ERP implementation in the project-based organizations of the construction industry

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Keywords

Abstract

To achieve a competitive advantage within the project-based environment, businesses must employ the state of the art technologies to survive the competition. Technologies such as enterprise resource planning in conjunction with the knowledge management process can help reduce redundancy, minimize cost, integrate operations, and improve quality.

This report introduces ERP as a solution to the problems identified as weaknesses in project tracking, resource management, and decision-making of project-based organizations in the construction industry. The implementation of an ERP system along with improving the knowledge management infrastructure at these organizations will enable the them to realize many benefits through improving their products, cutting costs, and gaining real time information needed for an effective decision making process.

To support the use of ERP and the improvement of KM infrastructure, two case studies will be presented. The findings of these case studies will be re-used to suggest solutions for the PBO to gain similar outcomes. Three alternatives of ERP systems from SAP, Oracle, and Microsoft will be introduced with their respective merits.In addition to the re-used alternatives, an additional alternative, C-ERP will be recommended. The merits of this option will be detailed to allow for establishing a direct link to the scope of the construction PBO.

Finally, a four-stage implementation plan for PBO will be introduced, in addition to a six-phase implementation plan for the vendor to complete the installation and commissioning of the system.

1. Introduction

To achieve a competitive advantage within the project-based environment, businesses must employ the most advanced technologies to survive the competition. Such technologies help reduce redundancy, minimize cost, integrate operations, and improve quality. The need to integrate organizational processes and exchange knowledge effectively and efficiently between all stakeholders necessitated on most businesses the implementation of enterprise resource planning technology. The successful implementation of ERP systems can develop an effective integrated and shared data system that can link all departmental scopes of the organization. Some of the key benefits of the implementation of ERP systems are reduced working capital, the ability to integrate departmental services, and the availability of real time information about all processes (Xu et al., 2006).

The implementation of an ERP system along with improving the knowledge management infrastructure at any project-based organization will enable the company to realize

an abundance of benefits through improving its products, cutting its costs, and gaining real time information needed for an effective decision making process.

Report Structure

The remaining sections of this report will be structured as follows: Section two will introduce the problems related to knowledge management in PBO, the introduction of the relationship between ERP and KM, and lastly the impact of their integration. Section three will be about the identification of the problems faced by PBO in the construction industry in relation to knowledge management. Section four will introduce alternatives adopted from two international best practices. Section five will provide recommendations based on the proposed alternatives and their suitability to responding the problems faced by the PBO. Finally, the last section will provide a tentative implementation plan where all phases will be detailed, the time frame will be proposed, and the associated costs will be highlighted.

2. Problem identification and analysis
Knowledge management and enterprise resource planning

"ERP implementation is closely related to knowledge management. Although technology by itself is not knowledge management, knowledge management is often facilitated by the human who uses technology" (Li and Zhao, 2006). ERP systems are widely adopted and implemented nowadays since the platform can help enterprises gain a competitive advantage over their rivals and improve their performance (Xu et al., 2006). At the same time there is a high recognition of the vital role knowledge management plays in the success of these enterprises. In general, there are two types of assets in any enterprise, physical and knowledge assets.

ERP systems are concerned with managing the physical assets of the enterprise. Through the concept of integrative management of the extended enterprises, ERP improves the efficiency of productivity and operations of the organization. Whereas Knowledge Management systems are focused on innovation and utilization of knowledge assets of the enterprise, as KM emphasizes the enhancement of the competitive advantage through the exploitation of knowledge assets. Knowledge management is essential to the efficiency of enterprises. Knowledge is embedded in the documents, practices, routines, and processes of the organization. Knowledge management is the process of "acquiring, organizing, and communicating both explicit and tacit knowledge so that users may use the knowledge to be more effective and productive" (Xu et al., 2006). Knowledge management systems are designed to manage the process of collecting, coding, disseminating, integrating, and facilitating knowledge (Ajmal, 2008; Xu et al., 2006). More and more attention is paid to knowledge management related advantages in organizations. Efficiency and effectiveness in managing organizational knowledge leads to superiority in product quality and operational excellence.

ERP is a system for the integration of business concepts. The driving force for the implementation of ERP is the need for the integration of processes across the supply chain, in addition to reducing operating costs, and improving the overall performance of the organization (Xu et al., 2006).

The successful implementation of ERP system can produce a superior integrated shared data system that can link all departmental scope of the organization such as human resources, customer relations, suppliers' relations, financial management, development management. The savings in the working capital, the ability to manage the extended departmental services, and the availability of real time information about all processes, are some of the potential advantages ERP systems bring about to the enterprise (Xu et al., 2006).

ERP and KM systems are two distinct systems that are focused on different characteristics, however the primary goal of either system is to enhance the performance of the organization and to improve its core competence. Both systems must be implemented simultaneously in the framework intended for the integration of enterprise information systems.

Impact of ERP on KM

In addition to the benefits ERP systems bring about to the organizations through reducing working capital, providing real-time information for informed decision-making, and the management of the extended enterprises, it also enhances the performance of knowledge management systems. ERP can provide a large body of real-time information that can be utilized as knowledge after due processing and integration. Therefore, ERP becomes a vital tool for the capture, explore, and transfer of knowledge. ERP can also enhance the organizational learning by facilitating the innovation through using analytical methods rather than being confined to the analysis of the per-defined operating systems. In addition, ERP implementation will allow the organization to explore more knowledge about its business and related processes, which will make relevant knowledge available for capturing and sharing.

"a balanced perspective of ERP and KM systems can assist in exploiting explicit knowledge as well as exploring and sharing tacit knowledge simultaneously. In other words, utilizing the respective strength of the enterprise system and KM in tandem enables the alignment" (Zakari and Ahmad, 2012).

3. Major problems
3.1 Project tracking

In the traditional approach, the project manager may require a long time before recognizing that there was a problem that needed immediate intervention, and might be the last one to know that losses are being incurred since financial reconciliation normally takes considerable time to be reported. Resource management can highlight new and unique information from the projects that can be captured and shared by the knowledge management system, which will further boost the competitive advantage of the company.

3.2 Resource management

Real time function of the integration of knowledge management and resource management platforms across all departments is essential for the efficiency and effectiveness of executing all duties until the completion of the project. For instance, cost valuation reports for payments of various segments of developing a project impacts heavily the resources available for the completion of all projects. Some projects incur cost overruns, while others get stalled by certain regulation, and in some cases the investor's request to freeze a particular project. While the human resources are working regardless of eventualities and cannot be terminated until the project is ultimately terminated, there must be real time information to shuffle them around, and to check the finances of each project to better manage the resources available.

3.3 Decision making

Getting all of the departments working together and making them share knowledge on a unified, yet practical and effective platform is desirable and can solve, to a certain extent, most of the problems that are currently taken for granted as an inherent trade off for benefiting from the real-estate development industry. By merging the functions of resource management and knowledge management of all departments in a unified platform, it becomes more likely to

exchange up-to-date information and obtain a vivid and precise snapshot of the financial and operational soundness of any project in real time. This will allow the management of the PBO to make measured actions to rectify the financial and operational measures of the projects during the daily operations rather than overhauls when it is too late.

4. Identification and evaluation of alternate solutions
4.1 Re-using best practices

Two case studies, where ERP systems were used, will be introduced in this section. The findings of these studies will be shared to establish an action plan for the PBO in the construction industry. "Sharing research results is an established academic practice, whether through publication or through more informal means with colleagues and collaborators" (UOB, 2012). The emphasis will be on re-using the findings of these two studies and implementing the same strategy, which is the implementation of ERP system, to obtain similar outcomes in solving the problems mentioned earlier, which will save time and cost. "Reuse is the idea of leveraging previously developed capabilities into a new project for the purposes of improving project characteristics, i.e. cost, schedule, risk" (Fortune and Valerdi, 2010).In both cases, the reasons for pursuing ERP systems were almost identical. Progress tracking of projects in multi-project context, and resources management are the primary factors necessitating such transition.

4.2 First case study from Latvia

AndrejsTambovcevs (2012), Faculty of Computer Science and Information Technology, Riga Technical University, conducted a case study of ERP implementation in a large Latvian construction material procurements and purchasing company. The intention of the research was to introduce how ERP systems could be implemented and how its implementation enhanced the performance of the studied company.

The study focused on company X, which is a subsidiary of multi- billion Euros conglomerate company M. Company X is a construction company that was established in 1995 and had around 115 employees. The company was among the top construction firms in Latvia according to its annual revenue. The company specialized in large-scale housing, hi-tech structures, infrastructures, and mass transit projects in Latvia and abroad. The problem originated from the everyday scope of the company, trying to control project progress and managing the resources in multi-project context.

The processes at company X can be grouped into three categories; architectural design, prefabrication, and construction site activities. Among other activities, designers develop architectural design blueprints for construction based on input from customers, where the support of CAD tools is fully utilized. This element of building production is integrated with other processes such as purchasing, sales, and logistics through the enterprise management system that is composed of several programs. Company X had retained different information systems to carry out its business processes such as accounting, design, fabrication, marketing, etc. These systems had its own functions of collecting and storing information and lacked functional integration, leading to difficulty for company X to realize its competitive edge and full potential.

The need for accurate and real-time information encouraged the managers of the company to consider the implementation of ERP systems to enhance the competitive edge of the company. To handle the full process of ERP implementation, a central ERP team was formed comprising four departmental representatives from Company X, two IT consultants from parent Company

M, and three independent external consultants.The benefits of ERP after implementation in Company X as introduced by Tambovcevs (2012) were as follows:

- "Enhanced company operation through streamlining, improving and controlling business processes of major importance such as procurement, customer offers, customer complaints, equipment maintenance, marketing campaigns and others.
- Significant cost-reductions and timesavings in all business processes.
- Ability to manage service related personnel and related costs through the use of the resource management module of the system.
- Upgraded use of the company's already operating quality management system, which was not supported by an information system.
- Flexible and efficient production planning by implementing the manufacturing management (scheduling) module of the system.
- Facilitated communication and data transfer of critical information for the whole enterprise.
- The company exploited the abilities to control sales and promotion activities through the system, received quantitative data about the results of each promotion technique and managed to increase sales department efficiency."

4.3 Second case study from Egypt

The intention of this study was to determine the contributing factors to the successful implementation of ERP and subsequent business performance using a qualitative approach.
Ahmed Elragal and Ayman Al-Serafi, (2011) from German University in Cairo, conducted a case study on an Egyptian SME branch of a multinational organization. The multinational company is located in Europe and is specializing in chemical products. The company, which was referred to as "Chemco", operates over five continents and has more than 100 branches worldwide. The annual revenues of Chemco reached $6.5 billion in 2009. The Egyptian branch of Chemco was established in 1997 with 150 employees.

The IT system at Chemco Egypt before the implementation of ERP consisted of legacy systems based on IBM AS400. Chemco is using SAP-ERP system globally, whereas Chemco Egypt is using Oracle JD Edwards World system that is more appropriate to the SME nature and more compatible to the existing infrastructure. The implementation team consisted of a project management board from the company, external consultants, and employees. The researchers' results in the case of Chemco Egypt have indicated the implementation of ERP has helped the company improve its performance and that many benefits have been achieved. These benefits according to Elragal and Al-Serafi (2011) include the following:

- "ERP is very important and the ERP system in general has a great effect on business performance.
- ERP helps saving a lot of time doing tasks and jobs by eliminating the number of tasks needed to finish the business processes.
- The ERP has helped the manager reduce routine on the job.
- The ERP system was very successful in providing more knowledge to the financial manager about business processes.
- ERP has shortened the time needed to deliver products to the customer.
- ERP has a great effect on the capability of the company to produce or provide more products and services.

- ERP has reduced the amount of inventory, improved greatly the capability to respond to customers.
- ERP has reduced the number of errors in shipping and sales returns.
- ERP has a great effect in improving communication with customers and integration with partners.
- ERP system has increased customer satisfaction."

4.4 Available platforms

The leading providers of ERP systems, ranked in order, are SAP, Oracle, and Microsoft. Their packages are designed to cater for the requirements of the target organizations and its legacy platforms. These three systems are almost identical in generic scope such as accounting, HR, CRM, SCM, finance. However, there are some unique functions and features of these systems that will be detailed below:

4.4.1 SAP ERP R/3

It is a client server based utilizing a three-layer model, presentation, application, and database layers. SAP is structured using an advanced business application program, ABAP, which is its own proprietary language. ABAP uses Open SQL to interact with the database system. Through the financial function of SAP, decision makers can get a deeper insight throughout the enterprise and gain control of finances as the system ensures compliance and allows for predictability of financial performance. SAP provides comprehensive integrated human capital management (HCM) through the optimization with human resources processes. This solution is provided for organizations of all sizes and industries. SAP HCM maximizes the potential of workforce, while supporting in parallel growth and innovation. SAP Operations, is another unique function that allows for the management of the full life cycle for product procurement and associated logistics. This function automates the full process of development leading to reduced costs and enhanced quality as it controls the process in real time. SAP Corporate Services, is another function of SAP ERP that allows the managers to organize their functions by streamlining of administrative processes in the areas of: project portfolio, real estate, quality, assets, etc. The performance function supports the full life cycle performance management. It supports as well "financial analytics, operations analytics, and workforce analytics, as well as consolidated financial and statutory reporting; planning, budgeting, and forecasting, strategy management and scorecards, and risk management" (Piazzoni and Suh, 2008).

4.4.2 Oracle ERP

Oracle is a platform where "at least one application running on it to access and process the data. Data is stored logically in the form of table spaces and physically in the form of data files" (Piazzoni and Suh, 2008). The products of Oracle are divided into various packages to allow the company to track its sales. These packages include enterprise edition, which the full suite and runs on all standards and comes with a large selection of applications. Standard edition is suitable for med-size organizations. Standard edition one is the entry level package and requires a minimum of five users. The most attractive application choices available through Oracle ERP include: Enterprise Performance Management, which supports the decision makers with a range of strategic, operational, and functional processes. Business outsourcing application allows organizations to track the progress of work of their outsourced extended networks. The human capital management of Oracle is a very powerful application. This function is almost

identical to the HCM of SAP as it integrates human capital management (HCM) with human resources processes. And finally, the project management application, which allows for the exchange of project knowledge across the organization, maintains records in real time, and allows communication of information needed to track the progress of ongoing projects (Piazzoni and Suh, 2008).

4.4.3 Microsoft Dynamics ERP

The project management function of Microsoft Dynamics is integrated with accounting applications, which allows project managers to improve performance and the profitability based on the generated real time information. This function as well allows for the projection of budgets, manage resources, track progress and time delays, and the adaptation to variation in conditions. Collaborative workspace, this single web-base function extends the applications, processes, and information to all employees, suppliers, consultants, and partners. In the configuration and development function, Microsoft Dynamics facilitates through this function, the addition and modification of functionality smoothly and without much efforts of programmers of the organization. The business intelligence and reporting function allows the management of budgets, to view trends and relationships across the organization, and provides reports and snapshots of the current situation of projects as well as the organization (Piazzoni and Suh, 2008).

5. Recommendations
5.1 C-ERP

Since the operating context under which project-based organizations in the construction industry operate, and since the activities are being carried out by different parties at different geographical zones, it is imperative to choose the best ERP alternative suiting these circumstances. The three leading providers of ERP systems, SAP, Oracle, and Microsoft, are offering additional modules to respond the project-based and the real time environment needs of development companies. Therefore, in addition to the three alternatives given in the previous section, it is recommend to use the modules offered through the C-ERP platform.

C-ERP system conforms to the development nature of PBOs in the construction industry, and is different from the generic ERP. Among other characteristics, C-ERP is project based, accessible from remote locations such as the site and global offices, and project life cycle oriented (Tatari and Skibniewski, 2008).

The expected benefits from the implementation of C-ERP can be as follows: "real-time visibility of the finances of projects and enterprise; managing projects on time and within the budget; enhanced decision-making capabilities; strengthened client, supplier, and subcontractor relationships; eliminating data reentry; and increasing management efficiency" (Tatari et al., 2008). As the implementation of ERP became widespread, software applications facilitated the implementation of ERP in diverse applications "such as project planning and management, subcontracting, material tracking, service, finance, and human resources. Currently, SAP, Oracle, and PeopleSoft offer C-ERP solutions" (Tatari et al., 2008).
The functions of C-ERP cover the whole project life cycle. Tatari and Skibniewski (2008) described the main functions of C-ERP below.

5.1.1 Project bidding & marketing

Under this function, C-ERP automates the process of bidding, proposals, marketing programs, customer database, reviews and analysis of competitors.

5.1.2 Project planning

C-ERP provides full automation of scheduling, project budgeting, resource planning. This single software prevents data entry duplication especially during the different stages of the project.
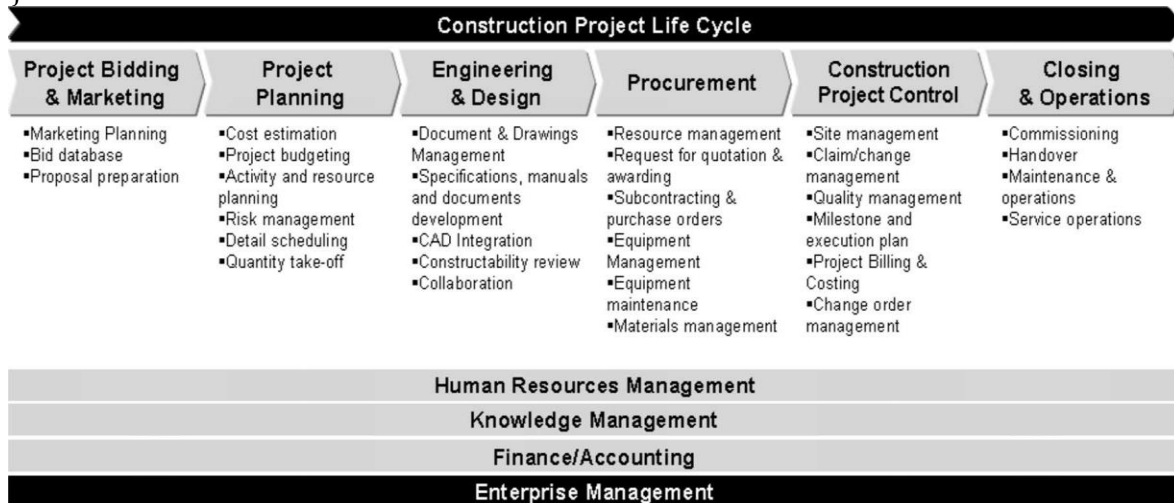

FIG. 1 SCOPE OF C-ERP SYSTEM IN CONSTRUCTION PROJECT LIFE CYCLE (Tatari et al. 2008, p.199)

5.1.3 Engineering and design

C-ERP automates the details of specifications and maintains the drawings in conjunction with its document management systems. It realizes as well the integration of the CAD drawings preventing duplicates of drawings and associated specifications throughout the project life cycle.

5.1.4 Procurement

This procurement function of C-ERP "streamlines procurement of required materials, equipment, and services. It automates the processes of identifying potential suppliers, supplier evaluation, price negotiation, contract management, awarding purchase orders to the supplier, and supplier billing" (Tatari and Skibniewski, 2008).

5.1.5 Construction project control

Main offices and project managers can keep track and better manage the projects and in particular, control cost through this function as it allows for the integration of real time billings and project costs, in addition to managing variation orders.

5.1.6 Human resources management

This function handles all issues related the work force, including the payrolls, attendance, experience, qualifications, performance evaluation, end of service, gratuity, sick leaves, insurances, visa status, contracts, wages protection system, accommodation, and promotions.

5.1.7 Finance/accounting

One of the powerful functions of C-ERP is the finance and accounting function, which streamlines and integrates the "financial operations of both the enterprise and projects, collects financial data from all departments, and generates all financial reports, such as the balance sheet, general ledger, accounts payable, accounts receivable" (Tatari and Skibniewski, 2008).

6. ERP implementation plan

In order for the PBOs to make the necessary decisions regarding the implementation of ERP systems, they must follow a four-stage plan to maximize the success rate and optimize the

benefits of such implementation. This plan will consist of feasibility, request for proposal, evaluation, and finally negotiation stages. For the purpose of managing the four stages, a project team must be appointed representing all departments and to be led by a decision maker.

The project team must invite a single vendor to demonstrate the benefits of ERP implementation so that everyone will become acquainted with the expected functionality improvements to the overall organizational processes, and to the respective departments as well. This will facilitate the production of an RFP that will reflect of the exact requirements as well as the concerns of each department. From the reviewed literature as well as some of the local vendors, a sufficient duration for the implementation of the ERP system is 6 months.

Once RFP's are sent, returned proposals evaluated, negotiations completed, and a vendor is appointed to deliver the system, ample time must be allowed for the inclusion of the specific customizations to the general purpose ERP.

The vendor's implementation program should be as follows:

6.1 Software and hardware

This stage includes the procurement of packaged ERP software, the number of users, the number of modules required, and complexity of integration required (e.g. the integration of AutoCAD), and the procurement of new computers, system software, and upgrade of existing platforms.

6.2 Customization

This is the most important stage that can determine the success of ERP implementation. Time and cost overruns are expected in this stage and it is advisable to be patient and allow modifications and revisions to be done to the original contract with the vendor as necessary.

6.3 Integration

This stage is covers the integration of ERP system with other enterprise applications. This integration includes the integration of various ERP modules, the integration with other e-business applications, and integration with legacy systems.

6.4 Data conversion

In this stage, the conversion of the format of the existing data to be compatible with the requirements of ERP is carried out. This will lead a total knowledge management upgrade that can be implemented in parallel leading to an optimized organizational performance.

6.5 Testing

Testing the full system before launching the new process across all departments. This testing stage will include performance, regression, component, unit, and user acceptance.

6.6 Training

Training workers the workflow and interface in ERP are always tougher than any other business software. It is a costly stage, as workers need to learn new processes of doing their normal jobs in addition to getting their grips on handling the new platform.

6.7 The cost

There are three factors involved in determining the cost of ERP ownership, the price of software, the cost of external services, and the internal costs. "The depth and breadth of functionality deployed, along with the cost of software, services, and on-going maintenance combine to provide a price performance of ERP" (Piazzoni and Suh, 2008).

Tambovcevs (2012) indicated in his research that ERP systems are among the most expensive software in the market today. He has cited various surveys conducted on estimating the average cost of this software, particularly the most recent one conducted by the Aberdeen Group of 1,680 manufacturing companies. In this study it was found that there was a correlation

between the size of the company and the cost of ERP. Tambovcevs (2012) reported according to the survey that:

"a company with less than $50 million in revenue should expect to pay an average of $384,295 in total ERP costs, according to the survey results. A mid-market company with $50 million to $100 million in revenues can expect to pay (on average) just over a $1 million in total costs; a much bigger mid-market company, with $500 million to $1 billion in revenues, should expect to pay just over $3 million in total costs. And those companies with more than $1 billion in revenues can expect to pay, on average, nearly $6 million in total ERP costs."

Company Size	Av. # of Users	Average Software	Average Service	Average 3 years Maintenance	Average total cost
Under $50M	38	$176,597	$126,022	$81,676	$384,295
$50M - $100M	92	$482,941	$351,374	$247,554	$1,081,869
$100M - $250M	195	$695,395	$581,090	$443,066	$1,719,551
$250M - $500M	344	$985,714	$655,263	$346,639	$1,987,616
$500M - $1B	475	$1,364,286	$1,110,000	$617,735	$3,092,021
$1B - $5B	2187	$2,360,577	$2,081,000	$1,479,208	$5,920,785
Over $5B	3365	$2,652,500	$2,102,778	$1,163,531	$5,918,809

Table 1: Average software and services costs by company size (Piazzoni and Suh 2008, p. 10)

Tambovcevs (2012) concluded that ERP systems are expensive no matter what size or kind of companies are using it. These cost figures reported by Tambovcevs (2012) seem to concur with figures provided in the comparison study conducted by Piazzoni and Suh (2008) in 2008 as illustrated in the Table 1. This study utilized the information from the same Aberdeen Group's study of 2007 that Tambovcevs (2012) used. The table shows more details as the figures are broken down into average software cost, average service cost, and three-year maintenance cost.

ERP Vendor	Average # of Modules Used	Average % of Funct. Used	Average # of Users	Software + Service + 3 YrsMaint.
SAP	12.4	69.1%	834	$702
Oracle	11.3	72.4%	1365	$513
Microsoft Dynamics	10.6	73.2%	116	$607

Table 2: ERP usage and costs per user per percentage of functionality used (Piazzoni and Suh 2008, p. 11)

Table 2 shows a comparison between the three vendors, SAP, Oracle, and Microsoft Dynamics in the average modules used, average functionality used, average number of users, and the software, three-year maintenance, and service sum per user.

Conclusion

Project-based companies are facing difficulties in coping with competition in a very competitiveenvironment. In such circumstances, technology, such as enterprise resource planning systems, can play an important role in making these companies achieve a competitive advantage and survive the challenges hindering the project-based organizations in the construction industry from realizing their potential.

These challenges were highlighted, which were project tracking, resource management, and decision-making problems. The relationship between these problems and the lack of implementation of knowledge management and ERP was established.

To find solutions for the PBOs problems in the construction industry, two case studies of similar circumstances were introduced, and their findings regarding how they solved such issues were highlighted and suggested to be re-used in the PBOs. ERP systems were proposed to gain competitive advantage and subsequently, three options of ERP systems from SAP, Oracle, and Microsoft were introduced with their respective merits.

In addition to the re-used alternatives, an additional alternative, C-ERP was introduced. The characteristics of this option were detailed to allow for establishing a direct link to the scope and context of PBOs in the construction industry.

Finally, a four-stage implementation plan was introduced to handle the process until the successful utilization of the system. This plan consists of feasibility, request for proposal, evaluation, and finally negotiation stages. Finally, a six-phase implementation plan for the vendor to complete the installation and commissioning of the system was suggested.

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