Appropriate use of the Internet in Computer Science courses

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Abstract

New computer and communication technologies now provide the educationalist with a wide range of tools for use in the educational process. Many of these technologies such as computer-assisted learning and multimedia have had quite a rocky road to becoming effective tools. It was only after these tools emerged from the initial hype that they truly found a place in education. The Internet is still in this initial hype phase and is in danger of being used superficially. This paper begins the development of a theoretical basis for the appropriate use of Internet tools in computer science education. The proposed selection matrix will help realise the potential of these tools within the context of maximising learning outcomes.

1 Introduction

Technology is an evolving beast that feeds on hype and expectations. The Internet is now the latest in a long line of technologies on which educationalists base their hopes for the future. Recent additions to this evolutionary path include TV, VCRs, computer-assisted learning and multimedia. Each of these technologies had quite a rocky road to becoming effective tools in the process of education, and a number of valuable lessons were learnt during their maturity. With the introduction of the Internet to mainstream education, we must ask if these lessons being heeded.

The hype that has been generated by the introduction of the Internet to education has probably surpassed that of the invention of the textbook. The enormous interest in the application of the Internet to education has generated some unrealistic expectations by students, lecturers and the public in general. For example, a recent press release by the Victorian Department of School Education in Australia claimed that:

'At a push of a button, more than 520,000 Victorian students and their 35,000 teachers will have the world's greatest knowledge and resource centres at their fingertips'[4, p.40].

The British Open University also believe that:

'By 1997, some 20,000 students will be equipped with a computer and a modem at home and will be using electronic mail and computer mediated conferencing as a normal part of their learning environment. They will also have access to other networked services such as remote information sources through the Internet' [7, p13)]

Whilst we think that the intentions of these institutions are strategically sound and that their plans will be achievable some time in the future, there are a number of major issues that must be resolved if this implementation is not to suffer from the teething problems that other technologies have experienced.

The first issue relates to the expensive hardware and access costs associated with Internet as well as the current problem of inadequate bandwidth on the network. Adding half a million users to an already struggling backbone will result in frustration and disillusionment by users as response times increase. The Internet does provide some real benefits for education, but it is far from the solution to cheap mass education as is claimed by some policy makers. New mechanisms for charging universities for Internet access have seen some departments considering reducing the level of student access. Strategies for increasing bandwidth within an affordable charging structure must be found if the Internet is going to make the impact on education that the public now expect.

These access and funding problems may be solved over time but there is a more important concern that has been caused by the current hype over the possibilities for the educational use of the Internet. Some educationalists caught up in this wave of excitement are converting every aspect of course delivery, management, evaluation and assessment into a form accessible by a range of Internet tools. Much of this work is devoted to the identification of new ways of using a particular Internet tool and is generally instigated as a response to the tools available rather than actual learning needs. This current fervour concerning the Internet is not caused so much by the introduction of any new methods or strategies, but by the evolution of technology and that if there is an educational revolution, then it is technologically inspired.

The educational community's recent experiences with the introduction of hypertext-based instructional software in

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the 1980's and interactive multimedia in the early 1990s taught us a number of lessons. These technologies were promoted actively by those who believed they could provide students with the ultimate learning environment This was as much a misconception as the implication that teaching automatically results in learning. The initial simplistic adoption of these technologies was reminiscent of the poor approaches to the use of CAI in the 60s. It has been acknowledged for some years now that the early use of hypertext and multimedia in education paid little regard to methodological and theoretical issues and basically were used purely for cosmetic reasons rather than contributing to the educational effectiveness of a course. Jonassen [12] in 1985 stated that new techniques for instruction have:

'too often constituted only reactions to emerging technologies'.

Lanza [13] in 1991 stated that:

'The simplistic approach would lead to the realisation of instructional programs which would be only apparently but not substantially new, i.e., programs developed by means of the innovative technology, but inspired by principles, methods and strategies belonging to an out-of-date perspective of the learning/teaching process that is wholly inconsistent with the essence of the new technological capabilities'

It seems that once again with the introduction of the Internet that these historical lessons are being ignored especially with the development of many WWW based courses that are nothing more than electronic page turners.

The maturing of multimedia into an effective tool has shown us that it is the instructional design process that is the key to the educational effectiveness of any technology. The range of media, appealing interfaces and alternative ways of achieving communications and information dispersion are important but secondary to the students' actual learning process. Romiszowski [11] has highlighted the danger of ignoring the generic instructional design process and becoming too mesmerised by the 'bells and whistles' of the computer itself as a presentation medium.

It also is important to clarify that technology such as multimedia courseware or an Internet based learning system will never be the sole provider of learning experiences. These technologies are just tools that assist in the process of learning in much the same way as a text book or a video might be used. As Clark [2] reminds us, the contribution of media to the effectiveness of learning is no more than:

'the truck which delivers groceries to the market contributes to the nutrition in a community.'

The key to the educational effectiveness of any course relates only to how well the student has achieved 'learning'. The use of technology such as the Internet must be based on a strong theoretical and philosophical foundation in order to be effective, a view strongly supported by Hannifin [8].

It is clear that the process of instructional design has not evolved at the same rate as the technology. There is a need for a rethinking of old teaching processes and the devising of new methods that utilise new technologies including the range of Internet tools that are now available.

2 Multi-Modal Learning

Swinburne University of Technology has committed itself to a planned and structured approach to the utilisation of new technology in university courses. Instead of an ad-hoc implementation of technology, Swinburne has adopted an approach through its "Multi-Modal Learning" program. Multi-Modal Learning (MML) simply means using many ways to learn. MML promotes the use of new media and methods designed to capitalise on the benefits offered by communication and computer technology. These may be added to traditional lectures, tutorials and textbooks to offer alternative learning experiences to achieve different types of learning objectives.

One central feature of the MML approach is the requirement that all students have access to a computer with a modem at home. A dial in network has been installed to allow remote access to the Campus Wide Information System and other on-campus computer facilities. Students can access e-mail, the World Wide Web, library catalogues, network news and can download and upload files directly relating to their course.

This use of electronic communications is a great step forward in tertiary education although the MML approach not only provides enhanced communications with lecturers but also encourages the use of independent learning materials. A range of resources including printed independent learning materials, computer-based learning materials, videotapes and audio tapes are maintained to enable students to learn efficiently at their own pace and at times of their own choosing.

The key to the MML approach is the use of Learning Guides. Learners learn best if they are fully informed about the learning they are doing. Learning Guides are booklets that may be likened to learning maps. They are prepared to assist students to know what is to be learned and how to demonstrate that learning has occurred. Students use their Learning Guides to focus on what needs to be learned with what resources and allows them to take responsibility for their own progression through the course.

Multi-Modal Learning has been successful as it incorporates some of the best practices found in distance education courses along with a number of innovative approaches to traditional campus based education in a funded and planned structure. This approach has been extended to many of the subjects offered at Swinburne University of Technology including the data communications subject offered by the School of Computer Science and Software Engineering.

3 Course delivery

The process of course delivery within a university involves a structured set of interactions between students, staff and the content material to be learnt. These interactions may be broadly classified into the three categories of general administration, communication and finally teaching and learning. The category of general administration includes the distribution of syllabi, assessment details, schedules, procedures and regulations as well as the task of subject evaluation. Communications includes the communication that occurs between the lecturer and an individual student, between the lecturer and the class, between two individual

students and finally between an individual student and the whole class. The most important aspect of course delivery is that of teaching and learning which includes the tasks of distributing tutorial and lecture material, managing laboratory sessions, individual research and assessment of student learning. This classification covers the key aspects of course delivery although there is no attempt to establish any order of importance.

There are a variety of Internet tools that may be used in a number of ways to support the process of course delivery. At Swinburne University, in the context of Multi-Modal Learning, a number of Internet tools have been trialed in the delivery of a data communications subject. The tools experimented with include Electronic Mail, Listserver, Internet Relay Chat (IRC), File Transfer Protocol (FTP), Gopher, Archie and the World Wide Web (WWW).

This data communications subject is run over a 13 week semester in the second year of the undergraduate program. This is a compulsory subject for students who study the computer science major, and typical enrolment of this subject is about 250 students. Students generally would have been exposed to some of these Internet tools before the commencement of this subject. All students enrolled in the subject were given an Internet account and the only restriction placed on the account was the 5 Mbytes of disk storage space.

Led by the subject convenor, the teaching team for the data communications subject has two lecturers and five or six tutors who run various laboratory classes. Some of these tutors are part time sessional staff and generally are available on campus only when they have classes.

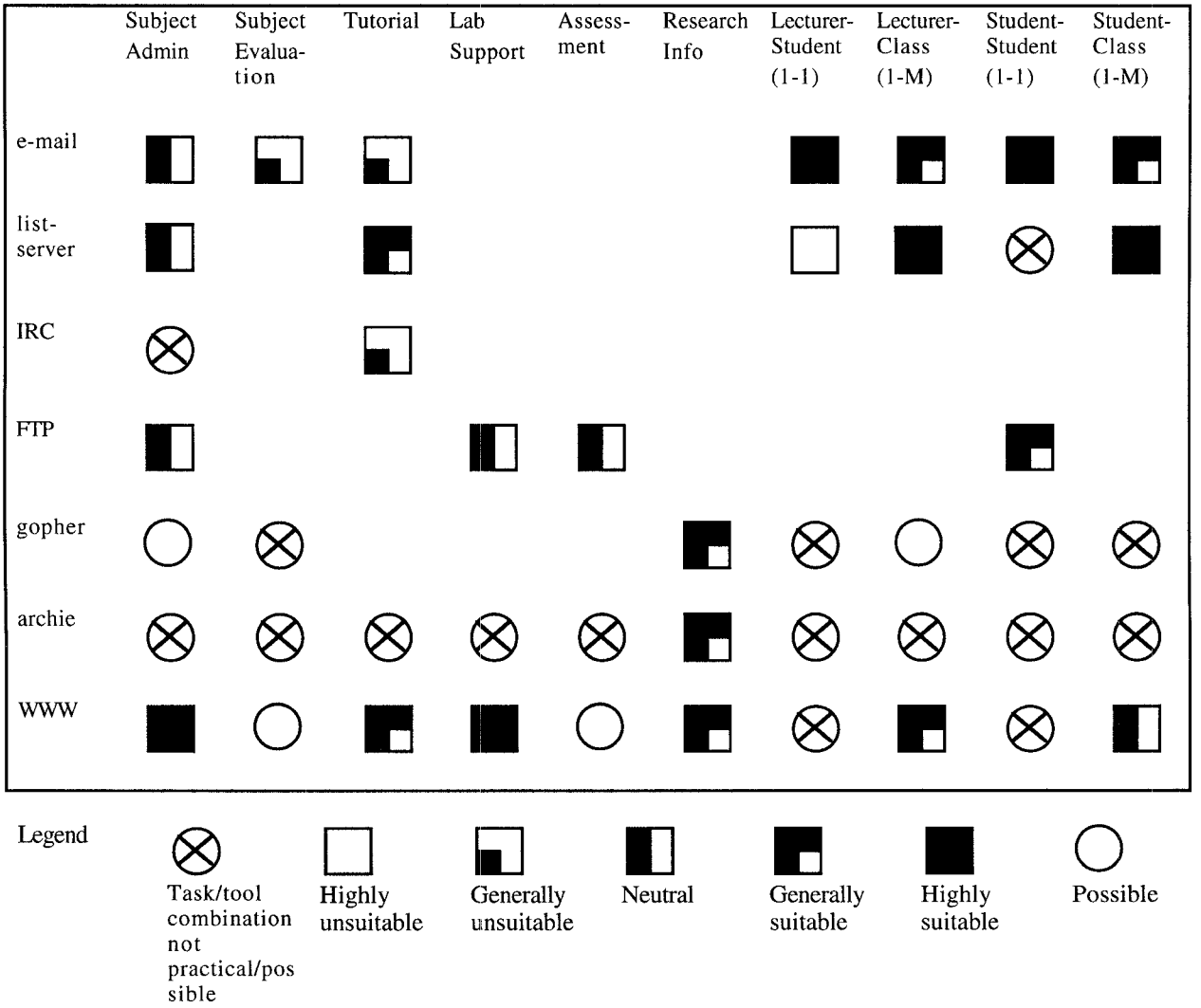

Figure 1 A matrix for the selection of Internet tools to support the education process

4 Selection matrix

The main aim of this research is to find out the appropriateness of each Internet tool to support the different aspects of course delivery, both from educationalist and student perspectives. The tool-task combinations have been rated by the following criteria:

demand on resources, general useability, support for both asynchronous and synchronous interaction, and the success of meeting learning objectives.

This study is based on an on-going trial of Internet tools to support the running of a data communications subject at Swinburne University. These tools have been experimented over the past four years and initial findings of this research, which can be summarised in a selection matrix, are shown in Figure 1. The selection matrix shows the Internet tools in rows and the tasks in columns. The tool column has been arranged in a descending order of bandwidth requirements. Five scales were used to rate these tools, ranging from highly suitable to highly unsuitable.

The ⊗ symbol has been used to indicate that the task/tool combination is either impractical or impossible.

The ○ symbol represents those combinations that are possible and are currently being examined for use in course delivery. Other combinations which have not been explored are represented by an empty cell.

5 Discussion

5.1 Subject administration

The task of subject administration, mainly carried out by the subject convener, typically involves the distribution of the syllabus, assessment details, schedule, references, procedures and regulations. An ongoing task of handling both general and student specific queries in also part of the administration of a subject. Traditionally much of the course documentation has been distributed in the form of a paper handout at the beginning of the semester. This task is cumbersome with some students not attending the first session, as well as the inevitable occasional loss of these documents by students during the semester. Student queries have generally been handled by personal consultation with the subject lecturer which is a time-consuming process. Furthermore, the limited on-campus availability of session staff during the day also makes it difficult for students to consult them.

In this study, a number of internet tools have been used to support administration:

5.1.1 E-mail

E-mail allows students to send individual queries to staff at any time and more significantly allows staff to answer those queries at a convenient time.

5.1.2 List-server

The data communication subject first used a list-server in 1995. This proved to be a very effective method by which to post timely announcements. The use of the listserver was more convenient than the World Wide Web as it required only a simple e-mail. The Web also required students to actively seek out information whereas the listserver posted each student an e-mail.

5.1.3 FTP

Some of the course documentation is also made available on an FTP server. This allows students to obtain and make copies of documents in their original Word format.

5.1.4 World Wide Web

All course documentation has been placed on a series of World Wide Web pages (http://saturn.csse.swin.edu.au/chris/datacomm/datacomm.html) to allow students to find, view, save and print information at appropriate times. Students have responded positively to the open access to these documents rather than having to spend time getting copies from the library counter reserve. Part-time students in particular have indicated that this system gives them the flexibility of being able to access documents from home. The use of a gopher server to hold administrative documentation is possible although appropriate use of the World Wide Web makes the use of gopher inefficient.

5.2 Subject evaluation

The use of e-mail to gain feedback from students in order to evaluate the course has been trialed. Students were required to return an e-mail form with appropriate text comments and check boxes filled in. Although this method provided timely feedback and was easy to administer, students commented that they would like feedback to be anonymous.

The use of forms within the World Wide Web is to be explored during 1996. This method will allow students to provide anonymous feedback in a timely and convenient manner.

5.3 Tutorial

The tutorial aspect of course delivery may involve a range of interactions from actual delivery of content to student discussion. Several Internet tools have been trialed to support the tutorial mode.

5.3.1 E-mail

In 1993, the use of e-mail as a tutorial tool was explored. Groups of 10 students were assigned to a e-mail tutorial group which shared a common e-mail account. A set of 10 tutorial questions were posted to each of the e-mail accounts to be answered over a two week period. Each student was responsible for answering one of the ten questions by the first week of the tutorial. Students would simply add their answer to the e-mail file and post the e-mail back to the account. During the second week of the tutorial, students would have the opportunity to comment on the other students answers in order to improve them. This sometimes produces some lively debate over some issues. The e-mail containing the final answers would be submitted at the end of the second week for marking.

Many of the students commented that these e-mail tutorials were extremely useful and provided a forum for discussion and clarification of concepts. Problems were encountered with novice e-mail users who sometimes deleted the e-mail containing all the other students answers accidentally.

Further work on a secure interface is currently being explored.

5.3.2 List-server

The subject list-server provides a discussion forum which allows students to find answers to specific questions about the course material by e-mailing questions to the discussion group. All other students receive the question and are encouraged send answers back to the discussion group. The lecturers and tutors also participate in the resolution of the questions. During the semester a variety of questions were discussed, some discussions lasting several days and involving a number of students and staff. Students, especially the part-time post-graduate students, indicated that this provided them with a mechanism for opening up a debate on issues that could not be resolved in lectures.

5.3.3 IRC

Internet Relay Chat (IRC) is an Internet service that may be likened to a CB radio system. IRC provides users the ability to join channels and participate in live discussions with other users world wide using a textual interface. Once a channel has been joined, whatever a user types on their computer will be echoed to all other users who are currently on the channel. The interface provides a screen that scrolls up as the discussion proceeds. Discussions are usually social in nature and do provide an interesting experience for those participating.

During 1994, a special IRC server was set up to be used for remote tutorials by allowing a tutor situated at the campus to communicate with a number of students who were working at their homes. Software known as WinIRC was used to allow the tutor to communicate either individually with a student or with the group as a whole. Each student had two windows on their screen, one displaying the group conversation and the other their own individual conversation with the tutor. The tutor had the group window as well as a window for each individual student. Students worked on a tutorial sheet which required them to show answers to the tutor at regular intervals. It was found that the tutors screen could only manage up to six students before becoming too cluttered. Whilst the students found the experience satisfactory, the tutor found managing six simultaneous conversations difficult. Work on the establishment of suitable procedures for tutors and students to follow as well as an investigation into appropriate subject areas that suit IRC remote tutorials are now being examined.

5.3.4 WWW

The course home page (http://saturn.csse.swin.edu.au /chris/datacomm/datacomm.html) provides links to pages containing sets of tutorial questions along with solutions to these questions. This provides students with model question/answer sets to prepare them for the exam.

A number of lecturers at different universities are exploring the use of the WWW to deliver actual course content. [1,5,6,9] who in general found that there is potential for the Web as a delivery mechanism if several practical and paradigm issues are addressed.

Content from several modules of the course has been placed on the World Wide Web in a variety of modes to explore the possibilities for delivery via the Web. These modules may be accessed through the course home page.

The course has for several years used a set of computer managed learning tests which not only provide an assessment of the learner's understanding of the content but does include a tutorial aspect by providing a list of areas where the student did not perform well along with the test result at the end of the test. This immediate feedback enables the student to find out if he or she has adequately grasped the material studied and allows the student to seek appropriate help. The use of forms within the WWW is currently being explored in order to provide these CML tests over the Web which would allow students to use these tests off-campus.

5.4 Laboratory support

Data Communications is a practical subject therefore relies heavily on a set of laboratory sessions to allow students to gain a deeper understanding of the many abstract and complex concepts introduced during lectures. The various laboratory sessions involve students to develop and implement a communication protocol to support transfer of text and binary files between two PCs. The Internet does provide some support for laboratory session by acting as an on-line source of documentation and code.

Several programs and sections of code are accessed by students using FTP. The use of FTP is preferred to the standard network as it is able to be accessed by students from home.

All of the documentation and instructions concerning the laboratory sessions are accessible through the World Wide Web which means students can perform the experiments at a later stage if they miss the laboratory session.

5.5 Assessment

Use of the Internet to support the task of assessment of students is a contentious issue. Problems relating to security, authenticity and reliability still need to be addressed before the Internet may be used as a mainstream assessment tool.

The use of FTP to assist in assignment submission has been explored within the data communications course. Students would submit their programs by uploading them to an FTP server. This proved to be more convenient and reliable than the traditional method of submission on floppy disk.

The use of WWW forms to directly act as an assessment tool is currently being explored by a number of universities [3,10] but until the problems with authenticity and security are solved, the use of the Web for assessment must be limited to formative feedback rather than evaluative assessment.

5.6 Research support

One section of the data communications course examines emerging technologies. This usually involves students performing some research into a particular communications

technology that is still in the development phase or has recently been released. The Internet is an extremely valuable research resource as traditional sources of information are not timely enough to cover many of these new technologies. Gopher, Archie and the World Wide Web are all used by students to acquire most up-to-date information. One problem with the use of the Internet as a research resource is the issue of referencing sources correctly. Much of the information on the Internet is transitional and temporary, as such its location may change at a later time. Guidelines for referencing Internet material need to be developed.

5.7 Lecturer-student communication

The use of e-mail for one-to-one communication between staff and students is extremely successful. Many staff actually insist that students use e-mail prior to a personal consultation as it allows staff to handle student queries at times convenient to them. Students were told not to use the listserver for personal queries as this was to be used for general questions relating to content.

5.8 Lecturer-class communication

Although an e-mail group has been created for the data communications class, the use of the Listserver was the preferred method for communicating with the whole class about issues that arose from time to time. Other more permanent issues that were required to be communicated to the class were placed on the World Wide Web pages.

5.9 Student-student communication

Some of the assignment work in the data communications course requires students to work in groups. Students have found that e-mail is a very effective communication tool for collaborating on assignment work. Many students also use FTP to transfer programs and documents when they are working at home.

5.10 Student-class communication

Students have the ability to use the Listserver to communicate with the whole class group. This communication varies from questions about the course content, programming problems or research topics. Once again, it is preferable for students to use the Listserver rather than the e-mail group to communicate with the class. Some students have set up their own WWW pages which allows them to communicate passively with the class.

6 Concluding remarks

It is interesting to note that the best results are achieved at the two ends of the bandwidth spectrum. Whilst the effectiveness of the WWW has been rated highly in general administration and learning support, it should be pointed that for larger class sizes, there is significant bandwidth implication. Slow system response time would invariably frustrate the users and consequently turn users away. Less resource-demanding tools such as e-mail and listservers offer good value in communication tasks and they should always be considered first. This use of a list-server as a means of providing tutorial support was very favourably received by the students.

History reminds us that instructional systems should be developed with regard to a strong theoretical and philosophical foundation that is suitable for the technology to utilised. It is important to start any development with an analysis of needs and objectives which will in due process lead to the selection of the most appropriate technology. The selection matrix developed in this research enables the educationalist to choose the most appropriate tool for a particular education process. Further work is still required to complete other cells of the selection matrix; indeed when new facilities on the Internet are available, more experimentations should be carried out to explore their application domains.

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