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## Innovation on the graduation design based on BIM

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### ABSTRACT

As the final stage of undergraduate course for students in Construction Management, the graduation design is to verify the students' professional knowledge and ability to solve real problem in practice. But currently, there are many problems in the stage of graduation design, including selecting improper topics, incompletely appraisal mechanism, low efficiency and etc. This paper intended to introduce BIM technology to establish an innovation implementing process and make the graduation design more efficient and beneficial. The innovation model leads the graduation design to be visualized, integrated, cooperative. Based on the comparative study, this paper gives an improved performance in cost and time.

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### KEYWORDS

BIM;  
Construction management;  
Graduation design;  
Innovation model.

### INTRODUCTION

Graduation design is the final stage in the undergraduate education, and it is an important stage for students to combine theory with practice and to improve the ability of preliminary research. It trains the undergraduates with the basic knowledge of Management, Economics, Law and Civil engineering in Construction management. Thus it needs test students the following qualities in graduation design:

Currently, the mostly adopted graduation design topic in China is to make bidding documents for projects. This is because the commercial bid (contract terms), economic bid (price), technical standard (construction organization design) in the tender documents could test the above qualities. Through a survey of 394(378 effective questionnaires) graduate students majored in construction management during the 2011-2013,

66.66% students take jobs in project management or cost management, and 23.81% students choose to take up advanced studies. However, it is found that the graduation design help a little to their practice work and research in the survey, with 30.95% students unsatisfied. So it is necessary for the current graduation design patterns to be improved and innovated.

Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. The BIM technology is changing the work pattern of traditional construction management. Through adopting BIM, project managers are being provided with continuous, real-time, reliable, integrated and consistent information to achieve the goals of shortening construction schedule, decreasing cost, improving efficiency and quality. Thus adding BIM technology into the undergraduate course for construction management students is very necessary. In this paper, an experiment is being carried

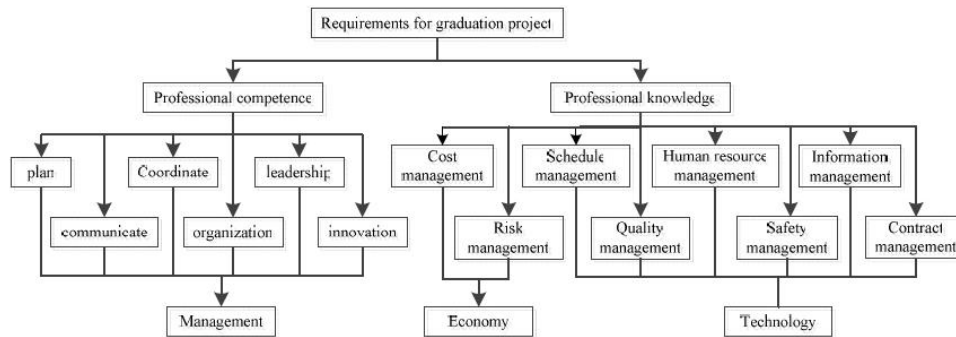


Figure 1 : Requirements for graduation project

out to practice using BIM in construction management graduation design, and put forward the related evaluation to compare efficiency and effectiveness with the traditional design under this thinking.

**RELATED WORK**

Nowadays, graduation design of the construction management exist some problems in some aspects such as selecting topic, the process of implementation and the evaluation method in China. Teachers often provide two options which are the graduation design and graduation paper<sup>[1]</sup>. However, Students want to do the design can not only help them learn advanced research, basic theory, but also can take best practice<sup>[2]</sup>. But for the current topics of graduation design, students cannot understand engineering theory and practice very well<sup>[3]</sup>. Meanwhile, interaction and information sharing between teachers and students is poor in the process of graduation design<sup>[4]</sup>; Using the achievement of graduate students excessively result in a little harvest<sup>[5]</sup>; There is no execution of standardized, systematic, scientific and management mechanism in process management<sup>[6]</sup>; Lack thoughts of lean construction, knowledge management, virtual construction in the process of the graduation design; Failed to use related professional software to solve the problem<sup>[7]</sup>; Submitting form and defense process of graduation design should be structured<sup>[6]</sup>.

The idea of integrating BIM into the field of education is being proposed with the BIM technology widely application in engineering practice. In sustainable building design, Wu Wei<sup>[8]</sup> put forward the teaching mode of BIM-for-LEED, using the BIM to express the key factors of the design to get LEED certification. Meanwhile, it puts forward architectural undergraduate course training plan in a thinking of integrated design

based on BIM platform<sup>[9]</sup>. Combining the simulation of construction management sand table and BIM students can act as the different stakeholders and establish a real-time and dynamic 5d (3d entity, time, WBS) database. It also improves the efficiency capacity of cost data<sup>[10]</sup>. Cal state use the BIM and the last planner system to simulate 4d schedule for a green building which has the LEED certification to make students understand the construction more visually<sup>[11]</sup>. In order to make students understand how to integrate project information, optimize the schedule and control the change management in different stages, Stanford university apply real case on BIM<sup>[12]</sup>. In the research of BIM application in the teaching for

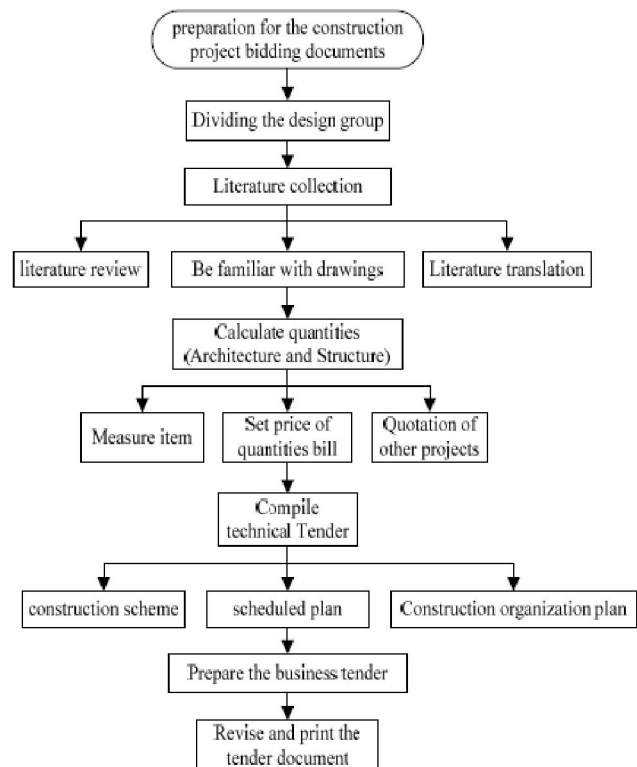


Figure 2 : Process of graduate design in the traditional way

TABLE 1 : Problems in traditional graduation design

Document	Activity	Time	Theoretical (professional knowledge)	Practicalness (Operability)
Economical Tender	Be familiar with drawings	About 10%	high error rate of design drawing leads to a result of inaccurate quality and increasing rework	Have difficulty to image turning 2D drawings into 3D drawings
	Quantity take-off	About 55%	Spend a lot of time on repetitive calculating	Spend much time on using of calculating rules repetitively
	Prepare the BOQ	About 10%	Have no intuitive cognition on unit project characteristics in set-price	Have no intuitive understanding of main engineering content in set-price
Technical standard	Project overview	About 5%	failed to understand the characteristics of the difference between projects	information involved in the early stage of the project can't reflect intuitively
	Construction scheme		There is plagiarism in construction method and technology,lacking of theoretical quality control	construction technology and method can't be reflected intuitively
	Scheduled plan	About 10%	Understand the process and draw construction schedule network diagram from the literal level	Failed to realize the virtual construction, get an intuitive feeling of project
	Construction plane layout	About 5%	The configuration of Cranes and mechanical equipment, the calculation of yard,water and electricity pipelines are divorced from practice	Failed to establish a close and intuitive connection between construction and field in order to study and arrange
Commercial Tender	The preparation of contract text	About 5%	A low correlation of contract text and technology and economic result in a high plagiarism rates	less connections between information of contract text and each stage

students' team cooperation, Cal poly joint three universities obtain the importance of mentor guidance and establish work flow in collaborative<sup>[13]</sup>,besides Tamera<sup>[14]</sup> put forward the work flow of multi-specialty team in BIM and dynamic mechanism of team management in the teaching. Through the use of BIM teaching unit and students' experience, CSU get the conclusion that the workload of students and teachers can be greatly reduced by using BIM, meanwhile students' spatial cognition and critical thought will be promoted by visualization and interaction of BIM<sup>[15]</sup>. After an survey from universities in the USA, Farid found that the main resistance of teaching with BIM includes: to change the existing undergraduate develop system, to increase facilities to support it<sup>[16]</sup>.

Much research proved that BIM have vast practical and theoretical value if BIM integrate into the edu-

cation, however resistance is also exist.

### PROBLEMS EXISTING IN THE TRADITIONAL MODEL OF GRADUATION DESIGN

It always takes 14 weeks to complete the traditional construction management graduation design for students in Chongqing University, and the survey results explained that 92.3% students who spend 81.7% time on preparing the economic tender, within which the 66%-70% of time is for the quantity take-off. It causes the students lack of time to prepare the project schedule, construction methods, and contract items, which often leads to a phenomenon of copying. The existed problems are as followings:

### THE PRACTICE OF GRADUATION DESIGN

### IN BIM MODE

In order to analyze effects from theoretical, practical and efficiency when integrate BIM into graduation design, this paper sets a group experiment and takes the project of Happy Middle School as an example. There are two buildings A and B in the project. Building A together ground four tiers, underground one tier, and building B has ground six tiers, which are connected by a corridor. The building area is 8851.16 m<sup>2</sup>. It was divided into two groups: traditional group and innovation group. To control the relevant variable, choose five students in each group. Two groups separately finish the graduation design based on one real project. Different work flows are as follows:

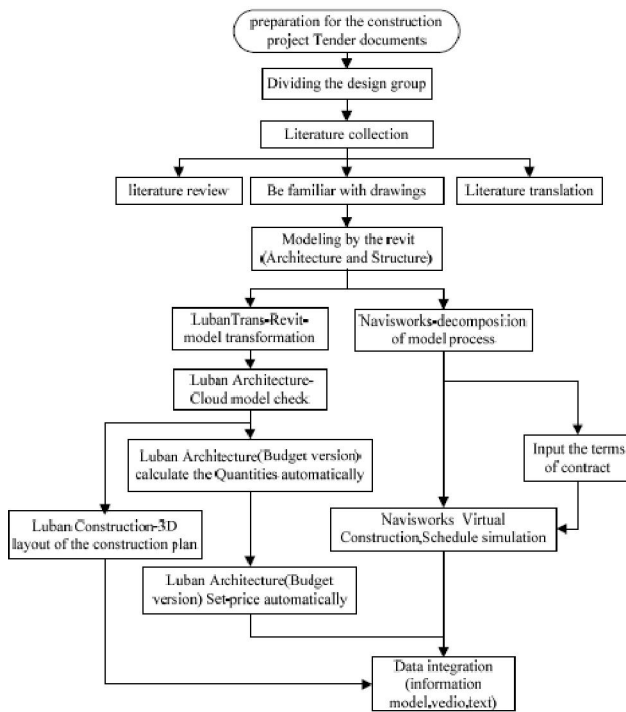


Figure 3 : Process of graduate design based on BIM

### Analysis of process

Students always found it lack of relevance among the three tenders so that graduation design don not have main line and be short at integrated and systemic. The graduation design based on BIM takes main line with the 3D model. Students add non-geometrical information (contract, cost, project etc.) into 3D model and lead them in Naviswork to generate schedule simulation and virtual construction; Meanwhile some software (like luban) localize the 3D model to be Lbim format and use it to calculate the quantities and set-price automatically. Then using the localized model to generate 3D construction layout. Based on the BIM work flow, it can integrate tenders into BIM to enhance the visualization of work flow, sharing of information and the convenience between students and teachers

### Analysis of implementation schedule

By experiments in two groups, we found that: The traditional graduation design can be divided into nine stages, 46 days are needed. Calculation of quantities (2013.5.1-2013.5.18) takes the longest time, accounted for 39.13% of the schedule, and the preparation of tender only accounts for 23.91% of the schedule. Calculation of quantities become the core of the graduation design, this make inspection of our four years' undergraduate study to stay in operating the calculation rules, which reducing the innovation that undergraduate students should have. Analytical ability to actual projects gets no training, including failed to optimize and control the cost and bring forth new ideas to construction scheme, a real-time optimization of schedule, comprehensive design and analysis of contract terms.

In contrast, the graduation design based on BIM divide process into 12 stages, with totally 31 days to

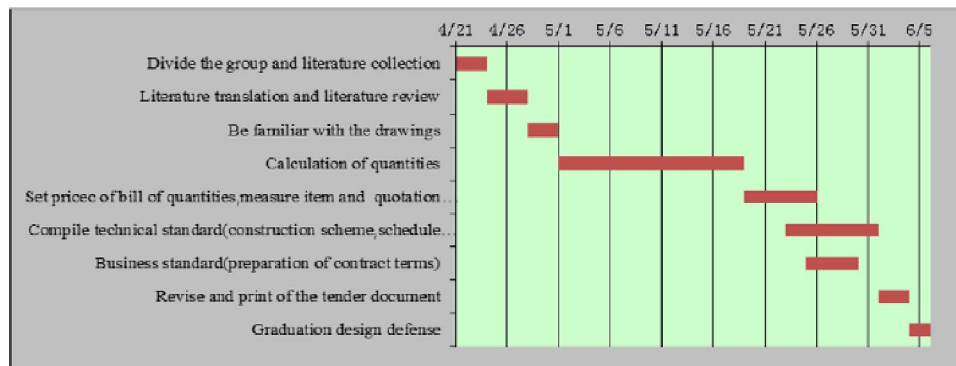


Figure 4 : Process of traditional graduation design implementation

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complete. It only takes one day to complete the quantity calculation and set-price, which is far less than the time of 25 days in traditional graduation design. In order to let the students be familiar with quantity calculation rules, the representative subdivisional work is chosen to do by traditional way. The time only accounts for 55.56% and 60% of the traditional graduation design in economic and commercial tenders.

### Analysis of the implementation results

The analysis and comparison between traditional and innovation graduation design are as following:

#### Model achievement

Compared with other BIM software such as Archicad, Autodesk Revit has the advantage of big group users and an integrated software system. The model is built by Revit 2013 in revit-link mode. Building A is established according to axis network, and Building B is established according to elevation. Team members import unified axis network and elevation to link model and check the collision, and modify the model. Through this process, team members are more familiar with the basic knowledge of structure and construction process, various components property, and specifications. Compared with traditional way, innovation way is more specific and reduces the copy rate by collision check of different groups' results.

#### Achievement of virtual construction

The virtual construction is achieved using the Navisworks2013 software. The team inputs the contract terms information which has the time constraints to the model. Then the team sets the related schedule and appearing time of contract information. Compared with the traditional mode, it is better at knowing the construction technology and schedule arrangement visually. Also it could grasp the specific timing and application of the contract terms at each stage. This help students find the problems in the schedule management and site management quickly and know how to deal with it. Final achievement is presented by the form of video and model.

#### Achievement of quantity calculation and set-price

The innovation team inputs the Revit model to the Luban Architecture (Budget version) software for generating quantities automatically through the Plug of LubanTrans-revit based on Revit. And it is adjustable automatically in real time according to the real-time quantities change of the model, then using the automatic set-price function of iLuban to get the price. Data of the construction cost is calculated by the Luban estimator and iLuban automatic set-price. The compare is as followings:

The two final offers are close. But there also are many reasons for some error. For example, part of the

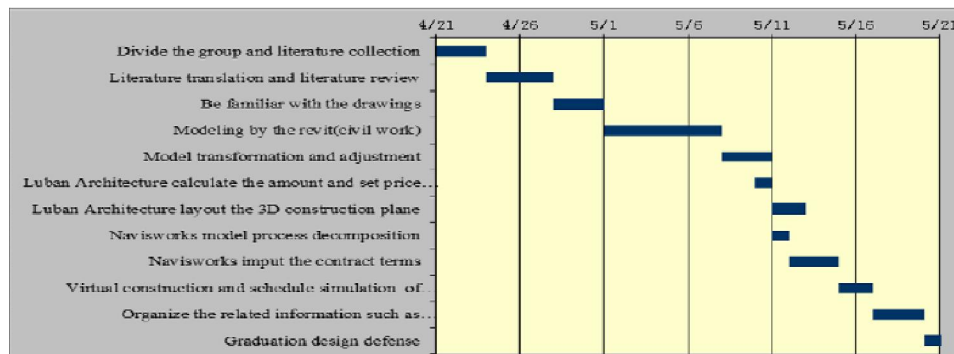


Figure 5 : Process of graduation design implementation based on BIM

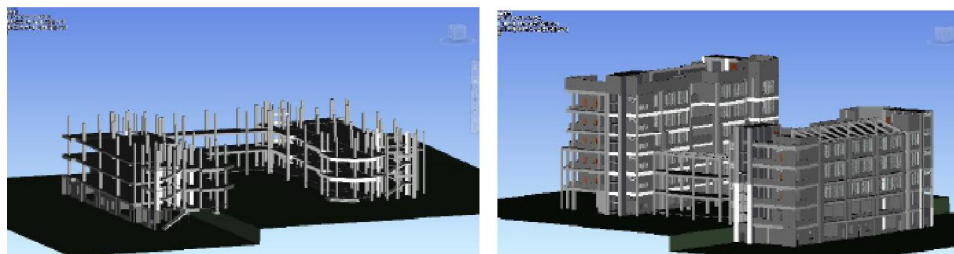


Figure 6 : effect drawing of Virtual construction

TABLE 2 : Table of unit construction cost Unit: Yuan

No.	Project name	Amount (iLuban)	Amount (traditional way)
1	sub-engineering fee	11221016.48	11269952.93
1.1	A.1 Earthwork	63253.92	62154.36
1.2	A.3 Masonry engineering	663194.01	678351.42
1.3	A.4 Concrete and reinforced concrete engineering	6158429.67	6227843.98
1.4	A.7 Roofing and waterproofing project	468369.41	429658.17
1.5	A.8 Anti-corrosion insulation heat preservation engineering	560877.59	529664.78
1.6	B.1 The ground floor engineering	833170.53	834912.08
1.7	B.2 Cylinder wall construction	1490636.25	1489655.68
1.8	B.3 Ceiling engineering	77698.02	75693
1.9	B.4 Doors and windows works	793050.37	813495.22
1.10	B.5 The paint coating pasting project	112336.71	128524.24
2	Step item cost	1127245.88	1287624.64
3	Other project fee	1730000	1730000
4	Special safety civilization construction fee	115054.13	119874.59
5	Fees	200252.22	209541.21
6	Taxes	488320.31	496412.48

quantities are calculated repeatedly in traditional way, part of missing components in the iLuban model will lead to the amount in traditional way a little higher than iLuban.

### Achievement of construction layout

Compared with the traditional 2D construction layout, students are more familiar with the size and space layout of each yard and main buildings through Luban Architecture 2014 or the Sketch up to do a 3D construction layout. Have a better intuitive understand to the concept and specific procedure of three supplies and one leveling which is still purely theoretical.

## DISCUSSION

It could be found there is a great breakthrough in the field of construction practice guidance and educa-

tion innovation for the graduation design based on BIM through the practice and comparison between the two ways of graduation design. The experiment provides a theoretical and practical reference for the reform of the construction management graduation design in the future.

### Guidance of construction practice

The graduation design based on BIM makes the students fully familiar with the whole process of the virtual construction, intuitively learning construction technology and the layout of the construction yard, enhancing the learning of control of consciousness and the management method of the three project goals for cost, schedule and quality. Compared with the traditional pattern stay in the 3D imagine of the whole real scene based on drawings, this is a great breakthrough in the visualization and practice guidance of the graduation in

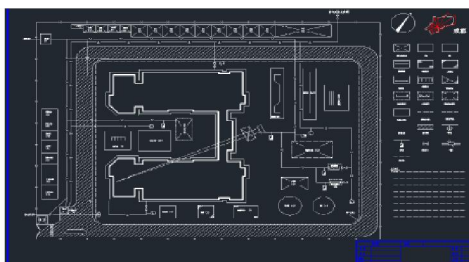


Figure 7 : Construction plane layout

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the innovation mode.

### Education innovation

From education point of view, process management, assessment mechanism and team work become the biggest problems in the traditional graduation design. The graduation design based on BIM makes innovation and perfection in these respects. Because under this mode, it has a stronger demonstrability of the graduation design stage achievements and there has the carrier for communication and evaluation between guiding teachers and students. Eventual results is heterosexual and in a variety of forms, reducing the rate of plagiarism and the constraint of the evaluation mechanism. In the task that the division of labour is clear-cut of modeling and imputing the contract information, team members integrate the model and information through a unified platform of the BIM model. For the work of virtual construction, construction layout and calculating the quantities automatically, team members can take a discussion and complete together. This not only can enhance the cooperation ability of team members, but also accumulated rich professional knowledge. However, some obstacles are found in the process of the implementation of the graduation design through this experiment and which are needed to be perfect in the future, including:

- (A) Setting the unified modeling standards and implementation plan, this will directly affect the accuracy of the model and the amount calculation;
- (B) Open the graduation design management platform because a lot of non-quantifiable information and data (such as contract terms) can't input to the BIM model. To realize the paperless and resource sharing, it is necessary to integrate the BIM model, video, text, picture and other forms of achievements in the graduation design management platform
- (C) Part of the software function is not perfect, there will be some parts missing during the period of inputting the Revit model to the Luban software, related construction layout software cannot calculate the size of yard and the type and number of tower crane, 3D layout is conducting manually and there is lacking of parameterization and informatization.

## CONCLUSION

By experiment in different groups for the graduation design, this paper comes to the conclusion that the implementation process and results of graduation design based on BIM would get a bigger improvement than the traditional way, it can be summarized as: more visual implementation process, more integrated information, more sharing of the stage achievements, more intuitive and profound understanding of the graduation design content, more collaborative of the team work, more orientative of the achievement of the process management. So it is necessary to promote this mode of graduation design, revised the obstacles and problems which are mentioned at the same time.

## ACKNOWLEDGMENT

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