Northumbria Research Link

Building Information Modelling for Visualisation in AEC Education

Margaret Horne
School of the Built Environment
Northumbria University
Newcastle upon Tyne
m.horne@unn.ac.uk

Mattias Roupé Mikael Johansson
Chalmers Lindholmen Visualiseringsstudio
SE- 402 72 Göteborg, Sweden
roupe@chl.chalmers.se

Abstract

This paper outlines the process used to introduce building information modelling into the academic curriculum of built environment students and reflects on the techniques used to ensure appropriate use of parametric tools for the purposes of visualisation. The integration of building information modelling into other curriculum subjects is outlined. The study introduces the collaboration between Northumbria University and Chalmers Lindholmen Visualiseringsstudio and considers the future potential of building information modelling and whether it may contribute to reduced time and cost of creating three dimensional models suitable for Virtual Reality worlds.

Keywords

Building Information Modelling, Visualisation, Virtual Reality, Built Environment Curriculum, MrViz.

1. INTRODUCTION

Recent advances in commercially available object oriented modelling software are offering new challenges to both working practice and educational establishments. Interest in building information modelling technologies is resulting in emerging strategies for its adoption, subsequent evaluation, and potential for integration. This paper reports on the considerations that were made in introducing building information modelling, in a phased approach, into the academic curriculum for built environment students at the Northumbria University, School of the Built Environment. Over 1800 students study a wide variety of subjects including architecture, architectural technology, building management, building surveying, building services engineering and quantity surveying. The study outlines the requirements of a 3D model in relation to these subject disciplines and focuses on the use of building information modelling as a visualisation tool and the possibilities and future potential to harness the technology for the creation of Virtual Reality worlds.

2. REQUIREMENTS OF A 3D MODEL

A three-dimensional model can be created for a number of reasons such as concept design, visualisation, structural detailing, energy simulation, abstraction of quantities and facilities management. It is therefore important that the information that forms a building model can be easily re-used. The advent of parametric building information modelling software which considers massing elements and building elements (walls, columns, doors, windows etc) rather than geometric lines, points, faces and surfaces (as in traditional CAD software) heralds a new way of working.

Architectural Technology (AT) is emerging as a profession which bridges the gap between design and construction. There is a growing need for specialists who can resolve both design and technical issues and ensure optimum building performance and efficiency. 3D modelling is of importance to the Architectural Technologist for purposes of visualisation as well as analysis. The importance of effective integration of IT into the BSc Architectural Technology degree programme resulted, in 2004, in the introduction of building information modelling into the academic curriculum of second year AT students. Whilst Information Technology modules within the curriculum were considered separate taught subjects, it was recognised amongst the course team that further integration of IT would occur once students had acquired the basic skills and techniques and could use the tools appropriately. Autodesk's building information modelling software Revit was selected to be piloted in a module entitled Computer Aided Visualisation and 3D

Modelling. Although the focus of this module was visualisation, it was considered from the outset as a vehicle to assess the file transfer capabilities and interoperability of building information modelling software with other 3D modelling applications. Virtual Reality technologies are also of importance to architectural technologists and necessitate the creation of 3D models. Ease of use was one of the criteria for software selection, as was reliable training and support and seamless integration of 2D and 3D.

3. EVOLUTION OF IT TEACHING METHODS

Students are entering higher education increasingly computer literate. The Architectural Technology students were taught Computer Aided Drafting in the first year of their course, which introduced them to the 2D CAD techniques still predominately used in industry [CIRIA05]. The teaching approach adopted for first year students of CAD was that of a systematic, logical introduction to the computer software capabilities, related to built environment projects. Thereafter students were expected to use CAD appropriately throughout their degree programme and to maintain and develop their skills via independent learning.

It was decided to use Revit in the students' second year as it would enable them to produce 3D models in a *much faster time* than would have been possible using traditional 3D CAD. They were introduced, via a series of structured lectures, to the concepts of object oriented modelling and the fundamental differences between building information modelling and CAD. The lecture programme focussed on the visualisation capabilities of Revit, albeit the students became aware that this software could be used for many other purposes, including the production of working drawings and sections. Building information modelling software is capable of producing high quality ray-traced or radiosity renderings that a few years ago were only possible in specialist visualization packages. Students learnt the fundamentals of the program by working through selected tutorials provided with the software. Once the basic skills had been acquired students were encouraged to apply their knowledge to a design they had previously developed for a professional practice project. Some students worked on a design project of a multimedia learning resource centre that was specified to be a modern, spacious framed building with a total of five storeys, creating a good working environment for quiet, concentrated learning activities. Others applied Revit to the design of a modern house.

4. THE MODELLING PROCESS

Throughout the modelling process, which spanned a twelve week period, it was evident that the students were learning much more than visualisation techniques. Building information modelling encouraged students to consider the building as a whole, and how building elements were related to each other. As students developed their three-dimensional models they were faced with the construction implications of their design decisions. Students were finding that they had to consider the entire building rather than individual sections and floor plans. As their model progressed and skills improved their motivation and enthusiasm increased. They had to work logically and enter information graphically rather than via a set of complex commands. They found more time to focus on the building design instead of constructing complex geometry based on faces and surfaces. Those students who were very already proficient in traditional 2D and 3D CAD were initially concerned that this experience would be undermined, but these initial concerns were dispelled as the students became more familiar with the software.

5. END RESULTS

Students produced some impressive renderings in a relatively short time. They were able to explore different material and lighting options in their design (Figure 1)

Figure 1

and place their model in context with background imagery (Figure 2).

Figure 2

They also gained knowledge of the issues pertaining to file size and rendering times for visualisation projects. The average file size, over a sample of thirty students, was 6.5mb.

The prescriptive nature of building information modelling, where components are selected and put together, was a concern raised by some academic staff in the School. Some components repeatedly appeared in project work and students were advised about the shortcomings of this. However, whilst some students were content to use only the pre-defined components, others were more ambitious and had to learn how to create customised components in order to realise their design. Some students created buildings with expressive forms, elaborate geometry and non-standard components, including curved I-section beams. Rather than restricting creativity [Cruikshamk01] the software enabled some students to focus more on design intent. Students' creativity followed as a consequence of mastering the software and they were encouraged to further their current knowledge in order to realise their ideas.

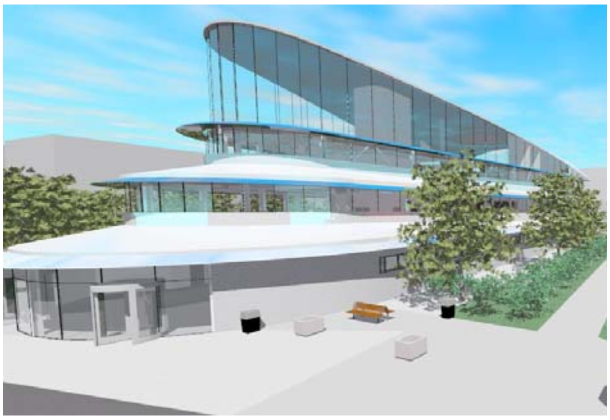

Figure 3

Figure 3 shows a rendering of a five storey building modelled in Revit 5.1.

5.1 Student Feedback

Student written feedback was collected to provide both quantitative and qualitative data on this strategy of introducing building information modelling into the curriculum.

From a total of 66 students all students felt that the learning outcomes of the Computer Aided Visualisation and 3D Modelling module had been met and 86% felt confident in using building information modelling for visualisation. 98% of students appreciated that the module was up-to-date and informed by current developments. 90% of students felt that their analytical skills had been developed and 87% felt the supporting course materials had been useful.

Students were asked to reflect on their experiences of applying 3D computer tools in the design of a building. The majority expressed comments about the user-friendliness of the software used, and the advantages in using software specifically designed to create buildings. Many agreed that building information modelling enabled them to make changes easily and this fact encouraged them to try different designs and ideas in 3D. Quotes from students included:

"Viewing in 3D provided instant feedback on design decisions – ultimately leading to better thought-out design"

"Creating objects in 3D helps to develop spatial analysis"

"Working in 3D was a good way to test an idea quickly"

"Working with building information modelling software helped to understand clashes in building construction – you cannot 'fudge' a design."

"Wall junctions must be correctly drawn, window mullions correctly selected, correct elevation levels defined"

"Alternative options – exploration of design was easier"

There were some concerns on the prescriptive nature of the software and a few students commented

"It is too easy to rely on pre-drawn components, resulting in the design process becoming very component driven, which could lead to a lack of creativity in design"

"I would like to spend more time learning how to create my own objects /families"

Several students did however spend time on bespoke designs:

"Allowed me to design bespoke components such as a curved roof and curved sloped walls"

"Eventually I began to focus on the design itself, not the operation of the software"

The majority of students highlighted ease-of-use, time-saving, of up to 75%, over traditional CAD modelling, and high quality renderings as important criteria for further adoption of the technology. They appreciated the continued need for accuracy and the ability to be able to interface with AutoCAD for detailing.

Despite some concerns, the overall feedback clearly indicated that this cohort of students had appreciated the opportunity of being introduced to building information modelling and realised its potential for the future.

6. INTEGRATION OF BUILDING INFORMATION MODELLING

The integration of an IT module with a professional practice module enabled the students to demonstrate the possibilities of computer application to design. Linking the two academic modules expanded the students' learning from software mastery to one of creative and technical thinking. They were able to generate two-dimensional plans, sections and elevations from the three-dimensional model. Some two dimensional detailing had to be drawn using traditional CAD, which still had a role to play. Several students preferred to start their design by creating a two-dimensional plan in CAD and importing this into the 3D software as an initial template on which to base the construction of walls.

Students were also encouraged to use their Revit models in an investigation into the thermal characteristics of building elements and the effect of facade design. They linked Revit with IES environment, a programme designed to simulate real environmental conditions on a building model and found that modifications to the Revit design could be made quickly in response to the thermal analysis output. Revit enabled the students to show the iterative process involved in building inception and feasibility design. Academic staff specialising in Building Services Engineering reported that Revit should significantly enhance the presentation of feasibility analysis reports on the thermal performance of building façade options and environmentally conscious building designs.

Some students also integrated Revit with a Building Technology module, increasing the number of subjects in their curriculum which included some degree of building information modelling, and supporting the premise that visualisation can play an integration role across subjects which have traditionally been delivered separately. Computers offer opportunities for changing the teaching process and furthering integration within the architectural curriculum [Asanowicz98].

6. VIRTUAL REALITY MODELS

Students of architectural technology also have a requirement to incorporate animation into their 3D models in order to describe the construction process and detailing required in today's complex buildings and fabrics. Virtual Reality facilities, enabling interactive animation, are more affordable than they have been in the past but applications for built environment projects are not yet widespread. The benefits and applications of virtual reality in the construction industry have been investigated for almost a decade [Bouchlaghem00].

VR technologies, adding the components of *interactivity* and *immersion* to building models, are not yet widely used in the field of building design due to the cost and time required to develop the models. Specialist visualising companies are often used when VR is required. The creation of a VR model is often based on the availability of traditional 2D and 3D CAD data which is them imported into software applications such as 3ds Max and Superscape. This involvement, by third-party specialists, adds to the production time and cost of VR models. However evidence is emerging that adoption of building information modelling software is resulting in productivity gains of 40-100% during the first year [Khemlani04]. Whilst the three-dimensional model created with such software is too detailed to be used directly in a VR model, because the data is object-oriented it is easier to simplify the building elements for use in a VR application [Roupé04].

As building information modelling is further adopted into the design process, and a new generation of students emerge into practice with 3D modelling skills, the demand for a seamless integration between building information modelling and VR will increase. At Chalmers Lindholmen Visualiseringsstudio a VR application called MrViz has been in the process of development for two years. The application is based on the open source libraries Open Scene Graph and wxWidgets and is used in educational projects conducted at Visualiseringsstudio. Recently new functions have been implemented in MrViz to simplify the creation of VR models and the implementation of improved data import together with a simple texturing tool has made the creation of VR models a much faster process. Exchange of student project data between Northumbria and Chalmers is enabling collaboration on issues of file size, file transfer capabilities and software interoperability.

7. CONCLUSIONS AND FUTURE WORK

The impact of using building information modelling for visualisation in the academic curriculum has resulted in

- Production of high calibre student visualisations.
- Increased student motivation in working in 3D.
- Increased speed of production of 3D models.
- Discussions between students and staff on the potential for further integration of building information modelling into the curriculum.
- Consideration on the potential of building information modelling as a contributor to the creation of Virtual Reality worlds.

The student feedback process, which encouraged critical reflection and assimilation, has provided the academic team with valuable insights into the students' learning process, and has provided a source for future development of teaching strategy. The challenge for academic staff is to ensure further integration of building information modelling into the curriculum is appropriate and timely, without restricting the creativity and imagination of the student. A new model for teaching is emerging which is challenging our thinking about how IT is introduced into the curriculum. Intelligent 3D models facilitate the exchange of information between built environment disciplines. Since the initial introduction of REVIT into the School of the Built Environment, Northumbria University, in 2004, the number of students now introduced to Revit has quadrupled. Building Services Engineers and Quantity Surveyors are applying the technology for their respective disciplines. A new generation of built environment professionals is emerging who will expect working practice to adopt new processes to enable the exploration and evaluation of design options more effortlessly than before.

The creation of VR models for building design is not an integrated part of the building design process due to current requirements of additional applications and expertise in VR technologies. Results that are obtained, often by specialist visualisers, often have limited support for interactive animations during run-time. Developments at Chalmers Lindholmen Visualiseringsstudio are ongoing. Currently MrViz has support for Autodesk's Revit files via the AutoCAD file format. Work is underway to make the Revit import into MrViz fully functional and to further the implementation of user-friendly 3D modelling functions and sophisticated texturing tools. Improved communication will result if Virtual Worlds become easier to create and use. Future integration of building information modelling and VR will further this.

8. REFERENCES

[Asanowicz98] A. Asanowicz. Approach to computer implementation in architectural curriculum. *Computerised Craftmanship, eCAADe Conference Proceedings,* Paris, 24-26 September 1998, 4-8.

[Bouchlaghem00] Bouchlaghem N., Khosowshahi F., White J. Virtual Reality as a visualisation tool: Benefits and constraints. *CIDAC, Volume 2 Issue 4* November 2000, 216-224

[CIRIA05] Construction Productivity Network, Virtual Reality and 4D Modelling in Construction, London, 16 March 2005.

[Cruikshank01] Cruikshank G., Paterson I., Natanson L. A creative Curriculum: Putting Technology in its Place. *SIGradi* biobio2001.

[Khemlani04] L. Khemlani. Autodesk Revit: Implementation in Practice. <http://www.autodesk.com/bim>

[Roupé04] Roupé, M, Johansson, M. From CAD to VR – Focusing on Urban Planning and Building Design. *AVR III Conference and Workshop*, Chalmers, Gothenburg, Sweden, May 27 – 28, 2004..