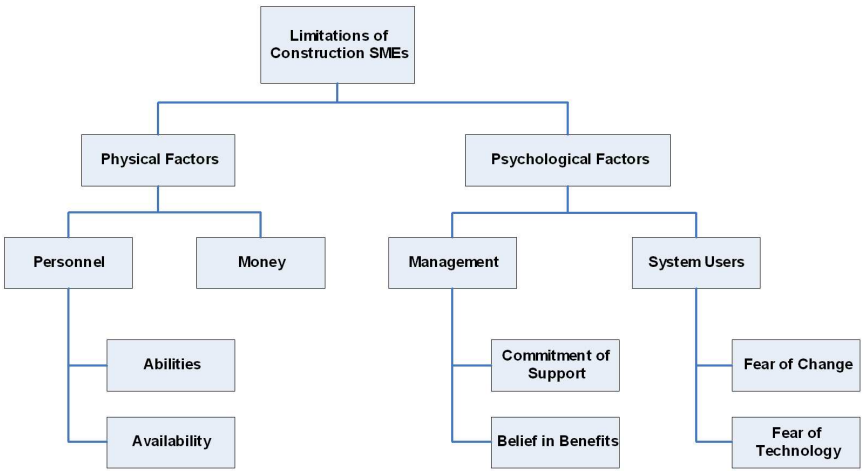

Figure 2. Generalized limitations of construction SMEs in implementing IT system developments

proficient personnel so it is more likely that the personnel they have possess limited abilities. Particularly they cannot operate sophisticated IT systems.

The other group of limitations are psychological factors which are obstacles created by their mindset. They are further separated into two groups of people in the companies, namely management and users. The management is policy and decision makers who are directly responsible for encouraging the implementation of the new IT systems and allocating necessary resources for operating them. The management can have its own levels of commitment of support and levels of values and beliefs in the benefits from the IT systems. In addition, the IT systems affect some parts of the work routine. Users who are at the operating level can have a resistance to this change. Some users fear technology and they think that it is too difficult to learn.

Typical Business Processes

The research has carried out semi-structured interviews with the five partner companies each one at a time. They provided information on the current business processes and also indicated their problem areas together. The analysis found that there was a common way of doing construction business. Figure 3 summarizes typical business processes of construction SMEs in a cross-functional diagram. All of them put themselves as main contractors who are responsible for managing projects such as administrating contracts with clients, financing projects, procuring materials and equipment to construction sites, and monitoring and controlling progress. They are outsourcing all workforces to local subcontractors. That explains why their business sizes are small (using the number of employees as criteria). This can help reduce the risk of fluctuating demands in the construction industry and also their businesses can be set up with a small amount of capital. Their local subcontractors are long-term partners whom they can trust and know proficiency well. They usually work on a few projects at the same time so that they can maintain relationships with many local subcontractors in order to balance their workload. When a new project arises, construction SMEs assign suitable subcontractors who are available at that time for the new project.

Local subcontractors are groups of different skilled workers and general laborers.

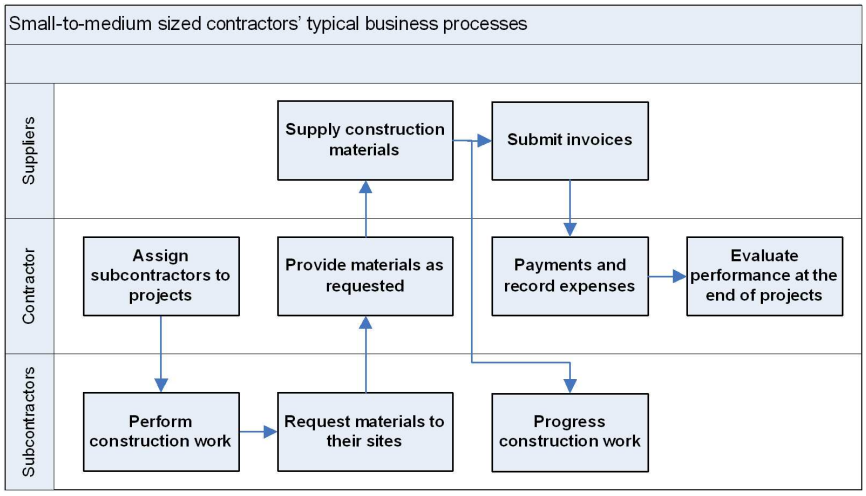

Figure 3. Construction SMEs' typical business processes

They work for wages but they are not running their businesses as a firm. They are doing their jobs while being supplied with all required materials and equipment. Thus they do not invest anything in projects apart from their physical labor. The construction SMEs cover all the expenses incurred and they record all these expenses in an accounting journal.

All of the five construction SMEs pointed out a similar problem area which they were concerning the most on the cost control system. They are currently using a simple paper-based cost control system which is not effective. The cost information comes so late that they cannot use it for controlling purposes. They reported that all expenses would become recognized long after projects had finished. In addition, since they record all expenses in a chronological order but do not categorize the cost account items, they do not know exactly how much profit they earn from a single project. They can only roughly approximate the amount. The irony is that they all have personal computers and office software package available, but they cannot use them to help with their work. Despite their ineffective control of a project, these contractors normally work on more than one project at the same time. This makes their situation worse. Therefore, the potential area for ICT applications is controlling the progress of tasks both in cost and schedules.

System Requirements and Development

The system requirements were gathered during interview sessions with all partner companies. The main requirements of the new cost control system were to monitor the progress of expenses of a construction project and to make a real-time comparison with the bill of quantities (BOQ) in order to determine the variance. The system uses the budgeted cost and the quantity of materials in the BOQ as a control reference. The type of materials that are requisitioned from a subcontractor should conform to the BOQ of that project. Also at any time, the total number of requisitioned materials should not exceed the number stated in the BOQ. The main inputs of the system are the BOQ and material requisition data of construction projects. The system needs to gather material requisition data which have occurred at any construction site to the contractor's office. The data gathering can be done through the Internet. All these inputs are finally stored in the database at the contractor's office. The main outputs of the system are many kinds of reports regarding material usage and cost. These reports will help the managements to discover the source of any cost overrun and allow them to take corrective actions in time.

The system requires database utilities at both construction sites and the contractor's office. These databases are timely synchronized through the exchange of data between the two sides. Figure 4 shows the Entity-Relationship Diagram (ERD) of the structure of the designed database of the system. The structure is organized into groups of data attributes. Two main groups are Bill of Quantity and Material Request. The group of Bill of Quantity has attributes for storing data associated with project BOQs. The group of Material Request has attributes for storing data associated with material requisition transactions. The total number of requisitioned materials can be queried and compared with the allowable quantity in the project BOQ. The other groups are auxiliary groups which contain other supplementary data such as Project, Material, Subcontractor, and Supplier.

After the system requirements are established, the cost control system is developed through the collaborative approach. Microsoft Access is selected as a developing tool for the new system. MS Access provides many advantages in this development. It is a reasonable relational database management system that is packed within the Office Solutions of Microsoft. It is very available and all five company partners are currently using Office software such as MS Excel and MS Word although they have never used MS Access. This means that the new system can be installed in their computers and run without any additional cost. Since most of the users are familiar with

some common user-interfaces and functionalities of this MS Office package, they can understand the new system developed with MS Access fairly rapidly. Also MS Access can be added with Visual Basic for Application (VBA) codes. This will allow any customized automations as required. Furthermore, MS Access provides a separate group of interfaces such as Tables, Queries, Forms, Reports and Modules that are necessary for this development. As a database management system, MS Access maintains the integrity of data and also provides security for those data. With these advantages, MS Access can overcome the identified limitations of construction SMEs.

The transfer of data between construction sites and the contractor's office is done via the Internet and XML formatted files. The reason for the selection of the XML format is that it is a compact format. The data contained in an XML format can be of a small size so that it is convenient to transmit through the Internet. Another advantage is that much database management software including MS Access can support XML files. Data on the system database can be directly converted into XML files and read back.

Figure 5 shows the data flow of the developed system through its different functions. The system functions are detailed as follows:

Add and Edit BOQ - the system assists the contractors since the beginning of a new project. It provides a form to fill in a BOQ of the new project. It also allows for editing some items of the BOQ in case of any change-orders. This form should be filled in by the users at the contractor's office.

Add and Edit General Data - supplementary or general data such as descriptions of materials, projects, subcontractors and

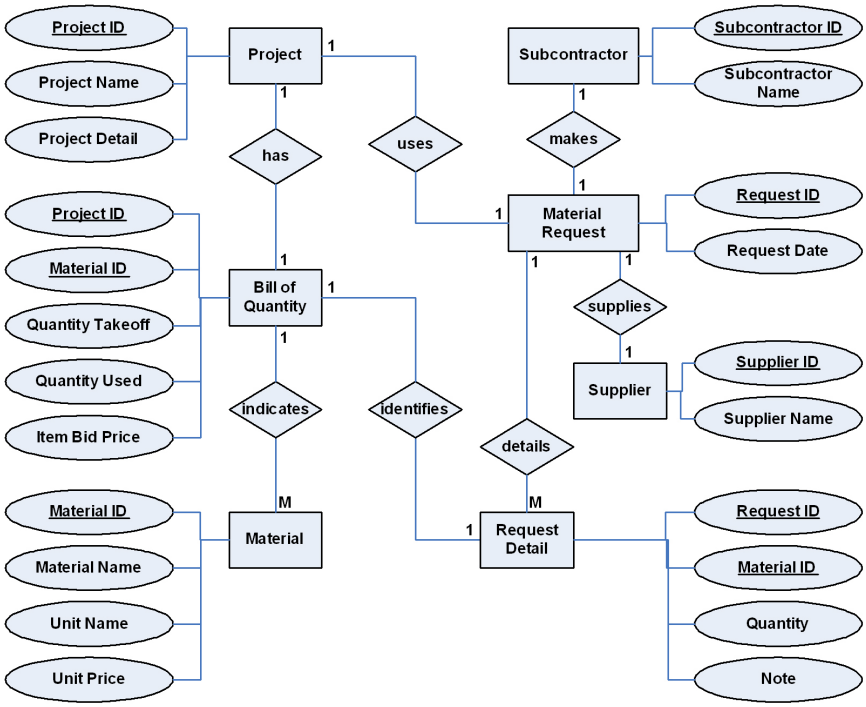

Figure 4. The structure of the database of the developed cost control system

suppliers can be added or edited through this form. These data are to give general descriptions of materials, projects, subcontractors and suppliers.

Material Requisition Form - the main input data of the system comes from the material requisition forms. The material requisition form which is used to be in a paper-based format is transformed into a computer-based format. The layout of this electronic form is imitated from the existing paper-based one so that users can feel confident in inputting all data. The form is filled in by the users (subcontractors) at different construction sites.

Material Usage Reports - are such as Material Usage Daily Report, Material Usage Summary Report and Material Usage by Subcontractors Report. The system provides various reports to monitor the material usage on the different progressing projects. First, the material usage daily report is used for summarizing all materials acquisition on any particular day on any particular project. Each project then sends this information centrally to the contractor's office via XML and the Internet. Second, the material usage summary report calculates quantities of materials that have been taken up to the present date. The calculated quantities are compared with the number stated in the BOQ item by item. The system also notifies the users of the items that exceed the number stated in the BOQ. This function can help alert the managements to the cost overruns of a project which have been a problem for contractors for a long time. Third, the system provides a report of material usage by subcontractors. This report helps indicate which subcontractor has taken those materials. It can also keep records of how each subcontractor uses his acquired materials.

Conclusions

From the statistics, it can be seen that the construction SMEs are the majority of the construction industry. While the main stream of research is being directed toward the integration and increase in the size and complexity of the ICT system developments, these developments are very difficult to implement particularly on construction SMEs. Construction SMEs have many limitations of both physical and psychological factors such as human resources, capital and management support. Therefore, a suitable ICT system development must require low investment, be easy to use and maintain, convince the management of its benefits, and target on their highest priority problems. This research used a collaborative approach in the system development and implementation processes. This aims to increase the acceptance of the users of the new system and the managements of the companies. Five partner construction SMEs were selected to participate in the research program. All partners were concerned about costs and needed a cost control system. MS Access and XML were selected as ICT tools

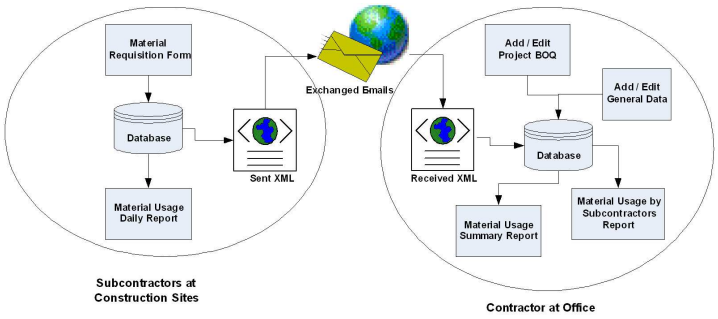

Figure 5. The developed cost control system for construction SMEs

for this development. The functions of the developed system were adapted from their existing business process and their document forms to ensure that users are familiar with. Although it is difficult to change paper-based work routines to electronic-based, the persistence of helps and encouragements and the use of the forms familiarity can ease the learning process of users. The developed cost control system can successfully be implemented on the five partner companies. The system helps gather actual cost data from different construction sites and centralize them to the database at the contractor's office. With this system the contractor can keep monitoring the progress of costs on their different sites and make a real-time comparison with the controlling cost on the BOQ. It is anticipated that this cost control system with the collaborative approach can also improve the efficiency of the business process of other construction SMEs.

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