Building Information Management and Modelling Teaching in Geospatial Engineering, Civil Engineering and Architecture

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Key words: Building Information Modelling, Education, Laser Scanning

SUMMARY

Building information modelling is currently an emerging technology within the building industry in the UK and in China as well as throughout the world. The departments of Civil Engineering and Architecture and Built Environment at the University of Nottingham Ningbo China have been gradually introducing Building Information Modelling content into their courses over the last few years and have plans to further increase this area by introducing Building Information Modelling teaching at Master's level in its Geospatial Engineering courses. The introduction of the teaching of Building Information Modelling has been seen as a priority by the Faculty of Science and Engineering and has been introduced to 1st year students as part of existing modules that traditionally teach Computer Aided Design and also by the introduction of two new optional modules in the final year of undergraduate study. The teaching of Building Information Modelling focuses on three main areas, management for architecture and civil engineering, Modelling using BIM modelling software from design plans, and data collection and processing for As-Built BIM model creation from laser scanning. Teaching takes the form of standard lectures and tutorial classes but focuses more on using hands on teaching methods and group work using both equipment for data collection and software for modelling testing.

To aid this teaching the University of Nottingham will establish a BIM teaching and research lab at their campus in Ningbo. This lab will be equipped with extensive BIM software and other modelling tools and facilities that will complement the already extensive surveying and mapping equipment and software available at the Ningbo campus. This paper will outline the teaching content used and give examples of student work on the newly developed modules as well as describing planned future developments in BIM teaching at the University of Nottingham. It also provides an example and initial analysis of these new teaching methods and how they contribute to current industry requirements.

Building Information Management and Modelling Teaching in Geospatial Engineering, Civil Engineering and Architecture

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1. INTRODUCTION

Building Information Modelling and Management (BIM) is quickly becoming an important part of the construction industry worldwide. In both the UK and in China BIM is changing project management within architecture, civil engineering and the construction industries. Geospatial Engineering can also play an important role within this changing environment. Due to the increasing demand for BIM projects within the construction industry there is also a greater demand for BIM education within Architecture, Civil Engineering and Geospatial Engineering as well as in other fields.

The departments of Civil Engineering and Architecture and Built Environment at the University of Nottingham, China, are working in collaboration to develop BIM related teaching content within their existing undergraduate programs as well as developing a new Master of Science program in Geospatial Engineering with Building Information Modelling. To achieve this aim, BIM related teaching content has been gradually introduced into these departments. Firstly an introduction to BIM has been included in the 1st year Engineering Communication module, which is part of the Civil Engineering degree, and is taught alongside CAD within that module. More recently 2 new modules have been included in the module catalogue and have been made available as options for final year students in the University. These 2 modules concentrate on BIM management (Architecture and Built Environment) and As-Built BIM using Geospatial Engineering data collection techniques (Civil Engineering) respectively. To aid this teaching the University of Nottingham will establish a BIM teaching and research lab at their campus in Ningbo. This lab is called the D-CiTi (Digital City Infrastructure and Technology Innovation Laboratory) and it will be equipped with extensive BIM software to aid teaching and also individual project work both at Master and Undergraduate Level.

This paper will discuss the teaching content used and give examples of student work within the new BIM related content. It will also introduce the structure and ideas behind the new MSc course. The D-CiTi lab will be briefly introduced. Finally conclusions and future recommendations for the future of BIM teaching at the University of Nottingham will be discussed.

2. BIM EDUCATION BACKGROUND

BIM is currently compulsory for all building projects in Europe and will become compulsory for all building projects in the UK by 2016. In Shanghai, for any governmental projects that exceeds project investment of 100 million RMB or more than 20,000 square meters of a single unit built

asset, it is compulsory to adopt BIM. In China BIM is becoming a vital tool in building management. In 2011 the China Ministry of Housing and Urban-Rural Development, set out its intention to decide BIM as one of the core technologies in survey, design and the building industry in the 12th five-year national plan in China (CMHURD, 2011). In 2013 at the International Conference on Education Technology and Management Science (ICETMS 2013) a paper was written by about BIM education in China (Yan and Shirong, 2013). In the paper they state that one of the main challenges firms face in winning and delivering BIM contracts is a lack of training for staff. In 2014 an investigative report in China found that 67% of Chinese companies involved in the construction sector saw a lack of BIM trained staff as a limiting factor to the expanding use of BIM within the industry (SCTA, 2014). A Royal Institute of Chartered Surveyors (RICS) report (RICS, 2011) showed that over 46% of companies surveyed said that they would be interested in BIM training. Also, a lack of expertise within project teams and the organizations was also ranked as top reason for not using BIM in the U.K. construction industry according to a survey report (Eadie et al., 2013). In both China and the UK there is evidence that there is a need for more BIM related content within existing modules in Civil Engineering and in Architecture and Built Environment. It seems that there is also a need for specialised courses in BIM and also BIM training courses and teaching facilities.

3. BIM TEACHING AT UNIVERSITY OF NOTTINGHAM, NINGBO

3.1 BIM Teaching, Qualifying Year, Civil Engineering

This section shares with the reader experiences gained since the introduction of BIM and 3D modelling to 1st year engineering students taking the module Engineering Communication (H21EC1). The Module Learning Objectives for Engineering Communication are threefold:

- To provide with the basic skills to make effective use of information technology and personal abilities for communicating, problem solving, and team working.
- To introduce concepts related to the creation and presentation of engineering designs and ideas electronically, graphically and orally.
- To appreciate the sustainability of a design solution.

The subject included Computer Aided Drawing (CAD) the aim of which was to provide the basic skills to make effective use of Computer Aided Drawing (CAD) for the production and communication of engineering drawings and ideas. To complement and enhance the students' knowledge of engineering drawings and ideas on BIM and 3D modelling using Revit Architecture were added in 2014. Building Information Modelling (BIM) for the module consisted of lectures and workshops and included in the required coursework The BIM teaching structure included two 1 hour lectures and two 2 hour workshops. The lectures reviewed the current state of the construction industry, the attraction and theory of BIM and its participation in maintaining a balance in terms of time, cost and performance on engineering projects. The initial coursework involved using Revit Architecture to produce a 3D model of a two storey house showing 5 different detail elements such as a stairway, illumination, visual styles etc. This part of the coursework was worth 10 credits.

Information and Communication Technologies (ICT), such as text messaging, online video conferencing, application sharing such as Wechat, and knowledge sharing, have become a 'natural' part of the work environment and are embedded in most of the business processes in the engineering and construction sectors. The development of soft skills, such as teamwork and good presentation skills, are essential for students. The set-up of projects team-oriented coursework was promoted in the module. With this in mind the second part of the coursework involved group projects that were worth 50% of the overall module marks. Students were placed in groups of 5 or 6 and given a brief to design and develop projects specific to each group. Both Revit and CAD were to be used by each group of students to produce the required outcome of their project brief. The project briefs included the development of a Hotel, Sports Stadium, Office Building, Arts Centre, Airport Terminal and a Shopping Centre. As part of the coursework students were to present their projects in front of an audience of judges comprised of at least 3 academics - 2 of whom were independent from the module. In conclusion the experience of the introduction of BIM showed that students easily took to Revit Architecture 3D modelling and showed their appreciation and understanding of BIM through their descriptions and explanations given in their final group projects. In summary, the introduction of BIM and 3D modelling to the Engineering Communication module could be considered a success and has developed a clear track record over the past two Academic Years.

3.2 BIM Teaching Final Year Optional Architecture Module

The first module based entirely on BIM at UNNC begun in the autumn semester of 2014. The module has been designed and run by the Department of Architecture and Built Environment. The module is called Building Information Modelling and Management (code EE3BIM) and is optional for final year students. The module was designed to appeal to students from different degrees within the University, but primarily was designed to serve the needs of students taking the BEng in Architecture, the BEng in Architectural Environment Engineering and the BEng in Civil Engineering.

The module was designed to achieve these learning outcomes in accordance with the Architects Registration Board (ARB, 2010) the British authority that prescribes the qualifications and practical experience required for UK registered architects.

The learning outcomes for Building Information Modelling and Management are listed below:

- Know the main types of BIM and other related digital technologies used for design, work-flow planning, co-ordination and communication on site;
- Articulate the major benefits that are claimed for the use of BIM and that are driving their development moving from 2D to 3D and multidimensional design and construction environment;
- Demonstrate familiarity with current ideas about information overload and the value of information within organizations;

- Appreciate the characteristics of organizational approaches to understanding use of these technologies;
- Apply these approaches to assessing the positive and negative impact of these technologies on different stages of the real-life projects;
- Understand how these technologies are changing the management and delivery of projects.

In order to achieve the learning outcomes the module consisted of a 4 week BIM training course teaching Revit Architecture, Structure, and MEP. In total four BIM labs were provided for each student to go through the series of Revit-based building models.

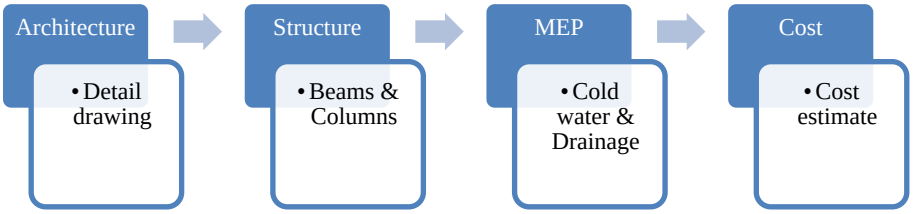
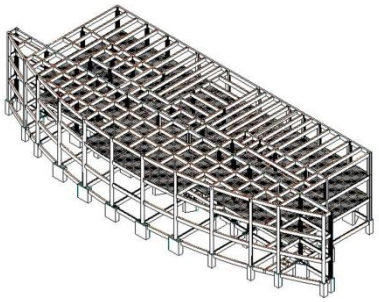


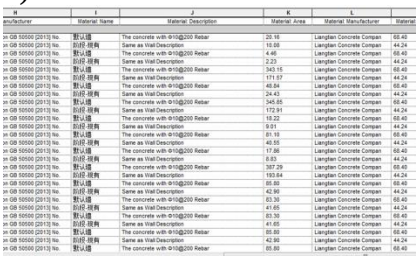
Figure 1. Group Project Process

4.



1) Architectural form

2) Structural form



3) MEP system

4) Quantity take-off spreadsheet

Figure 2. Group project of the real-life building project

During the BIM training Students were required to build a “dream house” taking into consideration, topography, architecture, structure and Mechanical, Electrical, and Plumbing (MEP) systems. After the 4 week BIM training is completed students are divided into groups of 5 and given a group

coursework assignment. The student groups were designed so that there was a mix of expertise in each of the groups. Figure 1 shows an example of the process undertaken by the students during the project and Figure 2 shows pictorial examples of what is produced during each stage of the workflow shown in Figure 1.

The course is assessed 100% by coursework, 60% of the mark comes from the group submission; the other 40% comes from an individual report. The group submission is assessed through a group presentation given to members of academic staff and is also peer assessed by other members of the class. During the presentation, students shared their experience of how BIM impacted the project collaboration, the pros and cons of using BIM as compared to 2D CAD, and the project delivery process. For more detailed information on this course the reader is directed to (Tang et al., 2015).

4.1 BIM Teaching Final Year Optional Civil Engineering Module

In 2015 the department of Civil Engineering introduced an optional module as part of its BEng in Civil Engineering. The name of the module is 3D Modelling for BIM (H23TBM). The module applies the surveying knowledge within the department to teach students how to use surveying techniques to produce as-built BIM models of existing buildings. Students are first taught the principles of data collection using Photogrammetry, Laser Scanning and Traditional Survey methods through a series of lectures. Students then undertake a series of practical exercises with survey equipment and software. Each practical class last approximately 3 hours and follows the workflow shown in Figure 3.

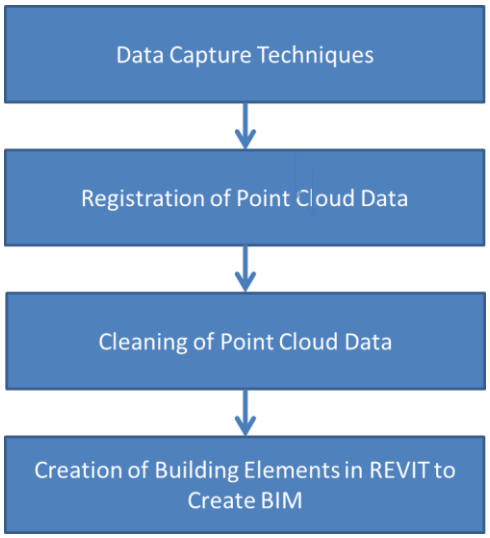


Figure 3. Group Project Workflow for H23TMB

The module describes the theoretical and practical aspects of photogrammetry and geometrical remote sensing. Subjects covered include: 1) Introduction to BIM; 2) Digital imagery and processing for BIM; 3) Selected work flow and procedures; 4) Data capture techniques and products

for BIM; 5) Airborne and mobile laser scanning; 6) 3D Modelling techniques 7) Recent Developments. The learning outcomes for this module are as follows:

On successful completion of this module, students will be able to:

- demonstrate an understanding of the theory of 3D data collection techniques;
- explain how different 3D data collection techniques work, and compare and contrast these techniques;
- demonstrate an awareness of, and give examples of, applications of data collection and modelling techniques used for BIM

Figure 4 shows the Point Cloud data collected by the students and the final BIM model created in REVIT.

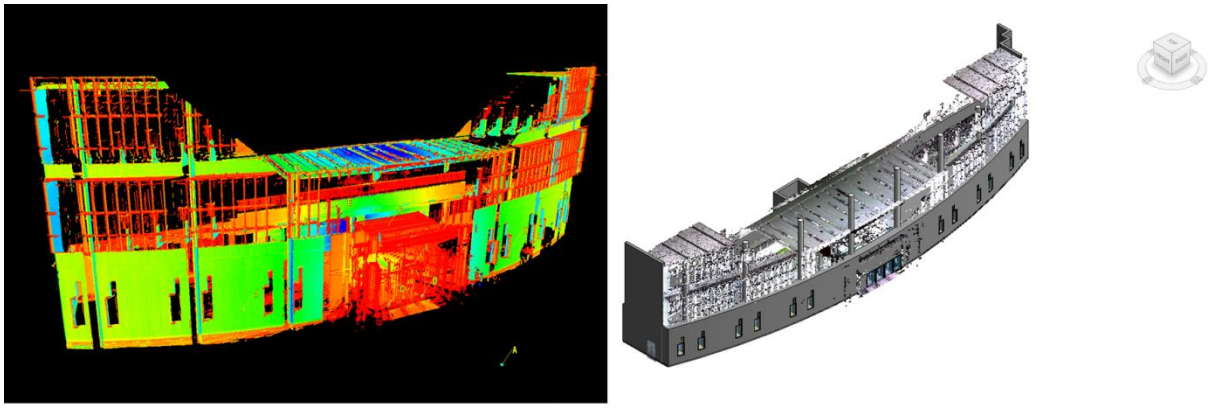


Figure 4. 3D point cloud from Laser Scanning (left); BIM created in REVIT (right)

The module is assessed by an individual report on the advantages and disadvantages of different methods of data collection worth 30% a group report (worth 20%) and poster (worth 10%) that describes the workflow of the as-built BIM model that has been created and finally by a 1 hour exam, worth 40% of the total mark.

4.2 New MSc in Geospatial Engineering with Building Information Modelling

The University of Nottingham currently offers 2 MSc courses in Engineering Surveying. At the UK campus a 12 month MSc in Engineering Surveying with Geographical Information Systems is offered whilst at the Ningbo, China campus an MSc in Engineering Surveying and Geodesy is offered. Over the last few years the importance of Building Information Modelling and Management has been highlighted by Civil Engineers, Architects and Geospatial Engineers amongst others. UNNC has introduced BIM teaching content into its Architecture and Civil Engineering Undergraduate Courses over the last few years as has been discussed above. In

addition BIM related research has also increased through the funding of GIS-BIM application in green built environment innovation team by the Ningbo Science and Technology Bureau.
In Collaboration the departments of Civil Engineering and the Department of Architecture and Built Environment will launch a new 12 month MSc at the Ningbo campus in Geospatial Engineering with Building Information Modelling. The MSc is made up of 180 credits. 120 of those credits are in the form of taught modules. 10 credits approximately equates to 100 hours of work for the student. The final 60 credits of the course are in the form of an individual research project. The new MSc combines existing modules in Engineering Surveying and BIM taken from the current BEng and MSc courses. In addition to the existing modules several new modules will be developed in the area of BIM management. Table 1 shows the modules that will make up the new course.

The new course will comprise a mixture of traditional lectures mixed with example classes and group learning. In addition to this many modules include a large practical element so students have the opportunity to learn hands on.

Module Code	Module Name	Credits
EE3BIM	Building Information Management and Modelling	10
H23TMB	3D Modelling for BIM	10
H24CPR	Civil Engineering Research Project	60
H24PLR	Research Project Literature Review	10
H24POP	Research Project Org and Planning	10
H24V11	Photogrammetry and Remote Measurement Techniques	10
H24V29	Fundamentals of Satellite Positioning	10
H24V31	Geodetic Reference Systems	10
H24V32	Analytical Methods	10
H24V46	Engineering Surveying	10
New	Building Information Modelling in Architecture	10
New	Building Information Modelling in Civil Engineering	10
New	Building Information Management	10
Total		160

Table 1 Modules for the soon to be offered MSc in Geospatial Engineering with Building Information Modelling. Modules in Black already exist at the Ningbo campus, modules in green exist at the UK campus and modules in Red will be created specifically for the MSc program.

5. UNIVERSITY OF NOTTINGHAM BIM LAB (D-CiTi)

The D-CiTi (Digital City Infrastructure and Technology Innovation Laboratory)**,** is a living lab that integrates research and innovation on BIM and Smart City development. Its process integrates both user-centered research and open innovation via multidisciplinary researchers, having Architecture, Built Environment, Civil Engineering, Surveying, Computer Sciences and Geographical Sciences disciplines, clients, Architecture, Engineering and Construction (AEC) companies, international professional institutions and global software vendors. This laboratory is supported by extensive state-of-art, modern equipment and key experts in the University of Nottingham and other associated pioneering work of researchers and practitioners. It aims to engage in problem discovery and solution design with leading users, developers and adopters of BIM, further to develop code of BIM in China based on the Digital Built Britain (DBB), which involves code of BIM application, code of BIM storage, code of BIM delivery and code of BIM classification, and more importantly to address the agenda of Smart City and Digital Built Britain. With over 10-year BIM project and R&D experience, D-CiTi offers world-leading R&D on the:

- Provision of first U.K. Master in Geospatial Engineering with BIM in China
- Provision of certified BIM executive and management training course
- Delivery of BIM project and its solution and implementation
- Development of global BIM standard and its formulation
- Global BIM R&D collaboration
- Organising global BIM conference
- Market development

6. CONCLUSIONS AND RECOMMENDATIONS

The first BIM modules and first BIM MSc course at UNNC serve as an example in Chinese education for the teaching of BIM related content. The modules have so far proven to be a success with the students and student evaluation of the courses is being taken into account to improve these immature learning experiences to make them even better. The launching of the MSc course in Geospatial Engineering with Building Information Modelling in September 2016 will give further opportunities for the expansion of BIM teaching at UNNC and also in China.

7. ACKNOWLEDGEMENTS

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