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Changes and challenges brought about by the electronic environment in engineering education

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ABSTRACT: This paper presents the changes in the educational environment brought about by the introduction of *cyberspace*. The paper describes the evolution of the electronic environment at the University of South Australia, Adelaide, Australia, and its explosion with the introduction of the Internet. The authors' experiences are also presented with regard to developing and implementing interactive electronic tutorials for teaching the second year course Signals and Systems, which is common for all electrical, electronic and computer system engineering programmes. Experience has shown that a new technology can bring improvements, but only if it is used in a proper way. Many complex issues are to be addressed in order to take the maximum advantage of the new technology. The new technology is not only a new tool for the delivery of education but is a cognitive medium that is moulding students' learning strategies. Presently, new technology is rapidly developing, and there will be some time before difficulties currently being faced are overcome in order to learn to use it for the maximum benefit of students.

INTRODUCTION

The educational environment is significantly changing and reshaping with the introduction of information technology not only in schools but also in all areas of modern society. This paper focuses on the School of Electrical and Information Engineering, Division of Information Technology, Engineering and the Environment at the University of South Australia (UniSA), Adelaide, Australia. This School is one of the six engineering schools at the University and is taken as a representative for the authors' research on engineering education in South Australia. The School accommodates several undergraduate programmes, such as Civil Aviation, Computer Systems Engineering, Electrical and Mechatronics Engineering, Electronic and Microelectronics Engineering, Systems Engineering and Tele-communications. The School has developed into the current form mostly from the School of Electrical Engineering and the School of Electronic Engineering, which were parts of the South Australian Institute of Technology.

Fifteen years ago, in 1986, students used computers only in a few courses, mostly in the first year course Basic and FORTRAN Programming, and later in Systems and Control Systems courses (using analogue computers). During their entire undergraduate studies, they were exposed to computers for approximately 40 hours [1].

A survey conducted in August 2001 with second year students enrolled in engineering programmes at the School showed that:

- 95% of students have their own computer at home.
- Most students spend at least five hours per day, on average, using computers.
- Over 70% of students have access to the Internet at home.
- More than 75% of students utilise the Internet to find additional study materials.
- Students have been required to use Internet resources other than from the University in 25% of courses during their preceding studies.
- 100% of students use computers to write their reports and complete their assignments.
- Students were positive about the use of the Internet in teaching. In their comments, they valued both having plain lecture notes on the Web and having interactive material on the Web. They asked for more teaching material to be placed on the Web and for more computers to be available to students on the campus.

The students' response in this survey confirmed predictions that new generations of students will increasingly favour the use of the advanced technology like the Internet. Students were never before so anonymously positive in commenting the use of the Internet in teaching engineering courses in the School.

INTRODUCTION OF THE INTERNET

Over the past decade, there has been a greater increase in the Department of the use of computers in engineering education, probably more than other departments, due to requirements for the simulation of complex engineering systems. In engineering courses, students are required to master a number of specialised software packages such as *PSpice*, *PicoScope*, *ElectronicsWorkbench* (now *Multisim*), *MATLAB* and *Java*. Some of them are available to students free of charge (*PSpice* and *Java*) or for special prices arranged by the University. These software packages, as fundamental engineering tools, have evolved over the years and continue with their constant improvement at the present time. Their use has significantly improved the way engineering has been taught, but they never

brought such sudden change in the global learning environment there is now with the introduction of the Internet. The use of the Internet in education now changes dramatically, not only the way engineering programmes are taught, but it is also reshaping education of all fields and at all levels. The development of virtual classrooms is now a common practice. Recent literature suggests how to create virtual classrooms [2]. It also shows how to make virtual universities more *student-friendly* to reduce students' feeling of isolation [3].

A new generation of students commencing university studies has already accepted that the new technology plays an important role in their education. It is predicted that their learning will become increasingly dependent on the new technology in the future. New generations of students are already raised in the e-world and their cognitive strategies may be significantly influenced by the new technological developments. Thus, it is felt that there is no choice whether or not to use the electronic environment at the university level teaching, at least not in teaching electrical engineering. The UniSA is very supportive of the use of the electronic environment for teaching and learning and encourages staff to develop suitable material by internal Grants for Innovative Teaching and Learning.

The very first interactive course Web pages at the UniSA were developed in the School of Electrical and Information Engineering in 1996 [4]. The development was supported by the Internal University Grant for Innovative Teaching and Learning. The presentation of this development at the internal conference was very successful and subsequently many lecturers developed Web sites for their courses. Another such grant was used for the development of Interactive Electronic Tutorials (IET).

INTERACTIVE ELECTRONIC TUTORIALS (IET)

The IET was developed in 1997 with the intention to completely replace the classical *blackboard* tutorials in the second semester, second year course Signals & Systems 1N [5]. The IET was designed as a hypermedia package, that is a knowledge base organised in the way it is accessed and not in the way it is created. This assumes that users will take more benefit of the information accessed if they organise it in a way that is more meaningful to them. This is achieved by providing interactivity in addition to audio-visual effects that make an otherwise boring learning experience more attractive [6].

In addition to this cognition-motivated factor it was expected that the IET would increase the cost effectiveness in the delivery of tutorials and increase the competitiveness of the University. Also, the availability of the IET on the University computer network would allow students to choose their *best and most productive time* to conduct tutorials. At the end of each tutorial, the system would provide feedback on a student's progress both to the student and to the subject coordinator. The introduction of the IET was the School's major attempt to replace traditional tutorial classes.

It was expected that the IET would:

- Help students to become independent learners with advanced learning skills.
- Enhance the teaching and learning environment by providing alternative teaching media and methods.
- Improve the accessibility of teaching materials.
- Economise teaching resources.
- Create a potential for the subject's future online delivery.

All of the tutorials have the same structure that includes the following three main parts:

- Overview of theory;
- Solved problems;
- Test.

Solved problems are a set of examples that aim to train students in solving problems related to the particular topic. Rather than listing problems in a sequential mode, the option of selecting a desired problem is provided. Each problem is presented to students as a problem that needs to be solved. In this way, students are encouraged to attempt solving the problem before looking at the solution. While solving a problem, students are offered help in the form of *hot spots* that provide links either to the hint or to the relevant theory overview, but also to the solution in case students are not able to solve the problem.

In several places, the animations were created for presenting a number of new concepts in the course in a very effective and attractive way. One of the effective examples is the continuous time convolution concept where the animation is used to show how different responses dynamically arise when different signals pass through different systems. An example of a sequence of pages that form one animation is presented in Figure 1.

At the end of each tutorial, students evaluate the knowledge acquired during the tutorial. A quiz is provided as part of each tutorial for that purpose.

In order to make the package more attractive to students a variety of different types of quiz questions were used, like:

- True – false.
- Multiple-choice.
- Matching answers with questions by creating links or moving answers to correct positions.

IMPLEMENTATION OF THE IET

The IET was implemented for the first time in 1998 but not without technical difficulties. Consequently, the conventional tutorials were run in parallel with IET classes. Since that first implementation, a number of errors and *bugs* were corrected, but the IET was never used to completely replace the conventional tutorials as initially intended.

In 1999, a formal survey was done on the students' opinion about the electronic tutorials and their preferences between the IET and classical tutorials. The number of students that participated in the survey was 31. The summary of their responses is shown in Table 1. The majority of students strongly preferred classical tutorials, but it was not insignificant that almost one third (9/31) of students either preferred the IET or liked both tutorials equally. Most of the students who preferred classical tutorials stated that apart from its technical deficiencies, the main disadvantage of the IET was its inability

to answer the questions. Although the majority of students preferred classical tutorials, none of the students who participated in the survey were absolutely against the IET. They pointed out its advantages and disadvantages and suggested possible improvements.

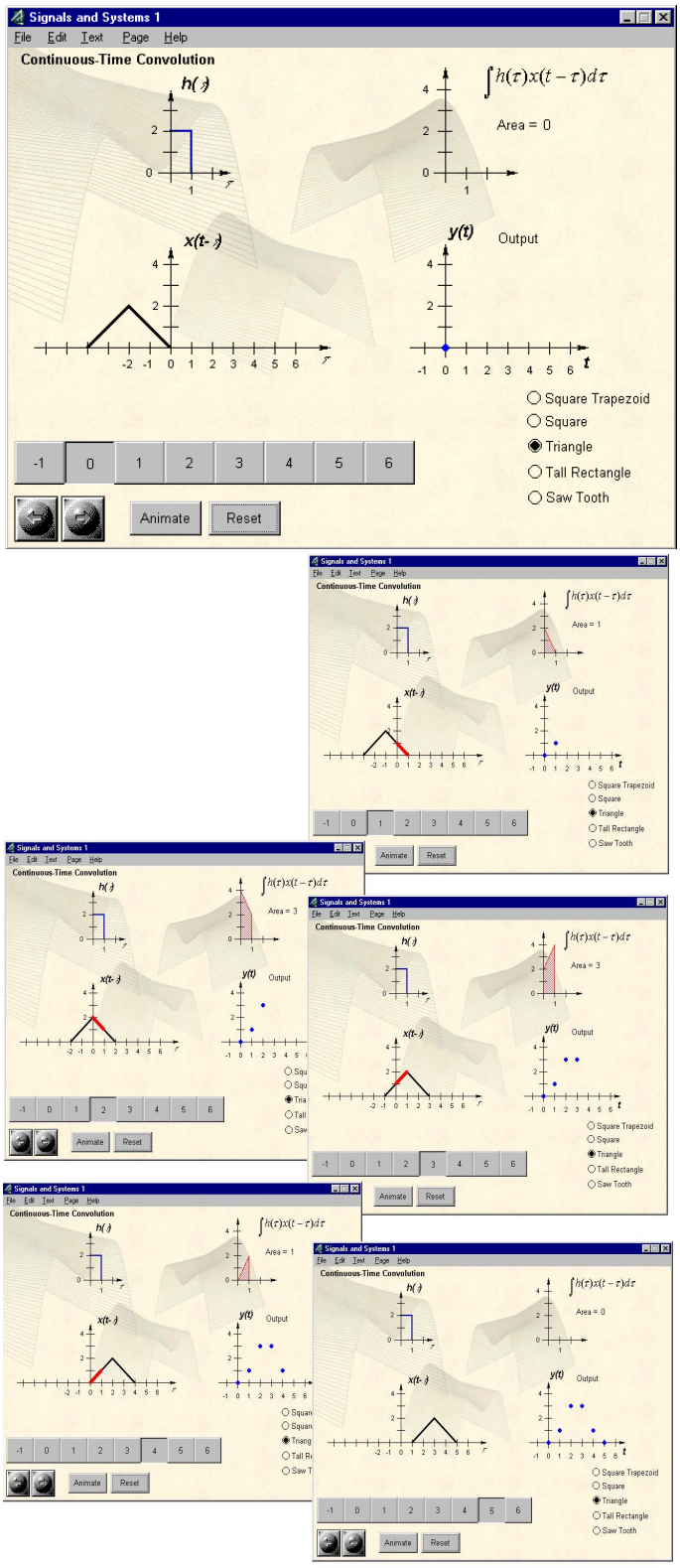

Figure 1: A sequence of pages for animated continuous-time convolution defined at the top part of this figure.

After the initial disappointment, it was learned that such responses were quite common and that student satisfaction increased with the enhanced quality of such packages. As such, the next step was to improve the quality of the IET. Now, the logical question was what and how to improve them? It was realised that the interaction between a multimedia learning package and a user is very complex; it involves cognitive issues on one side and the human-machine interaction issues on the other.

Table 1: Students' preferences.

Number of students who:			
	Strongly > 60%	Slightly 40%-60%	Total
Preferred the IET	2	2	4
Preferred *blackboard*	17	5	22
Liked both equally			5

It is now acknowledged that the effectiveness of hypermedia systems as learning tools depends to a large extent on their compatibility with the psychological processes by which students perceive, understand and learn from complex information resources. As a result, the psychology of hypermedia learning is emerging as a new area of research [7].

A summary of the research findings that were found useful is presented below; this can be used to improve the IET in order to make it more attractive for students.

Improvement of the IET

The need for more help expressed by students in the survey was interpreted in two ways:

- Some students were lost within the package, implying navigation difficulties.
- Some students could not understand the content, implying the need for improving the presentation of material and considering cognitive aspects of learning like cognitive styles and cognitive load.

Improving Navigation

Right from the beginning of the design of the IET, it was recognised that the navigation is the important issue and certain techniques were implemented that would enable students to easily navigate through the maze of the IET. A review of the package structure showed that in many sections of the system the navigation was limited to a single dimension. This worked well in the sense that it prevented students from being lost in the system. However, it did not give students the information about their position within the system.

Research shows that being able to exit the package at any point is very important to users. It is also important to be able to view the structure of the whole package in the form of a table of contents and the current position within the structure at any time [8][9]. This can be easily accommodated by introducing two additional buttons, one for the emergency exit (*exit* button), and the other (*contents* button) which pops up the *contents page*, which can also be used for quick navigation.

Other navigation tools were considered, like glossary and search, but this option was left for a later improvement stage due to research reporting that students, especially less experienced ones, prefer to use slower but safer navigation strategies, ie they prefer to go back to the table of contents rather than use hyperlinks for moving within the system [8].

Improving Presentation

It has been suggested that learning is improved if the way in which material is integrated in the hypermedia system is in consonance with the way in which the material is integrated at the cognitive level [7]. Therefore, the organisation of the material is of a high importance as poorly organised interlinked pages may cause students to become lost in a complex system. Also, material presented on one page only may be poorly integrated and could lead to a less efficient learning. Hence, improvements in the presentation were considered that would include changes both at the global level of integration and at the local level of integration.

Global integration of the material refers to the way in which the presented material is organised and what tools are provided for the user to manage the information [7]. An example is the way in which the material was interlinked the introduction of a *contents page* was suggested that could pop up anywhere within the package and be used for orientation and navigation within the IET.

Local integration of material deals with the layout of a page, ie the way in which pieces of information are presented and integrated on one page [7]. A hypermedia system is a powerful way of presenting material and despite the general opinion that the introduction of images and video clips would help learning it has been reported that it is not always the case. The pictorial information tends to increase the cognitive load and, if not properly used, can decrease the effectiveness of learning [10]. Crowded pages have also a negative effect on learning.

CONCLUSIONS

This paper sought to show how the introduction of new technology, in particular the Internet and the electronic environment in general, affected the teaching environment at the University of South Australia. It was presented how students' usage of computers has dramatically increased over the past decade and how the new generations are increasingly bonding their learning strategies with the new technology.

Experience was related that the students' preference might not always be towards the *cyberspace* learning environment and that the use of technology in education is more complex than it may initially appear. It raises a number of complex issues like how to design a suitable human-computer interface that would make the learning experience attractive and at the same time avoid the danger of increasing cognitive load that may decrease effectiveness of learning.

Despite the current problems, the authors agree with the suggestion that the introduction of technology-based teaching is imperative for the University if it is to meet the needs of students and society in the 21st Century [11]. Hokanson and Hooper suggested that a computer should be treated as an educational medium rather than just a tool in the sense that as a medium it may mould the way in which students structure the knowledge in their minds during the learning process [12].

In conclusion, the authors would like to express their opinion that the new technology is yet to show its full capabilities. At this stage, it is felt that the software available for authoring electronic material for education is still in the dawn of its development. The predictions are that we will soon face the shift from the virtual reality, which most of the broad community still considers as science fiction, to the augmented reality [13].

There is no doubt that the new technology will bring many advantages and will reshape the way we teach and learn. At this stage, the real challenge is to find the best ways in which the new technology can be used in teaching for the maximum benefit of students.

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