Enhancing students' strategic use of Computer Assisted Design (CAD)

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Introduction

The focus of this case study is the development of a web-based resource to enhance students' learning experiences in relation to computer-aided design. The tool was developed through a process of collaboration between engCETL, Dr Ian Campbell and his colleagues in Loughborough University's Design and Technology department. At the outset of the project, the intention was that undergraduate students taking a Year 1 module on *Computing for Designers* would be the main users of the resultant e-tool – though it was recognised that its generic qualities would in all likelihood result in its adoption for use in a wide range of other contexts.

Context

Computing for Designers is a core module for first year undergraduate students on the Industrial Design and Technology Programme offered by Design and Technology at Loughborough. Typically, the number of students is approximately 130, and the teaching of the module is shared by three members of staff from the department. The stated aims of the module are for the students to: obtain a good understanding of essential computing skills and develop CAD modelling skills in the context of Industrial Design and Technology.

The students are expected to commit 100 hours of their time to studying this module, which in terms of methods of teaching and learning consists of a series of computer-based sessions led by a tutor usually delivered in 90-minute blocks. The rest of the time is devoted to self-regulated study during which the students are required to complete a series of practical design exercises and assignments.

The *Computing for Designers* module offers students an introduction to computer systems, file handling, university networked applications and three-dimensional (3D) CAD modelling. The last of these provides students with an introduction to: fundamental modelling principles; feature modelling tools; applied features; basic modelling strategies; extracting two-dimensional (2D) drawings; and creating assemblies. Assessment of the module is by means of 100% coursework, the assignments consisting of two computer-based exercises/reports (each weighted at 50%) – the first to be completed in Semester 1, and the second in Semester 2.

Evaluation of the CAD assignments submitted by students taking the *Computing for Designers* module showed that many of them did not understand the need to adopt an appropriate modelling strategy when creating their 3D CAD models. Research undertaken by one of the department's PhD student (Allsop, commenced 2002) into developing learning strategies for CAD indicated that: *"a meta-level approach to the teaching of CAD, i.e. teaching 3D modelling strategies rather than tool-based tactics can improve a student's grasp of CAD tools significantly"*. In addition, preliminary results from that research showed that students following such a strategic approach in their CAD modelling assignments achieved marks that on average were 10% higher than those attained by their peers.

Problems

As part of the research referred to above, a web-based tool had been created as a method of supporting students in the development of their strategic skills in 3D modelling. However, at that stage it was considered to be *"rather rudimentary"*, and *"to require further development"* before it could be brought into more general use with students. In addition, the web-based learning tools available for use at the time from commercial sources were thought to be inadequate for the purposes they would be required to serve in the *Computing for Designers* module. This is because all these tools were aimed primarily at teaching users the vendor's own particular software version of CAD – and in so doing rarely addressed the generic meta-level aspects of modelling strategies needed by the students taking the *Computing for Designers* module.

The academic staff in Design and Technology responsible for the delivery of the module concluded that an improved web-based resource was needed, which undergraduate students could use in their own time and at their own pace – an e-learning tool to dovetail with their weekly teaching and tutorial sessions. It was anticipated that such an e-learning resource would provide a flexible, easily accessible and appropriately detailed aid to student learning, which would consolidate the concepts and techniques to which they were being introduced in the lectures and tutorials on 3D CAD modelling strategies. In addition, it was thought that the Design and Technology department's postgradute students with insufficient CAD experience could make use of the resource, as a means of developing their ability to adopt appropriate modelling strategies when creating 3D CAD models.

It was the determination to address these problems that prompted Dr Campbell, with the support of his departmental colleagues from Design and Technology, to submit a development project proposal for consideration by engCETL in May 2005.

Project aims

The main aim of the project approved by engCETL was to develop a web-based learning resource that could be used to enhance the experiences of Industrial Design and Technology students especially in relation to the Year 1 *Computing for Designers* module. However, it was anticipated that after a year of use in this context, the student feedback could be used to further develop the tool, so that it could then be disseminated in its refined form to other schools and departments across Loughborough University (especially to those in engineering) – and potentially to other Higher Education Institutions.

Key dates

2005 Project proposal submitted to engCETL
2006 Initial work on the development of the tool
2007 CAD tool piloted with a small cohort of undergraduate students
2008 Adoption of the tool for use with students

Project actions

The first stage of the project involved an analysis of the existing tool developed for use with students in Design and Technology with a view to identifying how it should be re-designed and what new content was needed in order to increase its effectiveness.

The second stage of the project was concerned with the development of the tool in order to improve its usability/functionality including:

- A section that would take the users from concept generation through to presentation and animation – the students consulted on this matter being of the opinion that their peers would be *"hooked in if they could take their model through the whole process"*.
- A section on how to recover the model when an 'error' message appeared on screen.
- A 'quick refresher' screen, which it was thought would be particularly useful for student users, as it would provide them with tips on how to get back into CAD after a break (e.g. over the summer vacation).
- A more effective guide on how to implement the strategy output to the product to be modelled.
- An index of all the icons/features referred to on the site, and where they could be located on menus and by means of shortcut icons.

In the third stage the emphasis was on improving the design of the tool including: the inclusion of a 'help' menu; the substitution of animations for text in places in order to make the resource more visual; further improving the navigation; and a facility that would allow users to select and see all of the possible features of a model that could be used in their designs, from the most effective through to the least effective.

In the fourth stage, the tool was sufficiently well developed for it to be used and evaluated by a group of Year 1 students on the *Computing for Designers* module. After an initial introduction to the principles of design a group of students were given access to the tool for two weeks in order to become familiar with its use prior to providing evaluative comments on its effectiveness. The student feedback was then used in the fifth stage to develop a final revised version of the tool. For example, the students questioned were of the opinion that the tool was difficult to navigate effectively, and that there was a need to incorporate additional written instructions into the animations.

Project outcomes and impact

The collaboration between the educational technologists from engCETL, and the staff and students from Design and Technology outlined above, meant that web-based tool that which emerged from the development process was robust, usable and 'fit' for the purposes it was intended to serve, and the contexts in which it was designed to be deployed. The resultant software works at two levels: the feature level, which shows the user a range of basic strategies for modelling an individual part of a larger design, and the assembly level, which shows a basic range of strategies to create a series of links between the individual parts. These links ensure that when one feature changes it automatically alters the other parts to which it is connected – thus saving student users a considerable amount of time when making

alterations to the CAD models they are in the process of designing. It is not surprising therefore, that since October 2007 the tool has been widely used by undergraduate students in Design and Technology, especially in connection with the *Computing for Designers* module. According to their tutors, the feedback from the experience thus far is that: *"the tool has been well received by the students"*. The department's postgradute students with limited previous experience of CAD have also been encouraged to use the tool to enhance their ability to adopt appropriate strategies when designing their own 3D CAD models.

In addition, because the tool was designed to be generic in its application to 3D CAD modelling, its potential has been recognised in disciplines other than Design and Technology, so much so that it has come to be used by students at Loughborough University in departments such as those in engineering. Awareness of the resource has been raised through planned dissemination activities, including webpages on the engCETL and Design and Technology websites and input at professional development events. Knowledge has also been spread through a variety of informal mechanisms such as those that centre on engCETL (e.g. meetings of its panel of seconded academics and the use of the centre's learning spaces and resources by students as a place to meet for collaborative activities such as group projects). Similarly, students on their Diploma in Professional Studies (DPS) and Diploma in Industrial Studies (DIS) placements are also helping to extend awareness of the CAD tool beyond the university to workplaces such as the industrial companies and design consultancies, where they are employed during their 'sandwich year'. These formal and informal social interactions within naturally-occurring networks of staff, students and professionals (what Lave and Wenger, 1991 and Wenger, 1998 have referred to as 'communities of practice') are proving to be an effective means of disseminating this and other e-learning resources developed by engCETL.

Currently, the tool is also being used outside of higher education as one of the 'recommended resources' of the 'CAD/CAM in schools program'[1]. This scheme, which is now supported by the Department for Children, Schools and Families, was first established in 1999 with the aim of ensuring that all secondary schools in the UK have access to CAD/CAM provision, and the necessary resources. As a 'recommended resource' the CAD tool developed by means of this engCETL development project was used in the initial training of pilot teachers, and is now used in schools nationally.

Discussion

The main outcome of this engCETL project has been the development of a web-based tool for use in enhancing students' learning experiences in relation to the computer-aided design of 3D models in a wide range of contexts. However, as Barker (2004) has argued, discussion of the use of e-technology resources in teaching and learning involves consideration of both the nature of the e-materials themselves and the ways in which staff and students actually use them.

One of the features designed into this particular e-tool is that a great deal of its content is visual, with much of the guidance on 3D modelling strategies being presented in the form of animated diagrams. Indeed, during the development process animations were deliberately substituted for text in places in order to make the resource more visual on the assumption that student users would find this to be a

[1] www.cadinschools.org

more effective form of communication. However, feedback from the Design and Technology students subsequently involved in piloting the tool was that from their perspective, these animations could be improved by *"the incorporation of additional written instructions"* i.e. by the inclusion of words of explanations to reinforce the messages, which in the main were being communicated by means of visual images. Feedback from other evaluations of the use of e-learning tools (e.g. those reported by Barker op cit) suggests that with regard to the understanding of concepts and where visualisation of physical form or change can be difficult *"animations do make it click"* for students (EASEIT-Eng, 2000-2002, case study 8). Barker also notes that students often remark that they find animations, if not clearer than textual explanations, to be *"at least something which keeps you interested"*. However, the same author goes on the point out that it should be remembered that *"some students prefer verbal or textual presentations to visual ones"*.

According to Gardner's theory of multiple intelligences (1983 and 1993) these differences in students' learning preferences, noted by Barker, could stem from their 'ways of mind' as opposed to their general intelligence. In advancing this theory, Gardner argued that an individual student does not have a single innate general intelligence (or IQ), but an array of intelligences drawn from a range, which includes amongst others the visual/spatial, verbal/linguistic and logical/mathematical. This is not to say that any one of these 'special abilities' or 'cognitive styles' (Morgan, 1996) will necessarily be dominant in any individual student - but they will all be present to a greater or lesser degree. Hence, some students will have a preference for materials presented to them verbally or in the form of written text, whilst others will have a tendency to prefer information and ideas communicated to them in the form of visual images such as pictures and diagrams. Similarly, these cognitive differences might well lead to students having preferences with regard to the methods which they use to communicate their knowledge and understanding to others – including their tutors. The 'belt and braces' approach used in the design of the CAD tool – combining the textual with the visual – would seem to have the merit therefore, of affording students, irrespective of subtle differences in their individual 'cognitive styles' or aptitudes, the opportunity to further their learning when using it to develop their own 3D CAD modelling strategies.

With regard to the use made of the CAD tool in Design and Technology and subsequently in other departments at Loughborough, it has never been regarded as a free-standing resource – as a method by which students could learn about 3D CAD modelling strategies entirely online independent of any other teaching inputs to their learning experiences. It was in fact developed originally for use as an integral part of a well-conceived strategy for the delivery of a particular module in which teaching, learning and assessment were closely integrated or in 'constructive alignment' (Biggs, 1999) in order to facilitate the achievement of the intended learning outcomes with regard to 3D CAD modelling. The methods used to realise those learning goals reflected deliberate decisions on the part of those responsible for the design and delivery of the curriculum for the module, of what they regard as the best and most appropriate means of promoting effective student learning. In this case, a mixture of 'traditional teaching practices' and e-learning – a combination that some writers refer to as 'blended learning' (e.g. Australian National Training Authority, 2003; JISC, 2004). Others (e.g. Oliver and Trigwell, 2005) have suggested that the approach they have adopted could equally be thought of in terms of 'mixed pedagogies' i.e. teacher-led lectures, workshops and tutorials combined with assignments in which the students, working in their own time and at their own pace, make use of the tool and other resources to develop their ability to design

3D CAD models. What is significant from this perspective is that the tutor-led sessions are congruent with the students' self-regulated learning, and the way in which the whole of this teaching-learning process is supported by the use of the CAD tool – a resource developed with this specific purpose in mind. There can be little doubt that in this case the technology-based learning tool under consideration is *"integrated into the course"* so that to the student it seems to be as *"natural a part of the course as lectures, tutorials and lab classes"* (Barker, op cit).

Conclusions

This project has succeeded, through close collaboration between educational technologists from engCETL and staff and students from the Design and Technology department, in developing a robust and highly usable web-based tool for use in supporting students' learning experiences in relation to 3D CAD modelling strategies. The tool was designed with a clear vision of how it could ultimately be used to best effect within a teaching-learning context provided by a 'blended learning' or 'mixed pedagogies' approach to the delivery of the curriculum. However, because the guidance it offers is generic it is not surprising that it is being increasingly used – not just across subject departments at Loughborough University, but beyond in a wide range of contexts where the acquisition of capability in 3D CAD modelling is part of the curriculum.

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