Something Old, Something New – A Novel Approach to Web Integrated Teaching in Engineering Management

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***Abstract**: This paper presents an approach to the design and development of a web based-method of teaching engineering management used by the author. Although the method is novel in the author's experience of web-based teaching, the approach implements elements from the early days of 'teaching machines'. The paper discusses the links of the approach to the historical context.*

***Keywords**: web-based delivery, multimedia education, engineering management*

Introduction

The idea of automated teaching has recently become attractive with the development of the web as a convenient technology, the budget pressures on universities and the desire to make materials available for students at times and places that suit the student. The idea can be traced to Simon Ramo (1958) who observed that technology was growing to dominate the world, and that automation is demanded in complex situations, particularly where it is difficult to locate enough qualified people to do the work. Ramo's vision of automated teaching contained a number of elements, such as multi-media presentation and student paced learning that have influenced the author's development of web-based teaching materials for an engineering management course. Ramo's vision went beyond the things that have been attempted in the current implementation, and are only now the subject of experimental development, such as remote laboratories. No wonder Ramo's paper ends questioning whether the ideas presented are ridiculous.

Contextual parallels then and now

Sputnik I, 1957, removed the complacency in being the best that the USA had previously held (Bevis, 1958), and this rapidly revealed a shortage of engineers and technicians. A quick industry response was to hire academic staff at salary increases of 50-100% (McCann, 1957, Staiton, 1958, Stewart, 1958) resulting in decrease in the number of teachers. At the same time there was a desire to increase the supply of technical personnel in order to feed the cold war defence effort.

This situation created a desire to efficiently and effectively teach students so that the graduation rate per academic would increase.

The current situation in Australia has seen a decrease in university budgets resulting in more work per academic staff member, and parallel expectations of increasing pass rates, in our case resulting from a definition of efficiency. In addition, social pressures on students, such

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as the need for part-time employment, and general Generation X/Y expectations of flexibility make means to provide student directed learning processes attractive if the processes do not demand personal activity by the instructor at all times.

This situation creates a desire to use web-based teaching processes. Management seem to regard web-based teaching means as reduced labour means to teach, and academic staff have various motivations for using the medium, but because of the substantial preparation required, labour saving is not a motivation.

The Early Vision

Weimer proposed the idea of machine teaching using video, audio and testing machines and student paced delivery based on comprehension demonstrated in tests, in order to allow the teacher time to inspire students (Weimer, 1958). Skinner (1959) demonstrated great foresight into the potential, and differences, of machine teaching in comparison to traditional methods. Machine mediated instruction requires that the instructor use the machine to build up a logical construction of the content, and not merely deliver materials designed for another medium. Skinner envisaged a subject be taught with the use of a large number of 'frames' (order 10000 to 20000) to logically construct the subject. This is because in face-to-face situations teachers often set confusing situations to force students to think, and the teacher facilitates the thinking process, but in the machine situation the student must be logically guided, unambiguously. In addition, immediate feedback concerning student comprehension is vital to learning and reinforcement of material. Stockman suggested that machines should be used in teaching of the dull sections of material to take advantage of their 'patience' and lack of bias (Stockman, 1960). Braunfeld and Fosdick (1962) created an electronic book for teaching that required that the student provide a correct response to a quiz question in order to progress. A system of this kind provides useful feedback to the teacher concerning the effectiveness of presentation of ideas through logs of student interaction, and can enable the instructor to identify weaknesses in presentation of matters that seem obvious to the instructor. In the early period the notion of automation of teaching was controversial, in relation to both its possibility and process, and seen largely as a 'blue sky' issue (Le Page, 1960).

Ley (1961) presented the idea of using machines to survey student understanding across a class through the use of randomised multiple choice questions with computer analysis of responses, a goal of many current instructors in web-based teaching.

Strum and Ward (1967) reported a 1965 experiment with an IBM instructional system and found many problems that remain difficulties including the problems of user interface, machine interpretation of the instructional significance of student answers, and the cost of hardware, software and materials development. They also noted the need for an intuitive student interface, to avoid overshadowing the content with system use procedures (Strum and Ward, 1962). Alton and Fromm (1967) observed that simulation is an effective tool for teaching only when students can vary parameters in the system and observe the effect rapidly, which is a facility that can be offered through the use of hybrid computing and now with desktop systems, but was not practical when using mainframe machines.

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Typical web teaching methods

Many people have experimented with web teaching methods, reporting their attempts in various venues. The work on real implementation of web teaching commenced in the mid 1990s as Internet technology, including web browsers began to become commonplace. Prior to this some attempts, such as at UniSA Flexible Learning Centre, had been made with technologies such as Windows Help tools and using SGML documentation tools. The great benefit of web browser technology is the variety of functionality supported by the standard, and the authoring tools now available, and cross platform support for the technology. This improves the effectiveness of developmental efforts and the usability of resources developed independent of the location and platform of the student.

The early work in electronic teaching materials followed from the tradition of external/distance teaching methodologies. This created a paradigm of collection of materials into a CD-ROM for distribution as the electronic equivalent of the reader pack distributed to the student, but with a much lower mass, and so providing a number of reproduction and distribution cost benefits compared with paper products. Another trend change caused by the technology change has been a shift from CD-ROM distribution to web server distribution, allowing the instructor the advantage of varying the materials visible to students during the teaching interval, either as part of the original teaching plan, or in response to difficulties that might arise with a particular class.

Some authors have reported attempts to provide interactivity with materials in order to develop student understanding of the concepts through use of simulation tools as part of the hyper-media use of the web-based presentation, for both whole courses and for illustration of parts of courses, or for application of formative or summative assessment processes (Bathgate *et al*, 1998, Bereen, 1998, Bhattacharyya, 1999, Billingsley, 2001, Doulai, 1997, Jenvey and Kaminskyj, 1997, Kaminskyi and Chapman, 1997, Machotka *et al*, 1999, Nedic *et al*, 2001, Palmer and Tulloch, 1999, Patterson *et al*, 2001, Ramer and Tang, 1999, Scott and Stone, 2001, Shortis and Woodhouse, 2001, Yeung, 1997). The idea that web-based delivery is necessarily different than classroom delivery is only rarely discussed (Boles and Pillay, 1999, Hussman and Bigdeli, 2002, Lam *et al*, 1998, McInnerney and Roberts, 2001). Chapman discusses the difference between web-based and traditional delivery as a function of the development effort (Chapman, 1998). The general theme that comes through these various works is the concept of web enabled teaching being an alternative approach to traditional classroom based methods, possibly used in parallel with classrooms. Thus, web enabled teaching primarily adds the anywhere anytime accessibility of web materials, but the form of materials varies from large, static documents of lecture note materials, through to animated demonstrations of phenomena, with interactivity provided. Most authors have described either custom software developed for the demonstration of a particular phenomenon, or the development of teaching materials within the framework envisaged by the developers of the chosen authoring tool. Authoring tools permit of possibilities such as the provision of static materials, interactive demonstrations, and formative and summative quizzes.

Systems Engineering Management N (SEM)

Systems Engineering Management N, SEM, is a second year undergraduate course in engineering management topics including, work and organizations, project, product and technology life cycles, requirement definition and requirement reticulation to specific product subsections, project related finance and the decision to proceed, and an introduction to

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several approaches to quality management. This has been discussed in an earlier paper (Ferris, 2001).

The course was taught first in 2001 using a full-text lecture note book, 250 A5 pages, 10 point. In addition a set of hard copy readings was provided for students. During the 2002 presentation of the course the lecture note materials were transformed into an interactive web-based form, and used in parallel with the remaining copies of the first print-run of the hard copy lecture notes. The delay resulted from difficulties associated with use of a new web materials development system, and encountering several problems not anticipated by the administrators.

The 2003 offering of the course has some readings materials accessible through the electronic library facilities now permitted by copyright law.

SEM web implementation

The author took a 250 page set of full-text lecture notes developed for the SEM course and translated them into a web presentation reflecting application of the ideas of Skinner (1959), Ramo (1958) and Braunfeld and Fosdick (1962). These source ideas were used because they provided a vision of means whereby the student can gain value from a web delivery of the material through gaining feedback on the student's ability to understand the content, at least at a superficial level. Thus, students are prevented from progressing through the material if they have not absorbed the material well enough to make a correct response to an elementary question.

The course is divided into a series of topic segments, reflecting the course syllabus statement, roughly corresponding to a chapter in the lecture notes. Each of these segments is broken into several sections presenting identifiable topic areas. These are the student interface level of the course presentation, providing a series of entry points into the study materials. Each segment is further divided into between three and fifteen 'pagelets', corresponding to roughly a paragraph of the lecture notes. The pagelets contain text, explaining a segment of the material, and where appropriate figures and equations. There are about 1500 pagelets.

In most cases of presentation of equations there is a link to a spreadsheet implementation of the equation, often including a plot of equation output, so that students can vary one or more critical parameters and observe a plot of the effect of that variation. This is provided to enable students to have experience of both the analytic and the numerical/empirical form of equations, with the latter being valued as a means of developing an intuitive sense of the significance of that represented by the equation.

Each pagelet ends with a 'Next' link, which delivers a simple multiple-choice question, having between two and four possible responses. The responses to the question are each created as a link, and the answer is expressed by choosing a link. The response produces a further page with the judgement of the response: 'Correct' or 'Wrong', and a short explanation of why that particular response is either correct or wrong. The response pagelet ends with a 'Next' link, which either gates the student to the next pagelet, or returns the student to the original, in the case of a wrong response, Figure 1. This approach is based on the view that if the student has incorrectly understood the first pagelet on the first reading, simply being returned to that pagelet will not result in correct understanding. However, an

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alternative expression of the concept is likely to result in improved understanding, and reinforcement when the student is informed that a correct understanding has been achieved.

All the questions have at least one correct response, but many have more than one correct response, and in a few cases all the responses offered are correct. This is because such an approach is easier to produce, and reflects the author's view that:

- the value of responses is enhanced if all the possible responses appear plausible because plausible responses demand that the student think;
- correct responses may be easy to identify, because obtaining a high proportion of correct responses on first attempt is encouraging to the student;
- the purpose of the quiz is to cause the student to pause and to reflect upon the content just read, and to consolidate knowledge and understanding obtained.

These web materials are combined with lectures presenting the highlights of the topics for the week, rather than a full exposition of the details, tutorials built on seminar presentations and discussion to build ability to argue about the course substance, and other assignments to develop and assess other course related abilities.

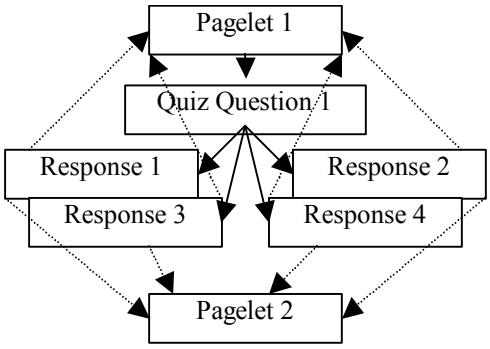

Figure 1. A state diagram of a typical pagelet and quiz question block.

Difficulties encountered

The teaching method that I proposed was different than that of other web teaching resources that the University had supported. The majority of other users had implemented approaches involving the placement of large sets of lecture notes, course notices, discussion forums, and formative and summative quizzes. This is because the software used in the corporate system was designed to address the needs of more traditional approaches to the formation of web-based delivery of content. However, the number of resources required is normally small. In contrast, the structure of my course required a very large number of small pages. This caused a problem with encountering an undocumented limitation of the software. The software could only handle a total of 32k characters in the full path file names of the entire set of files. It took a month to identify the cause of the total collapse of the system following addition of files to the space. The solution turned out to be simple, place only the files that needed to be visible in the learning resource in the learning resource directory space, and have all other files in other directories on the same server, where their file names do not contribute characters toward the 32k limit.

The major difficulty encountered related to the development effort required. The developmental steps were:

1. Production of a full text set of lecture notes, approximately 250 pages, 10 point A5. This was distributed as a book in the first year.

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2. Transformation of the full-text notes into the interactive web format. Equivalent of several weeks of work. This had two stages, the intellectual plan stage, and the clerical editing of files and creation of links. The latter was done personally for lack of clerical support.

Future growth

The current state of the interactive web presentation is considered by the author as a recognizable stage in the development of the materials. There are several directions of future enhancement envisaged.

1. Development of PowerPoint lecture presentations for topics, including audio and self play features. This format has been used by others for presentation of content in web-based distance materials, and has the advantages of providing information transfer in a different physical form, which may suit some students' learning style better than a text based approach.
2. Organization of electronic library resources, following recent changes in the copyright law allowing University libraries to hold materials, subject to limits, in scanned electronic form for distribution to enrolled students. This process allows the creation of links to the course web page, because the course web page access is limited to students enrolled in the course. Materials that it is planned to make available include book chapters, journal articles and magazine and newspaper articles that are relevant to the essay topics of the course.
3. Development of the course into an external/guided study mode course. This will provide the advantage of allowing greater flexibility for students in their progress in the course by reducing or eliminating the dependence of students on attendance at classes. To this end, the course has been offered in an external mode over the summers of 2001-2002 and 2002-2003 to very small numbers in each case, primarily as means to gain experience into the issues associated with these modes using the currently available course materials. The current opinion of the author is that it is desirable to maintain the tutorial classes for any student cohort where the number of students is great enough to have a tutorial class of about 12. The benefits will be both pedagogical, with the students gaining from the class interaction, and administrative, with classes being useful for student/instructor interaction.

Conclusions

This paper has presented an interesting history of the development of machine assisted, student paced, multimedia teaching methods. It is interesting that some of the earliest work, long before such systems were nearly practical, was speculative work performed in the early period of computing. The ideas expressed in the early dreams have only recently become practical.

This paper has also presented an application of the Skinnerian approach (Skinner, 1959) to mechanical teaching, as moderated by awareness of the ideas of Ramo (1958) and Braunfeld and Fosdick (1962), in the technical area of engineering management, indicating what such a project entails with current web development tools, and what such materials may be.

The author is still exploring the issues of student response to the materials, and means to augment the materials with further enhancements that add additional value to the system.

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