THE DEVELOPMENT OF A BIM BASED BUILDING MEASUREMENT LEARNING TOOL

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Abstract

The paper discusses the development of an integrated tool for teaching and learning building measurement. A 3D CAD IFC-compliant building information model of a small two-storey residential building was created complete with electrical and hydraulic services and all specification information using Archicad. A complete bill of quantities was measured from the BIM using Buildsoft, and exported to Microsoft Office. The exported dimensions and quantities were used to produce a fully annotated version of the BQ.

The outcome is a package comprising a CD-ROM and a conventional book. The CD containing the BIM, the Buildsoft files, a 3D model viewer and a complete set of drawings extracted from the model and saved in PDF format. The book contains a complete BQ in conventional format plus a version of the BQ with each item shown with its take-off and some notes explaining the measurement process and the relevant clauses from the Australian Method of Measurement.

Keywords: Building information modelling, building measurement, teaching tool.

Introduction

This paper describes both a new teaching and learning tool and the rationale behind its development. The tool has been developed in response to a variety of factors that are affecting the way construction students are responding to teaching and learning in the university environment. It is intended to better engage students with learning generally, and specifically to develop their skills in building measurement.

Measurement is a fundamental skill not only for quantity surveyors and estimators but for anyone involved in the construction industry, Having the capability to measure building work quickly and accurately to an agreed standard as well as possessing a good understanding of how measurement is done by others is necessary in many facets of work in the industry. Cost management is a core concern in virtually all projects and quantification of work is the foundation of cost management. Measurement can be tedious and it is work that students, cadets and junior graduates are generally not keen to carry out. Is is also an area that employers often identify as the skill most lacking among cadets and recent graduates (Best and Smith, 2007).This is unfortunate as the detailed measurement of a building provides the measurer with a great depth of understanding of how the building goes together and often uncovers significant discrepancies in the documentation.

Changing Methods and Attitudes

Apart from students' general dislike of measurement as an activity the attitudes of current students towards subject delivery and their learning experiences is changing. Attendance at conventional lectures in most Australian construction schools is poor, and this is only partly due to the pressure of trying to combine work and study. Our current students (and this will become more apparent in the coming years) have grown up with Internet access, wireless connections, 3G telephones, podcasts and SMS. The conventional lecture scenario has little appeal to students who are used to gathering information (and learning) electronically and the increasing demand for online subject content and all manner of material in digital form reflects the changes in the attitudes of the present cohort of students. Added to these concerns is the desire for flexibility in how and particularly when they will do their study – with the world available round the

clock via the Internet, perhaps through a portable device such as a Blackberry, the rigid nature of timetabled classes is becoming less and less attractive to them.

In this environment it is not surprising that measurement classes are seldom rated amongst students' favourite pastimes. It was partly in response to this scenario that the BIM based tool was developed. The other reason, no less important, is that it represents the way that measurement is most likely to evolve in the near future, with 3D CAD models being interrogated not only for quantities but also for the rich fund of information such as specification details that can be embedded in such models (Mitchell, 2008).

Teaching Resources

Largely because of the restricted market for such materials there is little published material related to building measurement available that is based on Australian practice. A few textbooks such as those written by David Picken (Picken, 1999) and Paul Marsden (Marsden, 1998) have been very useful but both are somewhat restricted in scope and Picken's book, at least, is no longer in print. Teaching staff in institutions usually need to prepare their own notes with examples and practical exercises for their students to use. Often this has been restricted to projects not much bigger than the typical "garden shed" as staff are constrained by printing costs, lack of large format copiers and limited class time during which students can work through larger, more complex buildings. This material has usually consisted of a small set of drawings in A3 or A4 format and perhaps an outline specification. Measurement has been carried out in a very precise way using figured dimensions (as in Marsden's book) and students have often been troubled by the lack of detail in the information that is provided. While it is true that out in the "real world" building documentation often requires users to exercise some imagination in order to fill in the gaps, this is cold comfort to students, particularly in the early years of study.

The problems related to teaching measurement are exemplified in the regular criticism of university courses from people in the profession who feel that both the quantity and quality of what is taught is below par (Best and Smith, 2007). Many firms claim that they have no time to teach junior staff how to measure and university staff point out that measurement is just one of many topic areas that must be addressed in the limited time available to them. Students and junior staff have few options if they wish to pursue additional study in this area due to the paucity of books or other learning tools other than those from the UK (e.g. Lee *et al.*, 2005) where both measurement and building practice are substantially different.

In response to the factors discussed above a proposal for the development of a resource for the teaching and learning of building measurement was put to the NSW Chapter Council of the Australian Institute of Quantity Surveyors (AIQS) in 2007. The proposal was for a tool that would enable students to gain an understanding of 3D models, learn how to extract data from such models, manipulate models to display selected components and systems, and extract details and hard copies of selected views or details from the models. Chapter Council agreed to underwrite the project with a view to recovering the initial outlay through subsequent sales of the product over several years. Two of the staff at UTS, Rick Best and Peter Smith, headed the team charged with producing the resource and a formal contract was signed between accessUTS (the UTS commercial consultancy office) and the AIQS.

The Building Information Model (BIM) Tool

The tool is built around an IFC-compliant 3D building information model (BIM) model of a small two-storey residential building, Buildsoft estimating software and the Australian Standard Method of Measurement (ASMM). It provides students with an interactive environment that allows them to relate the detail required by the ASMM to the building model and presents take-off and calculations for a full bill of quantities (BQ) in the format of a popular estimating software package that is widely used within the Australian construction industry. The complete package comprises a book and a CD. The book contains a complete ASMM–compliant BQ in standard format plus an item by item breakdown of the BQ. All dimensions are extracted directly from Buildsoft, and are presented in the horizontal or "across the page" style as they appear on the Buildsoft screen, with a written commentary following each item explaining the measurement procedure and the

relevant requirements of the ASMM. The CD contains the complete 3D model of the building, a free BIM viewer and a basic set of 2D drawings, extracted from the model, in PDF files.

John Mitchell, chair of the buildingSMART Australasia Chapter agreed to manage the modelling work and Paul Marsden, a quantity surveyor/academic, agreed to carry out the measurement and draft the commentary. Rick Best and Peter Smith are editing the work and will manage the process through to completion.

The CD-ROM

The project, a two-storey brick residential building comprising two apartments with tile roof was modelled using Archicad software. The resulting model is fully IFC-compliant and is completely detailed with siteworks and has plumbing and electrical systems included. The package includes the complete Archicad model together with free IFC viewer software that allows the user to open and view the three discipline models (architecture, electrical and plumbing) in various ways thus obviating the need for users to have the original CAD software. The viewer allows users to view 3D renderings of the building from all angles, and to select specific details and enlarge them so they can properly understand how the various components fit together. Individual construction details can be isolated and examined. Details within the model, such as the construction of the eaves, and the way in which a suspended slab is supported within brickwork can be viewed in 2D or 3D enabling students to grasp quickly what materials are used and how these details are constructed. Care has been taken to include all components such as flashings so that students are not left to imagine where these components are required. When students are still in the early stages of measurement training and their knowledge of construction detailing is still rudimentary they are often expected to measure items that are seldom, if ever, shown on drawings. An experienced measurer is aware of the need for flashings around openings for example, but often these are assumed or perhaps mentioned in general terms in the specification but not shown on the drawings. This causes confusion and often results in students feeling aggrieved as they believe that important information has been omitted from the documents provided to them.

An important feature is the correctly designed and detailed services; users can select, for example, a single system such as the electrical service and view it alone in 3D or within a wireframe view. This allows students with little experience of how such services are actually installed to see where cables and pipework run and how the various components make up the complete installation. A two-pipe drainage system with greywater recycling was included to reflect what is now becoming normal practice in residential construction in Sydney. Fittings such as bends and junctions in pipework are visible on the screen and this will help students to understand where fittings are required. This knowledge will be invaluable when they come to work on actual projects where services layouts are provided as single line diagrams at best and measurers must apply their knowledge and experience in order to identify and include all the necessary components.

The disk also includes a basic set of drawings extracted from the model and stored as PDF files that can be printed in A3 or A4 format. There are also instructions that enable users to print other views and details from the model as required.

The Book

The book includes a full bill of quantities (BQ) for the complete project measured in accordance with the ASMM. Early in their studies students are often unclear about just what a conventional BQ looks like and how it is formatted even though lecturers may show examples in class. For this reason a complete BQ, without annotations or dimensions, is included as a permanent reference for students. This BQ is, however, supported by a fully annotated, item by item breakdown that shows all dimensions, with locations and sidecasts, for each item and a written commentary that describes the measurement process and relates the measurement of the item to the requirements of the ASMM. Students can then work through each item from the model and/or drawings taken from the model and identify exactly how each item has been measured. They can refer to the model to see 3D details of any items that may be unclear and thus gain a far better understanding of the relationship between their measurement and the physical building and its components.

Further Developments

The tool described here represents the first stage of a plan to develop a suite of tools for teaching measurement and cost management, not just BQ measurement. Future additional modules based on the same model will include a typical builder's bill, a BQ based on a documented concise method of measurement and a standard cost plan prepared in accordance with the Australian Cost Planning Manuals (AIQS, various dates). It is intended that the concept will be further developed to include preliminary estimates, design alternatives, variations, construction scheduling and even post-contract activities such as the preparation and assessment of progress claims.

Conclusion

The package described here provides teachers and students with a unique and valuable reference tool for developing skills in building measurement in technical college and university building courses. It is also useful as a reference resource for junior staff in quantity surveying and estimating offices. It is one of only a handful of reference works on the subject developed in and for the Australian context. The 3D model that is at the heart of the package provides the basis for a detailed suite of resources that will eventually encompass the whole range of cost management activities and as such could be used to underpin a substantial range of learning activities in building courses.

Eventually, with more detailed client requirements (such as room data for example), cost classification tagging of building and service elements, IFC compliant cost tools such as the CRC for Construction Innovation *Estimator,* and Exacta *CostX*, will be able to generate costs directly from the IFC model data. Such tools already exist in Europe generating specified bills of quantities according to the Norwegian construction standards. This project takes an important step in the move, which is gathering momentum, towards intelligent open building data and smart applications that use this rich data.

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