Research on a framework for a BIM-based construction engineering and project management education platform

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ABSTRACT: Knowledge of construction engineering and project management (CEPM) theory is important for participants on a project. College graduates often have difficulties in using the methods and knowledge learned in the classroom to deal with the complexity and uncertainty of real projects. Building information modelling (BIM) is an innovative idea and benchmarking technology used in the construction industry. In this article, a framework for a BIM-based integrated education platform (BIMIEP) is proposed. This would allow the seamless exchange of knowledge about CEPM education among the tools of information and communications technology (ICT). Equally important are the value-added features, including a user-interface for industry practitioners to benchmark their projects, and also for researchers to use data to conduct capital project delivery research. Further, the user-interface supports educators with project models and knowledge to enrich their courses.

INTRODUCTION

There is a consensus in academia that it is difficult to teach construction engineering and project management (CEPM) in a way that is practical and relevant to real projects [1]. The CEPM theory is important in undertaking a project. While mistakes in the classroom result in lower marks, mistakes in the field can affect morale, waste resources and, in the worst case scenario, cost someone their life. Academics agree that practical knowledge about construction management tools and methods is difficult to learn. This is mainly because it is hard to gain an explicit understanding about how to apply formal methods and tools in practice given there are unique situations encountered on most construction projects.

The use of most formal tools and methods requires project managers to have an in-depth understanding of project-specific information. Current CEPM education does not produce enough professionals who can handle complex, real-world problems and is criticised as being ineffective [2][3]. The problem is that conventional CEPM education provides well-structured programmes and learning activities that do not reflect real-world projects. As a result, college graduates often have difficulty in using the methods and knowledge learned in the classroom to deal with the complexity and uncertainty of real projects [4].

Building information modelling (BIM) is representative of the latest development of construction ICT (information and communications technology) and is viewed as a key tool in enhancing sustainability and productivity [5]. Currently, BIM applications in the industry are still far from producing the promised benefits. Ideally, its use should be integrated across the whole project lifecycle and organisation but this is not usually the case. The rapid development and adoption of ICT provides a possible solution to overcome these constraints. Educational researchers have long established that computer technologies are an important component in supporting project-based learning. The advancement of BIM-based project management tools has the potential to overcome the practical educational problems referred to above and, with further advancement, additional practical educational problems, such as the rate of learning. Based on relevant research and practice, outlined in this article is a framework for a BIM-based integrated education platform (BIMIEP).

An integrated BIMIEP is critically needed to allow interoperability across different ICT tools, among different stakeholders and to allow data sharing across projects and companies. This would allow a sizable database with project models and data to be built to support CEPM education. Firstly, the BIMIEP allows the storage and generation of project-specific information in a structured way. This structured way of working allows students to understand in-depth information about a specific project relatively quickly.

Additionally, the BIMIEP allows the storage of project-related information in a central database. This central storage allows for the automation of many tedious tasks that are required during the execution of a project and the reduction of repetitive tasks that students traditionally had to do manually. The two advantages allow educators to design class

project assignments that simulate project conditions more realistically than before and allow students to make decisions in a simulated real-world project environment, e.g. planning complicated and interrelated work tasks, developing alternatives to address conflicts among project stakeholders, managing supply chains and producing change orders when external changes occur.

ANALYSIS OF RESEARCH ON CEPM EDUCATION

Educators have a long history of using computer technology in CEPM education [6]. There have been many successes with courses using 3D models, e.g. architecture design, quality analysis and construction [7][8]. With the development of 4D technology and its application in actual projects, Peterson et al used BIM software and actual project models to improve students' abilities in dealing with real-world problems [1]. Their experiment was carried out on two campuses and the results were very encouraging. Within the limited study period, the participating students' ability to deal with practical problems improved. Becerik-Gerber et al also found that a simulation teaching tool based on BIM allowed students with no industry experience to learn how to work collaboratively across disciplines and geographic areas [9]. Similarly, a project management teaching tool based on BIM was found to improve students' practical problem-solving abilities in an engineering project management course [10].

Given these studies, it is evident that real project models with comprehensive process information and performance data would enable educators to design enriched simulation courses and provide a better education. Particularly, the process information and performance data from real projects can be used to test the rationality of virtual scenarios and reveal the complex relationship between management and performance. Interactive education provides educators, construction students and the workforce with real world models and data to support simulation courses. Those courses should enhance students' learning experience and provide them with the necessary skills to handle the dynamic challenges in the real world.

KNOWLEDGE-SHARING MECHANISMS

The technical, social, management and legal issues related to knowledge sharing are addressed in this article, which recognises the differences between projects, companies and countries. A knowledge-sharing guide is needed to ensure that the BIMIEP and its applications are robust, reliable, impartial and sustaining for its users. Knowledge-sharing mechanisms cover four areas: technology, management, assurance and operation. The technical mechanism addresses mainly the technology platform, data standard and data transmission protocol. Management addresses the organisational structure and functions, including each participant's obligation, authority, benefit and the relationship among the participants. Assurance is related to data security and confidentiality policy, database management and maintenance, and monitoring. Operation focuses on knowledge sharing, knowledge quality control and knowledge storage.

FRAMEWORK FOR A BIMIEP

The BIMIEP allows the seamless exchange of knowledge among ICT tools used in CEPM education. Equally importantly, it provides value-added features with a user-interface to allow industry practitioners to benchmark their projects, and researchers to use data to conduct research about projects. The user-interface supports educators with project models and enriches their courses. The BIMIEP is broken down into three layers, as shown in Figure 1. More details about the structure are described below.

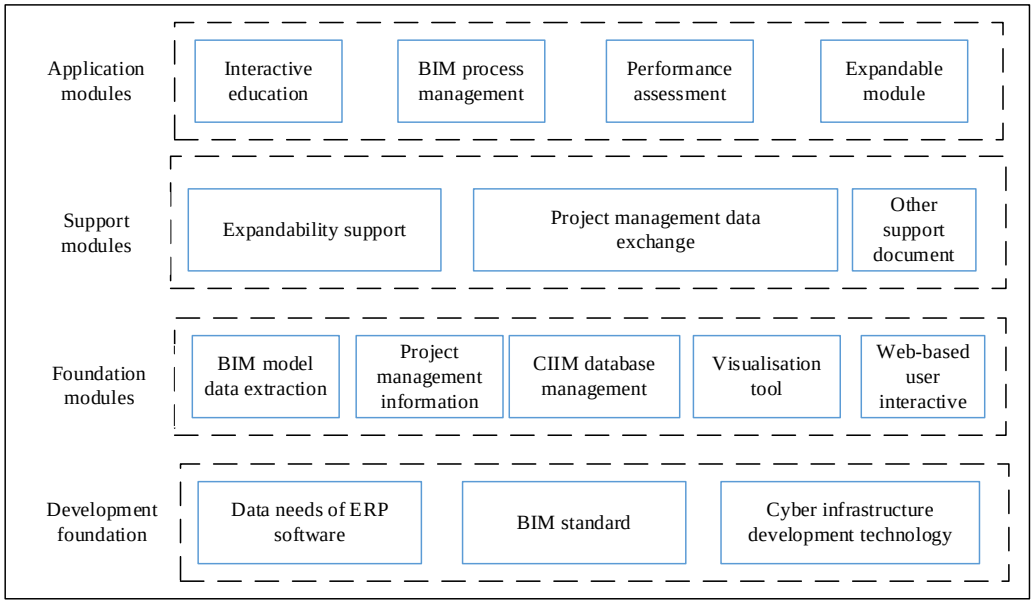

Figure 1: Framework of the BIMIEP.

The foundation layer includes five modules, which perform the following functions: extracting data from BIM, data processing, data storage and transmitting data to other ICT tools, such as enterprise resource planning (ERP). The description of these modules is subject to change since the end users also will be involved in the system design phase.

- BIM data extraction module: this module extracts data from BIM modelling software and, then, builds partial building information modelling (PBIM). This module can extract internal model data and industry foundation classes (IFC) data from two types of mainstream BIM software to support ongoing studies, such as determining the correctness of the IFC data conversion.
- Project management information module: this module calculates and updates the issue for construction quantity of components and their costs, taking account of differences between countries or regions. These data are linked with schedule and other project performance data on the basis of PBIM models to form a capital project information integrated module (CPIM).
- CPIM database access management module: this module provides other application software with CPIM database access and management functions, including version management, security management, permissions management, etc.
- Visualisation module: This module will be built on a high-performance game engine to provide a high performance and engaging visualisation tool for project management users.
- Web-based user interactive module: this is a user-oriented interaction module, and provides functions, such as project creation and management, account management, collaborative work environment management, etc.

Support modules provide application programming interfaces (APIs), data exchange standards and documentation support functions for application modules and their collaborative work environment. Specifically, the supporting modules include the following:

- Expandability support module: on the basis of modules A and E, this module provides the application program interface to improve the existing modules or add new modules in the future. This module allows users to improve or add application modules to fit their specific needs for scientific research, teaching and industry applications, as well as addressing differences between fields or disciplines.
- The project management data exchange specification: a standardised document for project management data specification, which describes in detail the publicly available data and their formats, and is released simultaneously with the other modules.
- Other supporting documentation: includes version upgrade instructions and other documents.

Application modules provide the functionality for specific users. Usability is critical. The involvement of users in the design and test of these modules will assure these modules are user friendly.

- Interactive education module: based on a project model and knowledge data collected by the cyberinfrastructure (Figure 2), this module can organise and generate models and instructions for a specific curriculum, as well as present the model with multidimensional visualisation and support the students' classroom interaction during teaching.

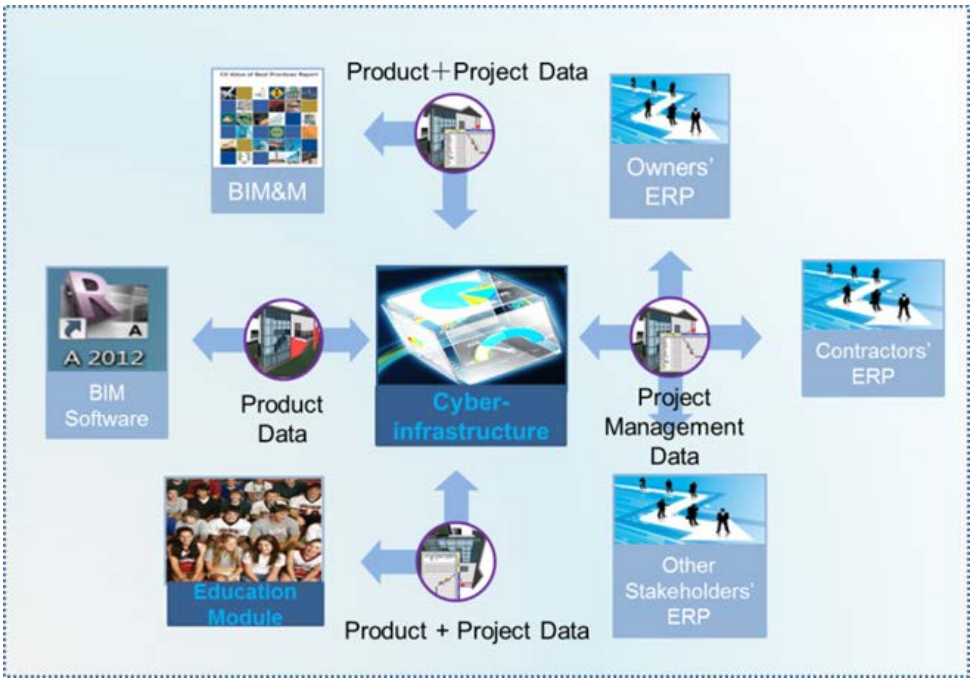

Figure 2: A BIM-based open capital project management information integration cyber-infrastructure.

- BIM process management module: this module is used to manage the BIM implementation planning and implementation process, including BIM application settings, data exchange requirements, project process settings, task designation, project control and other functions.
- Performance assessment module: on the basis of the Construction Industry Institute's (CII) model, this module will use the data extracted from BIM and ERP systems to assess the life-cycle performance of capital projects, including project execution performance (e.g. productivity, cost and schedule). business objectives and design efficiency.
- Expandable module.

CONCLUSION

In this article, it is shown that the introduction of BIM-based project management tools can help educators of project management courses to develop class assignments based on more realistic project settings. This would support students with learning how to apply project management methods to real-world project management problems. The BIMIEP is broken down into three layers: foundation modules, supporting modules and application modules. It allows knowledge to be seamlessly exchanged between ICT tools about CEPM education. It supports educators with project models and knowledge to enrich their courses. Finally, the BIM-based integrated education platform can help CEPM students to formulate an understanding of project lifecycles and will be able to provide a large amount of educational materials based on real-world projects and business situations. Hence, it can function as an education tool that CEPM programmes have long lacked.

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