The Future of Multimedia Tools in Engineering Education

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Abstract

In this paper an outline is given of the development and implementation of a set of multimedia lecture notes for an introductory fluid mechanics course in a Civil Engineering curriculum. Particular aspects reviewed include the motivation for using multimedia as a teaching tool, the hardware and software platforms utilised, the essential components of the software, the methods for implementing the multimedia tools and monitoring students' responses to them. A survey of students taking the course after the multimedia tools had been implemented shows that: Overall 75% of the students rated the multimedia lectures as being more effective in enhancing the lecturing environment, 20% rated them as average and the remaining 5% as ineffective. In addition this survey also shows that the students find the computer-aided graphics and animations particularly beneficial in developing their understanding of the subject matter. Future plans for the development of the software are discussed. These include modifications to the software to make it suitable for student self-access and the development of bilingual support for the material. This software will then form the basis for modifications to the way in which the course is implemented. A greater emphasis will be placed on students learning independently and on discussion style lectures. Multimedia technology will therefore be further integrated into an existing teaching/learning environment to enhance these aims. The self-access system will allow for a more direct focus, in the lectures, on developing the attitudes and skills the students will need to become successful engineers in the next century.

Graduate Engineers in the Next Century

Multimedia technology will play an important role in tertiary education in the future. Questions are now being asked about the role of traditional approaches to teaching (lectures, tutorials and laboratories) in the future and indeed the role of the traditional university (Ward, 1996). However, educating engineers involves a great deal more than just passing on technical knowledge and skills. Although technical competence is a very important part of engineering education, it is equally important that graduate engineers have well developed growth skills and attitudes. These skills and attitudes enable the graduate to continue to develop and thrive in a professional environment throughout his or her career. Important components for graduate growth include skills such as self-learning, critical and creative thinking, effective communication, sound judgment and attitudes such as being self-confident, professional, responsible and mature. In addition graduates should also be socially and environmentally aware, and possess an appreciation of the related disciplines and their roles in engineering.

These growth attitudes and skills will become increasingly important in the 21st century, where engineers will be required to adapt to a constantly changing professional environment in order to take advantage of new technologies and hence remain competitive. These future engineers will be flexible and working with teams of people to solve difficult multidisciplinary problems. An ability to communicate effectively with other people with very different backgrounds and attitudes will be absolutely essential. The focus of engineering is to solve problems for people, therefore engi-

neers must not only be able to communicate effectively with a diverse group of colleagues, but they must also be able to discuss possible engineering solutions with the general public.

It is difficult to see how even the most sophisticated multimedia tutoring system could provide the necessary education for students of engineering in the 21st century. Undergraduate students indirectly learn a great deal from interacting with each other, graduate students, technical and clerical staff and faculty. Unfortunately, many students have a preference for dealing with computers, where they cannot be embarrassed and are in complete control of the communication that takes place. Self-access systems encourage this anti-social approach to learning and therefore limit the learning experience to technical knowledge and skills. Although such systems have considerable value for certain teaching/learning scenarios, they must be employed with care. It is important that in a rush to embrace the new technologies that surround us, we do not neglect much of the indirect learning that is taking place in our current teaching and learning environments.

However, it could easily be argued that within the existing systems we do not place sufficient emphasis on developing growth attitudes and skills in our students. The emphasis is largely on technical knowledge and skills, and the indirect learning described above is generally left to chance. Recent changes to the Civil and Structural Engineering curriculum at the University of Science and Technology (UST) place a more direct emphasis on the attitudes and skills necessary for professional growth. Changes include the introduction of courses designed specifically for this purpose.

Integrating new delivery systems into existing teaching/learning environments may also provide more opportunities for faculty to develop the necessary attitudes and growth skills in their students. In this way new technology (such as multimedia) is used to enhance existing systems, rather than to revolutionise or replace them. An example of such an approach would be to develop a self-access system which provides an excellent teaching and learning environment for students to cover the basic material in a course. Lectures (which could be conducted with smaller groups) would then focus on *discussions* of the material the students have learnt from the self-access system, with an emphasis on the more difficult concepts and problems. Apart from the obvious advantages in terms of developing students' communication skills and self-confidence, the system also encourages the students to learn in a more independent manner.

Implementation of such an approach requires a self-access software package to provide the necessary support for a course conducted in this way. Such a package is currently being developed for a first course in Water Resources Engineering (fluid mechanics), which is part of an undergraduate Civil Engineering programme. The software is being developed in two phases, beginning with the conversion of the existing lecture notes to a multimedia format.

Phase I: Multimedia Enhanced Lecture Notes

The Water Resources Engineering course focuses on the fundamentals of fluid mechanics and includes topics such as fluid properties, statics, kinematics and dynamics. More detailed information about the multimedia lecture notes for this course is given in Davidson (1996a), Davidson (1996b) and Davidson (1996c).

Motivation

Three educational initiatives provided the motivation for developing a multimedia form of the lecture notes. The first required that the notes be restructured to increase the emphasis on the essential concepts in the course. Students have a tendency to try to memorise all of the lecture notes, rather than isolating the essential ideas and viewing the remaining material as supporting those ideas.

The second initiative involved introducing more local examples into the course. This would increase the motivation of the students to learn the material, because they would see the application of the concepts to the world around them. In addition it encourages them to think about these concepts when they are outside of the lecture theatre, encouraging them to develop a deeper approach to learning the material.

Thirdly, there was a need to introduce motion into the many static diagrams which are utilised in presenting material on dynamics and kinematics. Many students find it difficult to imagine the motion of a fluid presented in a static diagram. Animation of such diagrams helps students to develop more physical intuition for the problems they are solving.

Multimedia provides a platform in which all of these intiatives can be incorporated into a single set of lecture notes. Unlike traditional delivery systems, with multimedia the frequent use of videos, still photographs, animations and graphics is possible.

The Software

The software was developed using Asymetrix's Multimedia Toolbook (3.0) on a Pentium 90MHz personal computer, with a 1GB hard disk, 16Mbytes of RAM, a sound card and a video capture card.

The software is designed in a color-reference layered structure. The top (green) layer represents a complete overview of the course. Navigation from here leads to the second (blue) layer at which the major topics are subdivided. In general these subdivisions involve separating the material into key concepts, derivations and applications, providing additional emphasis on the essential concepts in the course. These subdivisions then allow access to the third (yellow) layer, which contains a set of multimedia enhanced pages for the presentation of the detailed material. Colour coding is utilised throughout the software to help the students link objects, text and navigational components on these pages.

Computer-aided graphics are employed to enable the gradual construction of complex diagrams. This allows students to build an understanding of the figure in a step by step manner. These diagrams can be instantly erased and re-constructed by clicking a small number of buttons. Animations bring static diagrams to life in various places throughout the software.

Video sequences from the laboratory, which help to demonstrate the ideas being presented, are incorporated into the software. These videos are commonly 30 seconds in length and can be played at the touch of a button. Field videos and photographs are also integrated into the lecture notes, bringing a sense of realism to the material.

The software was implemented for the first time in the spring of 1996. Each lecture begins with the overview page and then I step through to the location of the material for the current lecture. This provides the students with a constant location reference for the material being taught, in terms of the overall content of the course. The format of the lectures is similar to that for overhead transparencies. However, it is important to note that a variety of delivery techniques are employed during a lecture. Although the multimedia lecture notes form the basis for the presentation, I frequently break to the whiteboard to emphasize key points and to get students more actively involved in the lectures.

Responses

The response of the students to the introduction of the multimedia lectures was monitored through surveys and a conceptual quiz. The survey results show that 75% of the students felt that the multiemedia lecture notes were effective in enhancing the lecturing environment, 20% indicated

that it had no effect and 5% thought it was ineffective. Written comments from the students show strong support for this approach. Criticisms focused on problems with the projection system, in particular a lack of colour definition and a blurring of the images near the edge of the projection screen. The survey results also indicated that the students felt that the most effective tools, in terms of generating interest in the material and explanation of the concepts, were the computer-aided graphics and animations.

A conceptual quiz was also employed to gauge the effectiveness of the enhanced lecture notes. This quiz comprises questions which are relatively simple, focusing on drawing diagrams and simple mathematical formulations which demonstrate an understanding of the concepts presented in the first part of the course (fluid properties and fluid statics). It was conducted, without warning, several weeks after this material had been taught. Apart from indicating the students' understanding of the concepts, it also provides information about their retention of the ideas presented in the early part of the course. It was first conducted in the spring of 1995 when the multimedia notes were not used and then again in the spring of 1996 with the multimedia delivery system in place.

Although the performance of the students in the spring of 1996 was generally better than that in the spring of 1995, these improved results were largely due to the information gained from the quiz in 1995. Misunderstandings highlighted in the 1995 quiz were specifically addressed in the multimedia lecture notes before its implementation in 1996. These included more detailed construction of free body diagrams and the general structural changes employed to assist students in isolating essential ideas. It is important to note that it is the education initiatives built into the software that improve the students' ability to understand and apply the material, and not the multimedia software. Multimedia is a convenient environment in which to implement such initiatives.

Another important gauge of the effectiveness of the multimedia enhanced lectures is my own personal reflections. In the two semesters prior to introducing the multimedia lecture notes, I had taught classes of 90 students using more traditional delivery systems. Coinciding with the introduction of the multimedia lecture notes, the class size grew to 132 (UST is still in the initial phase of its development). It was more enjoyable lecturing to 132 students with multimedia support, than lecturing to 90 students without it. Students were more aware of the relevance of any particular lecture to the course as a whole. The frequent use of sophisticated graphics, animations, photographs and video made it less difficult to maintain the students' attention. In addition students were able to grasp difficult concepts relatively quickly and move to asking more difficult and challenging questions.

Phase II: The Future

The multimedia lecture notes represent an improvement on the previous delivery systems employed for the Water Resources Engineering course. However, they do not provide a good basis for self-directed learning or a more discussion based lecturing style. To achieve this aim, a self-access version of the lecture notes is needed and at present is being developed. The self-access system is not designed to act as a tutor. Instead it is based on a lecture on demand approach. The students are able to access the lecture notes and 'play' a sound recording of the lecture associated with each page of notes. During this playback all of the onscreen components (graphics, animations and video sequences) of the presentation are also activated at appropriate times. Tutoring will continue to be provided by myself and teaching assistants, so as not to reduce the human interaction component of the course. The self-access version will have two major advantages for the students. One is that they will control the pace at which the material is presented to them and the second is that the presentations will be bilingual.

The system will be implemented on a voluntary basis in the spring of 1998. Several issues must be resolved before the use of the self-access system can become mandatory. These include ensuring

that all the students have adequate access to the software and are making good use of it. While the students are learning with the self-access software, I will not be on the spot to answer their questions. These and other issues will be resolved as the project develops.

In this paper I have described one approach to placing a greater emphasis on growth skills and attitudes in a traditional core course in Civil Engineering. This is achieved through the introduction of multimedia teaching tools, however the focus is on improving the quality of the engineering graduate, not on the technology itself. It is important that faculty are active in incorporating new technologies into their teaching environments, where they have educational value. The technology is then employed to enhance the environment and to replace some of the basic tasks in which we are currently involved. This in turn allows us to place a greater emphasis on aspects of our students' education that cannot easily be taught with the new technology, such as the growth attitudes and skills essential to the future success of these students. If we do not focus on the value that we can add to students as humans, then we run the risk of failing to compete with the new educational technology that is rapidly becoming available.

Acknowledgments

Acknowledgment is made to the financial support of University Grants Committee of Hong Kong through the Action Learning Project and the Teaching Development Grant.