Fashionable Education: Is RGB the new black?

Karen McMenemy
Queen's University Belfast
k.mcmenemy@ee.qub.ac.uk

Stuart Ferguson
Queen's University Belfast
r.ferguson@ee.qub.ac.uk

Abstract

The last decade has shown a big revolution in learning and teaching across primary, secondary and tertiary level education with particular reference to mathematics and science.

Whilst this revolution has been ongoing, the developments in real-time 3D stereo graphics have allowed the production of realistic virtual worlds and computer generated animated movies by utilising low cost equipment and easy to use software.

This paper presents the authors findings as we introduced the concept of computer graphics and computer animation into the assessment procedure for a module of a degree program in Electrical and Electronic Engineering: Virtual Reality Systems.

The fundamental question that needs to be addressed is whether this source of fashionable education is simply a fad or will it become a closet staple? That is, does the use of educational entertainment improve the learning and teaching outcomes within science based subjects.

Our results show that by including a significant proportion of peer reviewed design material into the syllabus students become highly motivated and achieve a deeper level of comprehension of the subject material in the course.

Introduction

To all intents and purposes, the world we live in is three dimensional. Therefore, if we want to construct a realistic computer model of it, the model should be in three dimensions.

Since the foundation on which 3D computer graphics is built is geometry, then computer visualisation offers a wonderful tool for communicating geometry and geometric ally based scientific principles to students from mathematics, computer science, the natural sciences and engineering, as many researchers have come to appreciate (Majewski, 1999; Ruthven and Hennessy, 2002; Majewski, 2004).

Integrating geometry with scientific 3D visualisation offers a new dimension in communicating the excitement of science. In addition, as simulation based design and ultimately virtual reality becomes increasingly important in engineering practice, it becomes equally important to integrate visualisation techniques into the undergraduate engineering curriculum.

This paper reports on a case study and its outcomes where 3D computer animation and virtual reality engineering experiments were used to enhance the teaching of Engineering within the School of Electrical and Electronic Engineering, Queen's University Belfast.

In the following sections we document the structure of the Virtual Reality course and describe how we utilised computer graphics, animations and virtual reality experiments to motivate the students into life long cognitive learning.

Background

Learning, as stated by (Project E^3, 1995) is essentially about producing changes in knowledge, skills, understanding and attitudes through experience and reflecting upon that experience. Effective learning involves deep understanding, reflection and the capacity to transfer learning from one context to another.

Having fun while learning often enhances the experience and easy to use, freely available 3D animation software is an ideal adjunct to a course that has as a major component the theory of computer graphics and visualization. We used the open source package Open FX (Ferguson, 1999-2005) to enhance the learning experience of students undertaking the Virtual Reality Module at Level 2 of a Masters Course in Electrical and Electronic Engineering. By combining both a theoretical and practical teaching environment it has been shown that the learning outcomes for this module were achieved at a deeper and more enhanced level of learning than the motor sensory learning undertaken by most students studying engineering.

It has been shown that student approaches to learning are related to their teachers' approaches to teaching (Triggwell *et al,* 1999). A deep learning approach, where there is the possibility of a conceptual change and deeper understanding, can constitute an enhanced learning outcome (Marton & Booth, 1997). It is the process of how we achieved this deeper level of understanding in students undertaking a course which we describe in this paper.

The Virtual Reality course in question attempts to survey the important issues surrounding the creation and experience of Virtual Environments (VEs). The many reasons and methods for creating virtual spaces are discussed, as well as their implications. Examples of existing VEs are shown whenever possible, but students should learn primarily by creating their own VEs and by presenting their environments in critique sessions.

Thus the course aims are defined as follows where a teaching aim is couched in terms of what the lecturer is trying to do, grounded in what the subject demands:

- Describe the historical development of VE

- Describe the basic principles of VE
- Evaluate current VE hardware and software
- Identify and describe applications for current VE hardware and software
- To create and evaluate simple interactive virtual environments
- Identify and describe social and psychological factors and implications of virtual reality

The course projects were designed to require students to use a 3D animation software package to design virtual objects and environments. Practical work of this kind allowed students, not only to acquire knowledge of VEs, but also apply that knowledge in the work place and indeed all aspects of life.

With this in mind, the Biggs' structure of observed learning outcome (SOLO) taxonomy (Biggs *et. al.*, 1982) was utilised to help develop module learning outcomes. A learning outcome is something that students are expected to know or be able to do on completion of the module. In addition, it is critical for effective learning that the defined learning outcomes can be assessed.

The module learning outcomes have been defined as:

- To demonstrate the ability to create a virtual environment both theoretically and practically through laboratory sessions and written examination
- To demonstrate an awareness of the moral and ethical implications of Virtual Environments through class discussion and written examination
- To design virtual environments for various applications through the creation of realistic virtual environments
- To evaluate virtual environments designed by others through peer and self assessment of coursework
- To enhance key skills (presentation and written) through the oral and written presentation of coursework objectives

It is the assessment criteria for this module that forms the basis for the enhanced learning outcomes.

Assessment of Student Learning Outcomes

An assessment is a tool designed to observe students' behaviour and produce data that can be used to draw reasonable inferences about what students know. Present day unseen examinations, which dominate assessment in tertiary education, may measure a students' knowledge of basic facts and procedures and may produce an overall estimate of proficiency for particular subject knowledge. However, they fail to capture the breadth and richness of knowledge and cognition.

The time is right to rethink the fundamental scientific principles and philosophical assumptions that underlie current approaches to educational assessment. Mislevy (1993) noted 'It is only a slight exaggeration to describe the test theory that dominates educational measurement today as the application of 20th century statistics to 19th century psychology'. Indeed advances in the understanding and measurement of learning offer the potential for a much richer and coherent set of assessment methods.

Effective assessment begins by defining clear and explicitly stated purposes for the module. Clear and shared goals are the cornerstone for assessment that is useful and focused.

Learning is a complex process and variation in teaching and learning strategies and educational opportunities contributes to students diverse ways of learning. As such, variable forms of assessment were devised for this module so as to monitor what students know and what they can do with what they know.

Whilst standardised tests were still utilised to encompass 60% of the module mark, the remaining 40% was utilised for continuous assessment.

As such, the students were asked to develop a realist VE using planar polygons in a 3D modelling software package. The specification for this environment was left open to the student's imagination. The only criterion made was that the environment should contain models constructed by the student rather than generic models that were imported. A virtual tour had then to be created and rendered using animation software that would produce a good degree of realism and take the form of a short movie.

Students were asked to submit a portfolio of their work at the end of the academic semester. This portfolio was a collection of work that also illustrates the student's learning and development over time. Assessment of such form calls for actual performance from a student and can monitor the change and growth in a student's ability over time. 15% of the module mark was awarded for the technical competency and aesthetical appeal of the created virtual environment as well as their written evaluation of the creation of the virtual environment. Therefore this affords the student the opportunity to assess themselves. They had to reflect on their learning and growth and link these to the objectives of the coursework and to the module in general. Self assessment involves students in a process of self discovery and analysis that has educational benefits beyond an individual course.

It has also been shown that public events in which students present their projects for assessment by a team or panel of their peers benefits student learning. This also enables a means of sharing their experiences with other students. 10% of the module mark was based upon the quality of this presentation.

Whilst the case study discussed in this paper utilises a module in Virtual Reality, which blends itself well to the development of 3D environments, the same approach can be applied in any teaching environment that requires visualisation or graphic design.

Implementation

In our specific experiment the students were issued with the coursework specification in the third week of a 12 week semester. The coursework specification was left intentionally vague. Students were asked to generate a virtual environment using models that were both imported from standard libraries and self generated. They then had to generate an animation which tours their virtual environment.

Completion of the virtual world was required for week 10. Presentations of the student's virtual worlds were timetabled for weeks 11 and 12.

Students were given a brief two hour introduction to the 3D software, in addition to a number of tutorial exercises. Thereafter, online student discussion groups were set up so that students could communicate with each other about any difficulties they were having along with potential solutions.

Experimental Work

Experimental work was set to reinforce the important aspects in the design of a virtual environment:

- Realistic surface properties through real-time surface texturing (shaders)
- An appreciation of stereoscopic imaging for 3D immersive environments.
- Haptic effects for sensory feedback.

These were simple experiments, the students used a C like shading language to code up basic material designs, a digital still camera to make stereoscopic image pairs/movie clips and force feedback technology to design a variety of virtual forces, e.g. driving a vehicle over a rough road.

Experienced student demonstrators were on hand to provide expert guidance and carry out the laboratory assessment. That is, for each lab a student must complete all required practical work and produce a report. In addition, they must also self-evaluate the work they completed and also the laboratory itself by completing a minute form. They must also present their work to their demonstrators and must then answer any questions relating to their findings. Each laboratory accounts for 5% of the final module mark, resulting in a total of 15%.

Evaluation

Evaluation permits the critical question to be asked and answered: have the goals and objectives of the module been met? The simplest measurement of outcomes is by examination. However, examination results cannot measure deep learning and lifelong learning, which must now be accepted as ultimate learning goals. Therefore, a more pragmatic approach in educational evaluation for these parameters is to focus on students' perception of their experience within a learning program. This is the primary reason why students were asked to submit a self evaluation section with their formal reports and why they were asked to assess their peer's presentations.

It is the quality of the submitted practical work and students reflections of their own work and that of their peers that is investigated.

The quality of the practical work undertaken by the students and clarity of their formal reports documenting their work came as a large surprise to us. We knew from informal student comments that the class as a whole were taking the assignment very seriously. It also occurred to us that most seemed to be spending an excessive amount of time producing their virtual environments.

Having marked their assignments it was evident that much class discussion has taken place with regards the utilisation of (a fairly complex and under-documented) software application. Many students used robots to stimulate movement and many image processing effects, two topics that they had to elucidate from the software help files since these effects had not been explained to the students. They had been given a two hour introduction to the software and this covered the basics of generating models and creating simple animations using key-framed moving objects. Many students also added soundtracks to their animations. Again this had not been identified as a requirement – in fact it had not even been suggested. Of course audio effects do add to the quality and general ambience of the created environment and this indicated to us that students were proud of their finished pieces and wished to display them to the highest quality.

On reflection, the process of creating a 3D environment and then creating a tour of that environment is a visual learning process that not only provokes enjoyment but also encourages professional standards with regards to demonstrating the quality of an individual's own work to their peers through the group presentations.

However, it is clear from the standard and quality of the students work that they placed too much emphasis on this portion of the module assessment. One student made a very revealing comment when questioned about the assessment procedures for this module:

"I kind of know a lot of the animation design was left up to ourselves but I have never done a module like this before and so found it hard to write up. Format wise I just feel that the actual design brief could have contained a little more detail .i.e. how many models were to be built or how long the animation should be."

When writing the design brief for the assignment we specifically make it very abstract as we did not want to influence the students thought process. However, it is now clear to us that a more detailed brief is necessary to prevent students spending too much time on their design, probably to the detriment of other subjects.

Race and Brown (1998) report that when reports are assessed students may spend too much time producing then rather than actually understanding the subject matter. We would concur with their thinking on this matter. Not only were the student animations of a standard far exceeding the project specification, their reports documenting their progress were also of a superb standard.

The presentations were further evidence that students clearly enjoyed using their technical experience in conjunction with their imagination. Students were able to critically evaluate their environments and detail clearly suggestions for further work. This explanation demonstrated that they had grasped a clear understanding of the modus-operandi of the 3D software and could critically asses its usefulness in terms of increasing the realism of the presented environments.

The presentations were peer assessed. Peer assessments give learners a greater ownership of the learning they are undertaking as assessment is not a process done to them, but is a participative process in which they are themselves involved (Brown and Knight, 1994).

Having received feedback from the students as to the benefits of peer assessment it appears the students agree with this theory. One student indicated:

"I do feel that getting the peers to assess the work was very worth while and that having to present the animations was educational. To see what other pupils had done was an insight to some of the high standard of work and the effort that some had put into their animations."

Harris and Bell (1994) have stipulated that students need to be given feedback so that the method of assessment is of benefit to both the learner and the teacher. We therefore asked students to collect their assessed reports and animations from us so that we could deliver their feedback. Those students that did ask for their feedback indicated how useful they found this procedure.

Overall we believe that this assignment achieves educational objectives, not only in the cognitive domain (knowledge, comprehension, application, analysis of the technology) (Bloom, 1956), but also in the affective domain (positive response from students, attention and willingness to receive) (Krathwohl, 1964).

Conclusion

After posing the question as to whether the use of an element of entertainment in higher education improves the learning and teaching outcomes we have reached the conclusion that it demonstrably does. Our paper outlined how this worked in an unexpected context: that of teaching the fundamental mathematical principles of virtual reality and computer graphics to engineering science students.

We found that a crucially important factor in obtaining a successful outcome was the method of assessment. The assessment of student learning outcomes is very topical in higher education. All too often higher education institutions view the commitment to assessing their students' learning outcomes as a periodic activity – usually driven by an accreditation visit. However, it is clear that assessment is intrinsically linked to the student learning experience. Good assessment procedures insert a feedback component into student learning. By diversifying the assessment criteria in the Virtual Reality Module we hoped to enhance the quality of feedback to the student. This feedback has a considerable impact upon the learning outcomes, since it encourages students to reflect on the feedback provided.

We would stress that this type of assessment is of very high importance when the student is given a significant degree of freedom in directing their own learning. In another course with similar syllabus where traditional assessment methods were used the outcome was not nearly so successful; in terms of the quality and originality of the students' coursework. It seems to us that where students acquire a sense of ownership of the assessment process they work harder. It positively contributes to the learning process and the development of critical and analytical skills in the student. It helps them to see the true significance of the fun element of the course and get the most out of it, sometimes without realising it.

An anxiety about this form of assessment proved to be groundless. In the overall assessment for the module, marks were not skewed higher than standard assessed engineering modules. In addition, the number of students failing was reduced to a level that is normally found in modules assessed by coursework only. We believe this is due to the strong participation and motivation encouraged by the form of continuous assessment and project work utilised within this module, which seemed to instil in the students a deep level of learning that helped them perform well in the traditional examination.

Wider Applicability

Virtual Reality by its very nature is multi-disciplinary in that it can be utilised in a variety of different ways to serve the different needs of a variety of subject areas. Obvious application areas would include architecture, medicine and dentistry where generating 3D views of areas of interest would give the student a more realistic impression of their chosen course material.

Our school plans to deploy our easy to use computer animation software and assessment procedures as part of a course for first year students simply as vehicle to encourage them to learn, by experience, the art of presentation giving and report writing. Our hope is that, motivated by the component of entertainment that it offers, they will build working relationships with their colleagues and come to discover some of the unexpected ways in which they can progress their professional development.

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