

Practice and Exploration on Teaching Reform of Engineering Project Management Course in Universities Based on BIM Simulation Technology

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ABSTRACT

With the rapid development of information technology and global popularization of Building Information Modeling (BIM) technology, the original teaching methods of engineering project management can no longer meet the needs of the times. Therefore, it is timely to propose innovative teaching reform programs. This article combines the new construction engineering technology with the Building Information Modeling (BIM) involving the visual simulation method, and introduces them into the teaching programs. The curriculum system design, curriculum content, the method of teaching, and the form of examination, etc., are determined mainly by analyzing the practice and application of BIM technology both at home and abroad, this analysis and practice is done in teaching reform, extensively making curriculum reform research and consulting expert opinions. These are in accordance with the current social reality and graduate employment direction. It explores the teaching reform methods of the course to achieve the purpose of making students understand and learn the course more intuitively and vividly and also to master project management theory and practical skills.

Keywords: engineering project (EP), visual simulation (VS), Building Information Modeling (BIM), teaching reform (TR)

INTRODUCTION

As a course with strong application in subject teaching like building and management, engineering project management means achieving the best effect by managing and adjusting every aspect of the project, including project schedule, cost, quality and other aspects in order to maximize the project benefits (Cheng, 2004; Cong, 2003). With rapid economic development, the Chinese government has shown increasing demand for public projects, leading to project management talent with high quality that is becoming more and more scarce in today's society (Yan & Yuan, 2006). In addition, in recent years, China has vigorously encouraged and promoted the development of the collaborative innovation mechanism. This effort is a great opportunity for practical courses such as engineering project management as it is helpful for its teaching reform. At present, for universities, it will become the reform idea and specific goal on how to use the project case from production, teaching and research collaborative innovation and teaching situation of the resource reform. This approach will make students in engineering management major meet the new demand put forward by new development situation, and then scientifically and reasonably cultivate the professional engineering management talents that could adapt to the requirements of industry and the times. Based on the characteristics and requirements of the course, this paper introduces the methods and ideas of applying the Building Information Modeling (BIM) visual simulation technology to the teaching reform of the Engineering Project Management course from the perspective of production, teaching and research collaborative innovation. The purpose is to make students better understand the

Contribution of this paper to the literature

- From the perspective of production, education and research, this paper introduces the project cases and resources of production, education, research and collaborative innovation to enable undergraduates to meet the new requirements.
- Introduce BIM visual simulation teaching technology to re-design the course of design project management, and make the teaching process more interesting.
- The introduction and improvement of BIM workshops, the use of electronic sandbox to increase students' practical ability.

engineering project management operation methods, and then enrich their professional theoretical knowledge so as to master practical skills in the new era.

LITERATURE REVIEW

Practical Application of BIM Technology in Today's Educational Reform

BIM technology, that is, building information modeling technology, covers geometry, spatial relations, geographic information systems, the nature and quantity of various architectural components (Zhong & Ji, 2015). The Building Information Modeling (BIM) can be used to demonstrate the entire life cycle of the building, including the construction process and the maintenance process (Liu & Zhao, 2015). Due to the characteristics of visualization, coordination, simulation and optimization, BIM technology has brought tremendous changes to the world of the engineering industry due to the use of 3D holographic information technology. Many countries have formulated various policies to promote the development of the technology (He, Tu & Ying, 2011). Therefore, many universities in the world have introduced BIM simulation technology into teaching as an adjunct to setting up relevant engineering practice courses, and to enable students to master the project delivery process and meet the requirements of the construction industry.

For example, Arizona State University in the United States is one of the best universities to run BIM programs. They use a combination of lectures and laboratories, focusing on the combination of theory and practice. The lecturers not only explain, but also invite some professionals to carry out more practical explanations enabling students to fully understand the basic qualities required for engaging in this profession. At the same time, students become aware of the specific internal and external requirements for integration into industry, providing opportunities for interpersonal relationships, corporate internships, and job opportunities (Tang, Hua & Li, 2009).

Texas University School of Engineering Science has been offering students two courses on BIM since 2004. One course is for undergraduates, the other course is for graduate students. These courses define BIM as a 3D-2D model integration process. Students studying in this class need to skillfully use Autodesk Revit, Google Sketch-Up, Google Earth, Autodesk, Navisworks and other related software, and eventually implement a 4D collective build sequence model (Bai & Huang, 2013).

Pennsylvania State University Department of Architecture Engineering is also very effective in using BIM teaching methods. Their advantage lies in grouping all students to implement IPD (Integrated Product Development) operations. This practice enables students to learn from each other, and ultimately deliver the results. This approach will make students understand the importance of teamwork (Zhang & Chen, 2013). An important part of the BIM curriculum is to develop the ability of unite and collaborate. Although an individual with software skills, knowledge and talent can create a unique design, the final delivery of the results still need the entire team's efforts.

In comparison, using BIM simulation technology to carry out teaching reform in Chinese universities is still in the initial stage. The current bottleneck is that there is a lack of professors teaching BIM programs, resulting in the failure of most of China's major universities in construction and construction management to run the course (Xu & Li, 2013). Through the continuous exploration and reform in BIM courses, the best way to solve the problem is to apply BIM visual simulation technology to the actual teaching, and use the advantages of information processing and dynamic simulation to convert the written text in the course into a vivid three-dimensional interactive construction site simulation scene.

According to the continuous exploration and positive reform in the BIM curriculum in colleges and universities, we found that the best way to solve the problem is to actively explore the BIM visual simulation technology applied to the actual teaching. By using the advantages of information processing and dynamic simulation, the written text in the course is converted into a vivid, three-dimensional, interactive scene simulating the construction site. (Xue, 2012; Zhang & Yang, 2012).

The Background of Engineering Project Management Course Teaching Reform

The school in which the author works has made continuous efforts to explore and innovate in the field of engineering management. In class teaching, they have achieved the integration of classroom and practice. In 2002, the “project cost” undergraduate major was founded in China, and the “Project Management” course was set up as the basic course. Its teaching syllabus clearly stipulates that helping students master the basic theory and methods of project management through this course, including project planning, project system analysis, project organization and planning, implementation control, information management, and having the ability to engage in general engineering project management (Tang & Zhou, 2014). After nearly three years of development, the collaborative innovation center has successively undertaken and completed more than seven horizontal topic projects and over 10 vertical topics, accumulating a large number of practical project experiences.

RESEARCH DESIGN

The Implementation Scheme Model Design of BIM Visual Simulation Teaching Method

BIM visual simulation model teaching program with design principles

The principles of teaching reform in this course should adhere to the following principles:

- a. Imitate the working environment and construction conditions of the actual project in order to foster students’ ability to analyse and solve problems, cooperate and adapt in actual work.
- b. Dynamic simulation demonstration of visual engineering contributes to form a systematic, comprehensive and integrated concept of engineering project management.
- c. With simulating their own project participation, students can master the whole process of construction projects and understand the overall system.

Curriculum planning arrangement based on BIM visual simulation teaching method

For BIM simulation technology to be applied to a “project management” course, the course needs to grasp the basic knowledge of the course, for example: BIM’s basic working principle, the basic way it is used and commonly used software. Considering that students already have a certain degree of self-learning ability, the organization of “project management” course should have the following planning arrangements:

- a. For key concepts, technology, principles, theoretical and practical analysis methods of project management and BIM technology, detailed teaching for teachers is necessary.
- b. For the basics knowledge, the operation method and professional skills of project management and BIM technology, a solid foundation for students is essential.
- c. Analysis of comprehensive cases combined with project management and BIM technology, students need to understand the relationship between the relevant factors, grasp the combination of qualitative analysis and quantitative analysis.
- d. As this discipline covers a wide range of knowledge, students inevitably are puzzled by the professional knowledge of the situation in the teaching process, so we suggest introducing BIM technology to assist in teaching, and to achieve better teaching effect by simulating extracurricular practice environment.

In the teaching reform for this course, we carried out some reform and innovation in the form of teaching, and concretely implemented the mode of “combining classroom teaching with teaching + multimedia assisted instruction + curriculum design (visual simulation modeling) + field practice”, as shown in [Figure 1](#) and [Figure 2](#). According to the actual project case, classroom teaching can strengthen the key content of each chapter.

At this stage, the teaching content not only includes the project management, quality, progress and cost management, safety and environmental management, information management, completion and acceptance and post-evaluation, but also includes the basic principles of BIM technology, applications and software commonly used. Some chapters of the textbook adopt new teaching methods of combining BIM simulation, multimedia video recordings or live shootings, such as construction site management, construction material management, construction site health, safety and environment simulation. The multimedia teaching method combined with BIM technology has the characteristics of vivid image, combination of virtuality and reality, so that students can quickly acquire professional knowledge.



Figure 1. Office building simulation

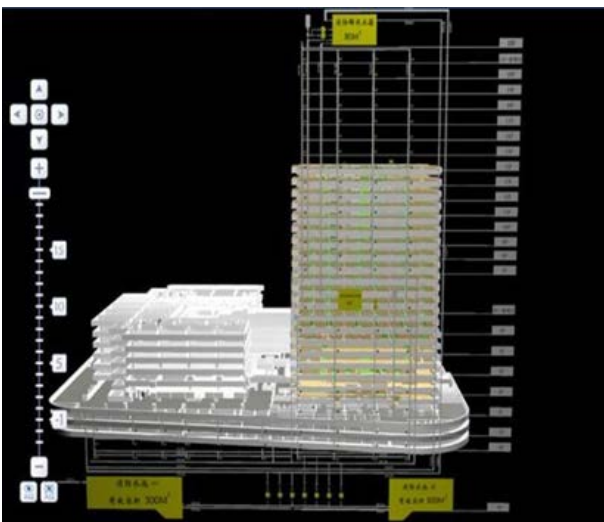


Figure 2. Simulation of the construction phase of the office building

Specific implementation of the program based on the BIM visual simulation teaching method

In addition to 36 class hours of theory knowledge, there were 12 class hours of machine operation and curriculum design. The main contents of curriculum design were: according to the engineering management steps, every 10 people as a group compiled the general situation of the project, selected the construction plan, construction schedule plan, construction plan design and all kinds of economic and technical indicators. They then build a visual simulation model. Through curriculum design, students can get a general understanding of the basic contents, organization design methods and steps of unit engineering construction and organization. At the same time, it was hoped that students realized the importance of team work and culture.

Because of focusing on practical ability, we adopted the model of “5+3+2”. That is to say, the final examination score, the daily practice and curriculum design accounted for 50%, 30% and 20% respectively (Tao & Hou, 2016). The examination questions were changed on the basis of fundamental theory and case analysis, so as to test whether students grasped the knowledge.

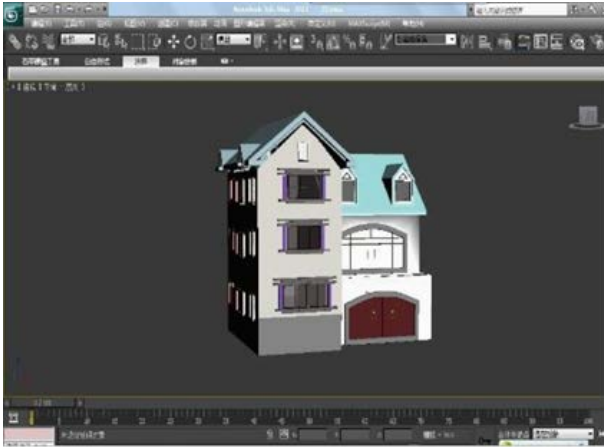


Figure 3. 3D MAX-based building simulation modeling

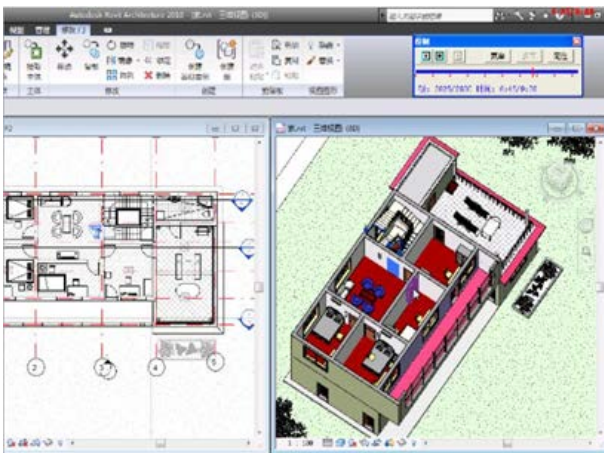


Figure 4. Construction project construction process design

RESULTS

Implementation of BIM Simulation in an Engineering Project Management Course Teaching Reform

Innovative applications of BIM technology in project management curriculum reform

For solving the problem that too much attention was placed on the students' practical knowledge instead of the ability of practice and application, we realized the need to reform the curricula system, focusing on the combination of the basic principles in project management, advanced management methods and the mastering of contemporary computer technology. On the one hand, the teaching content of computer aided engineering management software was added so that students could master the related software in the field of engineering management (such as Autodesk Revit, 3D Max, Project 2003, P3, etc). Through arranging the learning and application of the design work in specific engineering simulation modeling, we could train students to realize the specific process of modeling and designing data from engineering project management to the delivery of specific practical results with three-dimensional graphics software, for laying a solid foundation for engineering management and professionals in the future, as shown in **Figure 3** and **Figure 4**. On the other hand, the teaching of 3D visualization dynamic simulation engineering concerning concrete project management will be added to the curriculum, in which students could simulate different engineering cases with different project management tools (such as bar graphs, network plans, etc.) to solve the virtual sites in the environment. It will deepen the understanding of the theories and methods of engineering project management under the teaching model, as shown in **Figure 5** and **Figure 6**. Practice has proved that students find it more interesting and better accept similar forms of video animation learning. Therefore, the students' enthusiasm for learning is stimulated and the knowledge is changed from passively instilling knowledge to active absorption of knowledge.



Figure 5. Engineering project construction process visualization dynamic simulation teaching

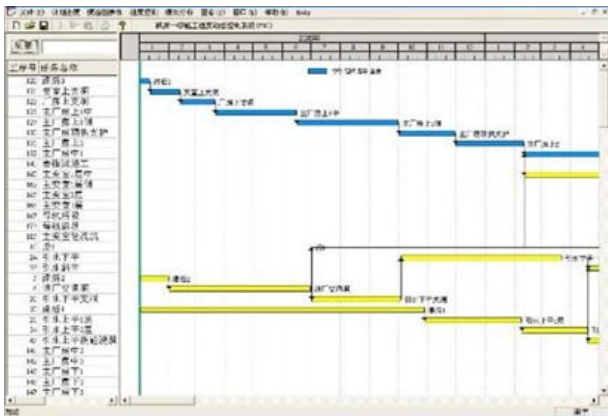


Figure 6. Project construction process management three-dimensional tools to achieve teaching

Teaching reform exploration of innovative introduction and improved BIM workshop

In addition, it could have good teaching results to transplant the BIM virtual visual chemical workshop model in the curriculum of project management. The model is constructed by building the project management BIM virtual simulation workshop and through combining the “soft” with the “hard” for using the BIM virtual technology, which can be more realistic to show the construction process of the project. It could also provide an atmosphere of site construction for students so that they can read the data from the paper drawing through the visual simulation engineering platform, and develop a large number of three-dimensional interactive building information models for them to provide dynamic simulation of the project site functions. The selection of a typical building project, the collection of BIM information, and the establishment of a case library provides a large project feasibility study report, project proposal, construction process demonstration, project operation effect, construction standard and construction specification for students to achieve the teaching effect of seeing.

The role of the project management BIM workshop

- a. More realistic simulation of the project site construction activities can make students observe on-site construction management activities of the real operation process, the details of the operation the text in the book is difficult to use;
- b. Through the virtual reality of the specific construction process, students play the role of practical engineering, organize and manage on the spot, understand the importance of team cooperation, and accumulate the direct experience of teamwork.
- c. The biggest characteristic of the BIM model is the integration and optimization of information in construction management by three-dimensional technology, which has practical significance for saving engineering cost, and can enrich and supplement students’ cognition of engineering economy, engineering valuation, construction organization and other aspects.
- d. The establishment of a BIM workshop in a curriculum provides students with a field-observable teaching model that enables the BIM building information model to provide students with more than just graphics, and can provide a full range of professional presentations.

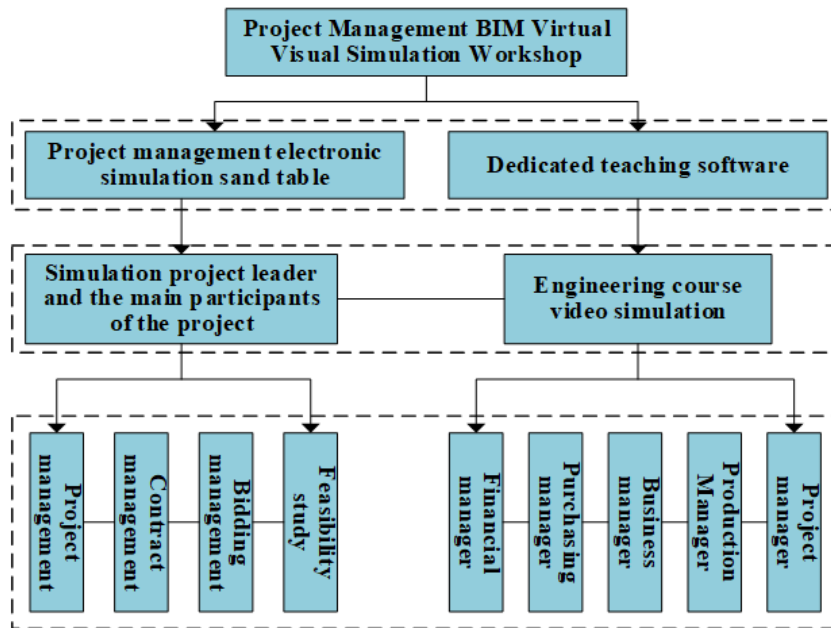


Figure 7. Project Management BIM Virtual Visual Simulation Workshop System Map

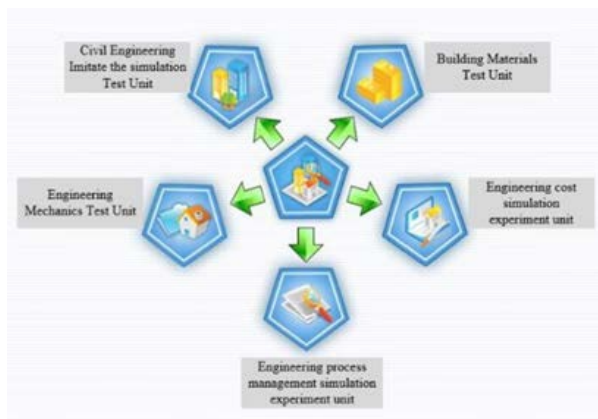


Figure 8. Main function module of teaching software

Project management of the BIM workshop course content

Curricula contents of the engineering project management BIM workshop consists of two parts, as shown in Figure 7. One is to introduce the project management of BIM using electronic simulation sand table. The use of BIM electronic table can help students simulate organizational strategy, project stakeholders project management, communication management, decision-making ability, project operation, etc. At the same time, the students can also optimize the period and cost through the design scheme by using the practice of electronic sand table such as the process of contract budget, construction budget, cost accounting and completion settlement in engineering project management. This way of teaching is helpful for students to understand the work of a project’s life cycle and work flow, and can be conducive to understanding the nature of the material flow, cash flow, workflow and information flow in project management. Students can choose the role of project manager, production manager, business manager, purchasing manager, financial manager, in the organization structure. The various departments of the project team experience division, which has greatly enhanced the project management course of interest and participation, and receives a better learning effect.

The application of BIM technology and actual BIM implementation cases to the engineering project management course is another aspect of the virtual simulation teaching software of engineering project management jointly developed by a professional and a domestic construction software company. The basic module of the software is shown in Figure 8. The software comes with a large screen, as shown in Figure 9, which can solve the engineering output of the video required including the feasibility study, bidding, contract management, project management and other dynamic presentation, especially in the construction process simulation unit. It delivers realistic information to students specifically and intuitively and enhances the students’ practical ability to work.



Figure 9. Teaching practice big screen

DISCUSSION AND CONCLUSIONS

From the perspective of production, education, research collaborative innovation, based on BIM simulation technology, this paper explores formation, purpose and principles of the project management curriculum reform. Compared with the existing domestic and foreign research results, this study not only reforms the curriculum, but also pays more attention to relying on the actual project, and develops virtual simulation teaching software so that the students can combine theory with the practice and come to the conclusion that all they have learned can be flexibly used.

Analyzing the current situation, improving the teaching quality of the “Project Management” course, and ensuring students acquire more project management knowledge in a limited time are important contents in the teaching reform of this course. It is an important content for teaching reform of this course to improve the teaching quality of the “Engineering Project Management” course and to ensure that students acquire more project management knowledge in a limited time. Therefore, this paper argues that in the future the specific goals and direction of the “Project Management Project” curriculum should follow the following points:

- a. Establish excellent courses that fit industry executive ability, and introduce excellent teaching materials in similar professional core courses at an international level.
- b. Actively use modern teaching methods connected with current development, and make full use of multimedia, video, BIM visual simulation and other modern teaching methods to carry out teaching activities, so as to increase information for teaching;
- c. Keep up with the times in teaching, using advantages of production, education, research collaborative innovation centers, and combine the latest industry trends with the professional knowledge that students have learned, and use BIM technical means to assist teaching.
- d. Paying attention to the combination of theory and practice, and strive to cultivate a group of professionals with both professional knowledge and practical ability.

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