E-Learning: Supporting the transition from skills to a knowledge based learning approach to design

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Abstract - Growth in the UK Construction Engineering Industry has lead to unprecedented enrolments of students across a range of Higher Educational (HE) awards at Wolverhampton University. Recognizing the role that Design Education has on Construction Engineers, the School of Engineering and the Built Environment encourages all students to study a year 1 Architectural Computer Aided Design (CAD) course. With a population approaching 200 on this practical based course, staff concentration is evermore focused on CAD skills acquisition to the detriment of Design Principles and Processes.

This paper presents a review of the current mechanism of delivery of the module which has been reviewed to identify how e-learning can best be employed to solve specific problems of large cohorts. Based on the user requirements obtained from students and academic staff, a new approach is developed that provides e-learning mechanisms for the key module competences. Live handouts were developed and a method of allowing students to put together an online 'webfolio' of work undertaken within the module.

Index Terms – Architectural, Computer-Aided-Design, Design, E-Learning

BACKGROUND

The application of Computer Aided Design (CAD) within design, architecture, construction and industry has expanded rapidly in recent years. A significant number of architects and other stakeholders within the construction industry now produce designs using a CAD based system [1] Subsequently, the Architecture and Product Design (APD) Department within the School of Engineering and the Built Environment (SEBE) has experienced rapid growth in the numbers of students seeking to study CAD, in particular the Level One Module AT1004 Fundamentals of Computer Aided Architectural Design 1.

The large number of students wanting to study the CAD module is providing several issues centered around staffing and facilities within the department. The increasing number of students taking the module has lead to a requirement for more staff and a greater number of iterations of the same class. However, it has previously been suggested that the methods of teaching CAD is required to change in order to remain effective with students being at the centre of the learning experience [2]. By adopting this concept for the teaching of the technical CAD concepts, the module is able to cope with increasing numbers of students whilst attempting to provide rewards that are more intrinsic and allowing the academic staff to provide a greater mentoring role in relation to the underlying architectural design topic [3].

CURRENT DELIVERY MECHANISM

A large number of Level 1 students' who are currently studying architectural, construction and product design courses, commence their computer aided design studies learning 2D CAD skills by undertaking the module 'AT1004 Fundamentals of Computer Aided Architectural Design 1'. Courses utilizing the module include:

- BSc CAD and Construction
- BSc Architectural Visualisation
- HNC/D CAD and Construction
- BSc Architectural Design Technology
- BSc Interior Architectural Design
- HNC/D Building Studies
- BSc Building Surveying
- BSc Civil Engineering

Weekly lecture and tutorial schedules are tailored by the individual lecturers to the needs and progress of the students within each group. Academics liaised informally with the module leader and their colleagues on the progress of each group, and the tutorials / examples used were reviewed to ensure parity and consistency across the iterations.

The module currently consists of a combination of formal lectures and practical workshops. Students were able to access the lecture notes via handouts distributed at each lecture. A series of tutorials and working exercises enabled the students to progress the theory on actual working drawings, building a portfolio of drawings through the module. Whilst this delivery mechanism has had some success the anticipated increase in student numbers projected over coming years will require a new methodology for delivery of the module. The department has embarked on developing an 'e-learning' approach to the module that will

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allow students to learn the technical concepts in a more autonomous way.

USER REQUIREMENTS CAPTURE

In order to best identify the requirements of the new system, both a questionnaire survey and focus groups were undertaken. These were divided into 2 sets, to identify salient issues relating to both students and academic staff needs.

The academic staff highlighted some key areas of concern with the current methodology of delivering the module, which would need to be addressed. One significant area was the student's lack of knowledge and understanding of how CAD is applied to architectural drawings. Due to the high number of students taking the module, the classes were now focusing on teaching the technical principals of CAD rather than the application of the tool to architectural design. This was a removal away from some of the key learning outcomes of the module and as such was required to be addressed. The large overall group size was also creating a significant variance of knowledge and understanding between students. Subsequently, this has lead to difficulty in reviewing and analyzing the progress of large groups with mixed ability. Due to the large group size, the cohort had been divided into 4 individual groups and a concern over the continuity and parity of learning across the lecture iterations also arose from the academic staff.

Based on the outcome of the academic staff focus groups, the key user requirements for the academic staff delivering the module included the development of key 'stage-gate' exercises to an e-learning methodology and the enhancement of students' knowledge and understanding of architectural drawings and how CAD is applied to this paradigm.

In addition to the requirements of the academic staff, a questionnaire was devised to obtain student input into the new proposed approach. The questionnaire obtained information pertaining to how students perceived the module at the current time and how elements of the module operated. In total six sections were defined in the questionnaire and these included:

- Student demographic – a wide range of students take part in the module with a diverse age range and study pattern. Additionally, students study the module in different locations and various time slots within the week. This information was obtained to view potential skew in the results with respect to age and cohort.

- The Learning Environment – This allowed the review of whether students were able to interact with the sessions due to ability to see the Audio-Visual equipment and included any specific problems they had with the software used during the teaching.

- The Current Learning Handouts – This reviewed whether students were able to follow the existing paper based handouts. This also reviewed whether students utilized the electronic versions of the handouts (in pdf format) that were available on the current virtual learning environment.

- The Lecture Delivery – This reviewed how lectures were delivered and allowed analysis of different lecture styles to be reviewed and analyzed to identify specific problems that occur due to multiple iterations.

- Previous CAD Skills – This allowed the previous knowledge of the software tools and concepts to be reviewed in conjunction with the previous responses.

- Current CAD Skills (Self Assessment) – This allowed students to provide a self assessment of the skills they thought they had developed through the current course structure.

Students who had recently completed the module were asked to complete the questionnaire on a retrospective basis and complete the questionnaire based on previous experiences. Additionally, students who were currently undertaking the module were asked to complete the questionnaire based on their experiences to date. The questionnaire was provided to current students in the final half of the module and so their ongoing experiences could be recorded. In total a response rate of 87% was achieved from all students who completed the questionnaire. The questionnaire utilized a four-point Likert scale for responses that elicited a range of responses to the questions. A simple percentage based analysis was undertaken on the questionnaires to determine the most significant responses, which could then be further reviewed towards the development of the e-learning approach.

The students identified several key requirements for the new e-learning approach. Students reiterated the need to access handouts/taught material online in order to continue their learning outside of the lecture or tutorial. Students also identified difficulties in the current methodology when learning fundamental CAD concepts such as layers and coordinates. Some paper exercises had been developed which had been of assistance to students; however, the transformation of these concepts into a digital technique would provide a better method of understanding. The application of CAD to architectural design was highlighted as a key limitation in the current approach and a significant student requirement was a method to bridge the gap between CAD concepts and architectural design using real life examples.

PROPOSED APPROACH

Based on the user feedback and in conjunction with dedicated focus groups, a new proposed approach was developed that would enable key CAD concepts to be taught through an 'e-medium' to large groups of students. This approach would allow students to develop the technical CAD skills required through a 'stage gate' e-learning approach, whilst leaving academics time to concentrate on the adoption

and implementation of the technical CAD skills to architectural design

The new approach will implement 5 key learning blocks that will form the core of the technical teaching of the module (Figure 1). These 'e-learning objects' would form the backbone of the e-learning strategy, around which the other teaching and learning requirements would be developed and incorporated

From a detailed review of user requirements, it was found that students are able to learn the direct commands needed to operate the CAD system with relative ease (for example the button pushed to draw a line on the plan). However, students struggled with 4 key concepts that underpin the CAD process. The use of coordinates is a key theory in creating accurate drawings, however many students fail to grasp the concept of drawing to a coordinate system.

Similarly, students found it difficult to grasp the concept of layers to control the view of a drawing and how layers can be used to build up a complete drawing from a range of constituent parts.

The utilization of 'blocks' of objects within CAD design is key to generating efficient files, however as a block is an abstract concept and may not in itself generate geometry, students had problems understanding the concepts. Finally, the issue of scale presented concerns as students are taught to draw using digital units of 1:1, which then need to be converted / scaled in order to be printed out.

The e-learning objects will provide students with non-CAD specific exercises that cover the concepts rather than software specific operations. This was a conscious decision taken during the development of the proposed approach to ensure that students obtained a deep understanding of the concepts, which could then be applied to a variety of specialized CAD software packages.

However, students are still required to learn how the concepts are implemented within a specific software package. In the case of this study, the students are required to implement the concepts using AutoCAD software. Therefore, CAD specific exercises are provided that consolidates the concepts in a practical application. For example, the coordinate learning object is connected to students drawing a line between two known points using the coordinate values provided.

Within each of the key elements, the use of a Computer Aided Assessment based 'quiz' will be used to test the knowledge of the students on the concepts covered in the e-learning object.

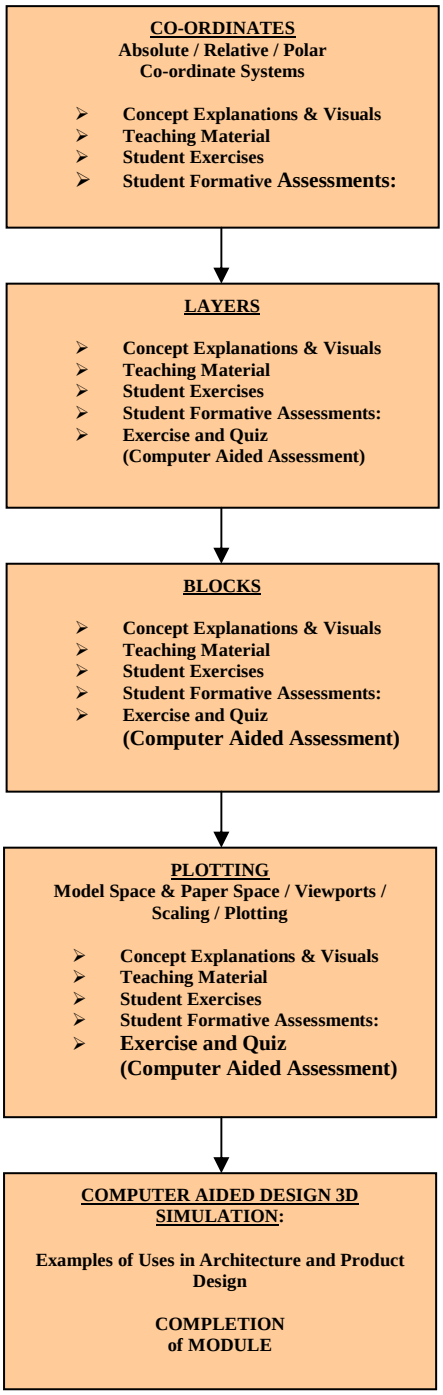

FIGURE 1
REVISED MODULE APPROACH

A further key issue raised by the academic staff was the ability to formatively review the progress of such a large cohort of students. In order to facilitate this type of assessment, the new approach proposed the development of a 'stage-gate' approach, which only allows students to access a more advanced topic once a preceding one has been successfully completed. Each of the e-learning objects will comprise a formative quiz at the end of the session that if completed successfully will allow the student to progress to the next level. The quiz contains multiple choice questions

based on tasks completed during the previous phase and students are required to answer all the questions correctly in order to proceed to the next level. Questions are mixed and contain some theoretical questions such as the definition of coordinate systems and some questions that show several solutions to a problem. An alternative question shows a range of commands and asks students to select the correct command to complete a task.

ON-LINE TECHNIQUES

The University of Wolverhampton has adopted a dedicated virtual learning environment (VLE) called WOLF (the Wolverhampton Online Learning Framework). This toolkit will provide the vehicle for the delivery of the proposed approach (Figure 2).

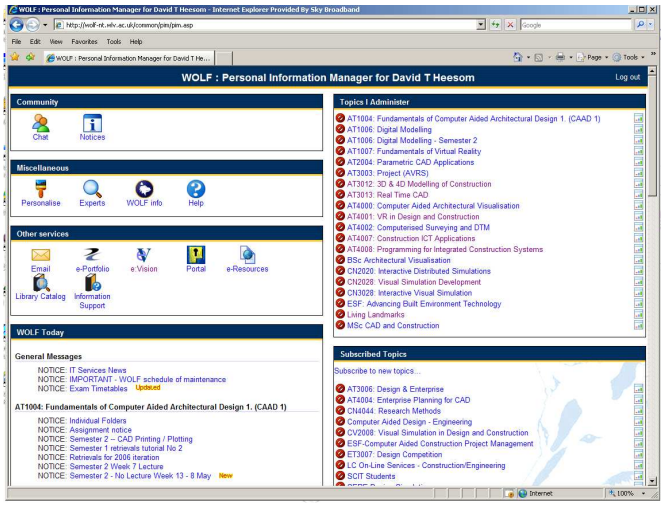

FIGURE 2
WOLVERHAMPTON ONLINE LEARNING FRAMEWORK (WOLF)

This internet based VLE provides students with the opportunity to access information at any time and is key to the University success in achieving the 'Learn Anytime, Anywhere' strategy. The teaching material for learning the technical CAD commands will be developed, utilizing a combination of computer generated images and 'videos' and textual explanations. The research has started to develop animated handouts which show students a video based tutorial to assist in understanding the steps required to use the software (Figure 3).

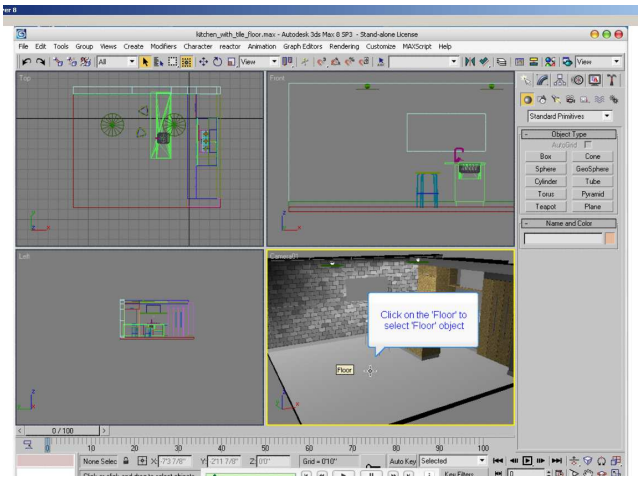

FIGURE 3
ANIMATED HANDOUT VIDEOS

Additionally, in response to the concerns of the lecturers and their request to improve the students lack of knowledge and understanding of architectural drawings an additional teaching and learning resource is being generated. The University of Wolverhampton has recently adopted a web folio system called 'Pebblepad' which allows students and lecturers to develop; share and critique work in an virtual space (Figure 4).

This environment provides the students with a resource of information, whilst tasking them to research and gain a greater understanding of architectural drawings and how the technical CAD skills obtained may be implemented within architectural design. The site is still under development and it is envisaged that this portfolio will provide supplementary e-information for each of the learning sessions.

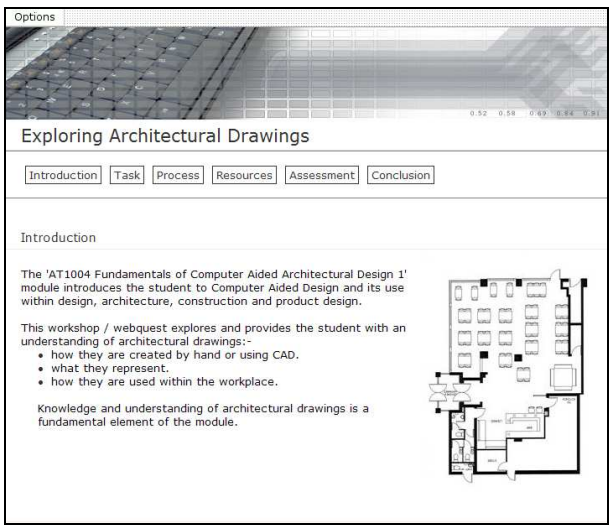

FIGURE 4
ONLINE PORTFOLIO UTILISATION

The web portfolio also provides students with the ability to upload CAD work and share this work such that it may be critiqued by peers and / or academic staff. To better facilitate this formative method of feedback, the module will utilize

'peer mentors' who will act as a critical friend to the students. As this module is studied at level one of the undergraduate degree program, final year students and postgraduate students will be used to provide feedback on design work undertaken.

FURTHER WORK

The work is currently ongoing and the system is still under development. However, the team has already began to identify further areas of work that will further enhance the system. The system is due to be rolled out to delivery of undergraduate modules in September 2007 and following this a review of the existing and proposed methodologies can be undertaken (however it is noted that there are significant variables to be taken into account such as different cohorts and varying skills sets within the cohorts).

The department of Architecture and Product Design is currently leading the investigation into the design of physical spaces used for e-learning within Higher Education Institutions (HEI's). It is envisaged that theses two studies will link to provide an integrated solution for e-learning that not only encompasses the technological aspect but also the physical space required. This is key to the delivery of ICT based design modules where some elements of the syllabus require CAD tools whilst still needing access to more traditional architectural design based information such as plans and physical models.

The final stage of the e-learning objects specified in Figure 1 are further being enhanced to bring 3D models into the teaching of construction details and how these link to the CAD representation. Within the UK, it becoming more difficult for students to visit construction sites to see the physical representation of there CAD drawings and so an alternative methodology is required. This study is proposing the utilization of high level 3D and 4D (3D + Time) simulations to demonstrate to students how there CAD designs / details are converted into architectural products. This will negate the need for site visits whilst still providing students with a visual representation of the construction site.

The project research team is also currently investigating how CAD is integrated into the design process. Currently, students are taught the concepts of 2D before being allowed to progress to generate 3D CAD models. One area of investigation is to reverse this process with students learning to create designs in 3D first and then abstract the 3D representation into a 2D form.

ACKNOWLEDGMENT

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