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**The Development and Evaluation of
Computer Generated Material for 43.220
Information and Communications**

A thesis presented in partial fulfilment of the requirements

for the degree

of Master of Philosophy

in Technology - Information Engineering at

Massey University

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EXECUTIVE SUMMARY OF RESULTS

Computer generated lecture and tutorial material was developed for a second year technology paper - 43.220 Information and Communications. The lecture notes were constructed as sets of pages within Freelance '96 and projected onto a large screen in the classroom. A series of six interactive computer programmes were created to replace the existing mode of tutorial delivery. Macromedia's Authorware 3.0 was used for the tutorial programmes which contained Information Theory and Coding problems. The tutorials were presented on eight IBM PS2 computers to student groups of two to six. Once the tutorial was finished, a copy of the Authorware programme was made available to the students for use in their own time. The interactive use of pre-recorded lecture material was also experimented with for three of the lectures delivered in the course.

A detailed evaluation was carried out to assess student and lecturer response to the computer generated lecture and tutorial material. The evaluation was aimed at identifying important factors that effect the quality of the delivery system, as perceived by those involved. Data was collected from the students and lecturers using observation, questionnaires and interviews.

The study was performed over a period of 12 months during which 43.220 was delivered twice. Two lecturers were responsible for the coordination and teaching of the paper to 79 students (37 and 42 students attended the first and second deliveries respectively). The major findings of the study are summarised below.

RESULTS

Since the introduction of computers into the classroom, very few researchers have investigated the responses of students and teachers to technologically based education.

Such research is crucial as a subject's perception of the learning environment can have a significant influence on the quality of their learning outcomes.

There was a preconceived idea among students that contact with the lecturer would decrease if computers were used. This was a concern shared by many students who undertook the course knowing that the delivery would be computer based. It is essential that student to student and student to lecturer interaction is maintained if the students are to remain positive towards electronically delivered education.

The computer based tutorials were a successful addition to 43.220. Students consistently rated them better than other tutorials and identified a number of improvements that have already been implemented. Two important factors contributed to student satisfaction with the tutorials.

The main factor integral to the success of the tutorials was the group interaction that occurred around the computer. The results revealed that the most enjoyable and effective learning mechanism perceived by the students was the high level of interaction between them around the computer.

Group interaction during the tutorials was inhibited if the group was too large. The results indicated that a high level of interaction occurred when groups of up to four students were around a computer. Interaction was impeded when the group numbers exceeded four.

The computer based tutorials received positive feedback because they were accessible to the students in their own time. From all the comments made about the tutorials in the first delivery there was only one request for a printed copy. During the second delivery of the paper, hard copy tutorials were repeatedly requested by a number of students. While the tutorials were in progress many students were more concerned with obtaining a copy of the computer programmes than participating in the tutorial.

This difference can be explained by examining the accessibility of the tutorials outside of class time. The first group of students had more access to the tutorials than those

who attended the second delivery. Some students were dissatisfied with computer based material because it could not be accessed in their own time.

Summary: The students were not reluctant to use computers for learning as long as:

- A high level of student to lecturer and student to student interaction was maintained
- They had control over the amount of time they spent on the computer
- A hard copy of the material was available or easily obtained
- There was good support from peers and staff members

Pre-recording three of the lectures on video tape was not received favourably by students and resulted in reduced attendance at lectures. Many students were extremely negative about the presentation of the pre-recorded lectures. An examination of the attendance at the video taped lectures showed that the class number dropped by approximately one third during this time. Attendance then increased for 'live' lectures.

When lecture material was clearly presented and interesting in content, attention increased. Many students commented that they paid more attention as a result of clear and interesting lecture material.

Realistic examples, humour and interactivity within the lecture all increased attention. Observation of students during lectures clearly showed that greater attention was paid to material accompanied by a realistic example. Attention was also observed to increase when humorous anecdotes were given, questions were asked, quizzes posed or the lecturer requested the students to write notes or discuss concepts amongst themselves.

The technology used to deliver a lecture did not alter students' perception of the material or the lecturer. At no time throughout the paper deliveries were any comments given that implied 43.220 was better because of the technology used.

Findings indicated that the use of technology made lecture material more legible and "cleaner" (to quote one of the students) but it was the material, lecturers and classroom interaction that were responsible for student satisfaction with the course.

From the perspective of the lecturer, interacting with the students during a lecture coupled with the ease of material delivery were significant factors identified during the study. Importance was also placed on the level of interaction with colleagues and support personnel during material development and delivery.

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INTRODUCTION

The information age is upon us. Technological advances, particularly in communications, have facilitated the conveyance of accurate and updatable information in vast quantities. Educational institutions have recognized the potential of such technology to increase the efficiency and effectiveness of their organizations. Institutions that depend almost entirely on technological knowledge transfer already exist and those who are not investigating how it may best be used in their university are likely to be left behind [1].

The impact of technology on education has been the subject of much speculation [2,3,4]. What is becoming apparent is that views of education are changing from that of 'option' to 'commodity' [5]. This has led to an increasing demand for a varied education and an even greater burden for educators, given that there has been little change in the modes of delivery [1]. Therefore, in education, it has been argued that "more must be accomplished with less. Automation through the successful application of powerful new technologies is undoubtedly one of the key enablers" [6, p. 59].

The Department of Production Technology at Massey University has been investigating how current technologies may best be utilized to facilitate multicampus teaching. Massey University, with its main campus at Palmerston North, now has a new campus situated approximately 600 kilometres north at Albany where the Department of Production Technology intends to offer one of its courses in the near future. Instead of duplicating many facilities, resources and staff at Albany an alternative is to have the courses remotely delivered. This has led to the establishment of two systems whose objectives are to increase flexibility in delivery modes without decreasing the quality of education delivered.

The first system has been developed to deliver education asynchronously^a via the World Wide Web. The Technology Faculty's Technology Electronic Forum (TEF) [7] is a database of lecture and tutorial material, lecture demonstrations, past exam papers, CD-ROMs and course information that can be accessed from the Internet and the Massey University Web pages. The TEF also incorporates newsgroups (comparable to bulletin boards) and Eudora e-mail facilities to encourage communication amongst students, and between students and departmental staff.

The Department of Production Technology's Hub Mirror Rim - Exemplary Manufacturing (HMR-EM) project [8] aims to create an interactive multimedia teaching environment where education is flexible and can be synchronously^b delivered at a distance. In simple terms, the Hub signifies the core activities for any of the Department's programmes [9] which are distributed to the rim. The rim may include people, industry or other educational facilities that can receive information and interact with the Hub using the appropriate communications mechanisms - the mirror.

Ultimately the HMR-EM will allow students to access information and communicate with tutors and other learners from many locations, thus improving their continued education and training. This will increase the flexibility and accessibility of the programmes offered by the Production Technology Department, giving the learner more control of their education.

One of the main goals of the HMR-EM project has been the creation of an environment where lectures can be delivered simultaneously to both the Palmerston North and Albany campuses. To achieve this goal it is intended that the students will be taught using computer-based material (including video, audio and CD-ROM demonstrations) controlled by the lecturer, who will be viewed as a 'wired presenter'. The lectures will be initially delivered over the existing computer network with a view to utilize a faster and less restricted link (such as A.T.M.^c and/or ISDN^d) between the Palmerston North and Albany campuses for their remote delivery in the future.

^a With asynchronous education, all lecture and tutorial material delivered on campus is available for student access outside of class times

^b Synchronous delivery allows classes to be taught simultaneously in two places at one time

^c Asynchronous Transfer Mode

The first step toward developing material for synchronous delivery from Palmerston North to Albany has been the production and evaluation of computer generated notes and appropriate educational software for a model paper - 43.220 Information and Communications

43.220 a single semester^e, second year paper is a course requirement of both Information Engineering and Computer Systems Engineering Bachelor of Technology degrees [9]. It covers information theory, communications systems, noise, bandwidth, coding, telecommunications, signals and modulation in two one hour lectures and a one hour tutorial held every week.

This thesis describes the development and evaluation of computer generated lecture and tutorial material for 43.220. Section one of this report details the production of lecture notes using presentation software, and the creation of interactive computer programmes that replaced the existing tutorials. The delivery of this material during class time is also outlined.

In order to investigate student and lecturer response to a technology based course delivery, and improve the computer based material, an in-depth evaluation was performed. Section two details the utilization of qualitative and quantitative research methods to identify the important factors and improvements associated with the delivery mechanisms.

The study was performed over a period of 12 months during which the model paper was delivered twice. Two lecturers were responsible for the coordination and teaching of the paper to 79 students (37 and 42 attended the first and second deliveries respectively).

^d Integrated Services Digital Network

^e One semester is 14 weeks of the University year

SECTION ONE

**THE DEVELOPMENT AND DELIVERY OF
COMPUTER BASED LECTURE AND
TUTORIAL MATERIAL FOR 43.220**

1.1 INTRODUCTION

The term 'multimedia' describes the use of more than one medium to convey information. For example, combining real life images with video, computer graphics and a voice-over can provide context and realism to course material [10]. Interactive multimedia can be defined "as a computer tool that includes a combination of text, graphics, sound, video and animation sequences packaged together" [11, p. 430].

The use of multimedia in the lecture theatre has been a controversial subject among researchers. Many educators are concerned with the time and effort required to produce quality multimedia products [12,13,14]. Even when time is available, reluctance to create course material is attributed to a lack of confidence, skills, resources and software to do so [2,4,13,14]. There are also problems with "new developers attempting to do some things with multimedia that are better done with conventional tools. Why would anybody want to read pages of text on computer when they can curl up on the couch with a book?" [15, p. 66]. However, what is apparent is that a desire exists for varied and interesting forms of visual stimulation within the classroom [16]. This can be achieved comparatively easily via electronic presentations and animation, video tapes, use of the World Wide Web and many other means [16].

Given that electronic presentation software, video, whiteboards and overhead projections are available in many educational institutions, a 'multimedia' lecture is already at the educator's disposal. In the case of 43.220, the electronic presentation of lecture material accompanied by computer-based tutorials were chosen to add a multimedia aspect to the course.

This choice was made because although computer generated material is more time consuming to produce than use of a whiteboard and overhead projections, it is easier to deliver at a distance when systems such as the HMR-EM and TEF are in place.

1.2 OVERVIEW OF MATERIAL DEVELOPMENT FOR 43.220

43.220 has previously been taught using a standard lecture format that encompassed a wide range of delivery techniques. These included note taking onto handouts from overhead projections, white board, black board and dictations. Existing lecture material was in handwritten or acetate form, the latter developed using Lotus Freelance 2.0 for Windows, and copies distributed to students. In order for the lecture material to be delivered synchronously at a distance all notes were adapted for electronic presentation and developed within Lotus Freelance '96^f. The interactive use of pre-recorded lecture material was also experimented with for three of the lectures delivered in the course.

The tutorials for 43.220 were previously delivered in an interactive environment where students were able to develop their problem solving skills. Questions and numerical answers were given on paper and the lecturers encouraged students to work through the problems until the answer was obtained. It was important that any alternative delivery preserved the ethos of the tutorials, while allowing for synchronous and asynchronous learning. For these reasons, a series of interactive computer programmes were created using Macromedia's Authorware 3.0^g. These included the original set of questions and other similar problems.

During the initial stages of development the course content of 43.220 was modularized into a series of "Frames" which included the lecture content, demonstrations and tutorials. Every Frame was accompanied by a set of learning objectives identified from the lecture material to be reinforced in the tutorials. An example Frame from 43.220 is given in Table 1.

Demonstrations were used during the lectures to break up the monotony of a single delivery format. These took the form of specially prepared video clips, Matlab examples and computer animations. Consistent with the aim of remotely delivering the paper, the course content could be used in both synchronous and asynchronous modes.

^f Lotus Freelance '96 is a presentation graphics programme which is used to create visual documents

^g Authorware 3.0 is an authoring environment for creating interactive information

| Frame 1 - Information |
|---|
| <ul style="list-style-type: none"> • What is information • Definition of a bit of information • The relationship between information and probability |
| <p>Demonstrations</p> <p>Video taped telephone network simulation Matlab example for probability vs. information Matlab example for entropy of English and images</p> |
| <p>Tutorials</p> <p>Tut 1 - Information content</p> |
| <p>Learning Objectives</p> <p>Students should:</p> <ul style="list-style-type: none"> • Know what information is and be able to define a bit of information • Be able to develop an expression for measuring information |

Table 1: 43.220 Frame 1

1.3 THE DEVELOPMENT AND DELIVERY OF LECTURE NOTES

The lecture notes were constructed as sets of pages within Freelance '96. The handwritten lecture material was quite comprehensive and approximately one week was dedicated to summarizing the concepts in point form. This procedure was performed to enhance the material for the computer screen. Presenting text concisely using plenty of blank space as opposed to book-like paragraphs is a recommended practice [17].

However, the notes could not be made too brief as the lecturer was unable to annotate the material during the lecture. Therefore, each Freelance page was carefully constructed to display the content in a summarised form while maintaining its context.

Lecture material previously compiled using Lotus Freelance 2.0 for Windows was imported to Freelance '96 and rearranged to provide a consistent layout for delivery. As with the handwritten material, extensive notes relating to a concept were summarised

for display purposes. When compared with the notes in their original form the computer material doubled, and sometimes tripled, the number of pages.

Within the classroom the prepared material was projected onto a large screen using a digital macro-mirror device. Due to an incompatibility between the software used for development and the hardware available in the lecture theatre, the computer containing the lecture material had to be transported to the classroom where it was connected to the projector. This process could extend the set up time from ten to twenty minutes (depending on the computer configuration) and emphasised the importance of standardising presentation and developmental techniques to coincide with availability of existing resources.

The use of incremental display building has been found to be an effective practice for computer presentations [17] and this was the method used for 43.220. Each Freelance page was duplicated and material deleted so that key points appeared one at a time. This allowed the lecturer to explain the concepts without the class being distracted by the presence of any other material. Typically each page was displayed using two to four incremental steps.

For the first delivery of the paper, the Freelance presentations used colour to highlight essential concepts and reduce the starkness of a white background. During the second delivery different background colours were also used to signal topic changes. A black and white collection of notes was generated from the original set, for distribution to the students.

Many of the lecture handouts for the first delivery contained gaps to be annotated by the students as the information appeared on the screen. This process was implemented in order to promote a more active learning environment [18]. Unfortunately, it also increased the complexity of note generation.

Working from the original complete set of notes, a presentation set to be incrementally displayed in full colour was produced. Material to be annotated was then deleted and a

further black and white set created for printing. This meant that any required correction or change to the lecture notes was made in three different sets.

A different approach was trialed for the second delivery of 43.220. The original set of course notes was refined and darker background colours added so that both black and white text was clearly visible. The body of text appeared in black and annotations could easily be changed to white which would still appear onscreen but be absent from the black and white printed set. Annotations were initially made with the drawings and text compiled by the Freelance programme. The numerous equations appearing in the lecture material were imported to Freelance from another programme and could only be altered for annotation by 'covering' them with a white rectangle.

The procedure for note generation is shown in Figures 1.31 and 1.32. Both paper deliveries are described and the amendments made to the procedure for the second delivery facilitated easier note production.

However, the time for material preparation far exceeded that used for a standard lecture without computer based material. The lecture notes were created over a period of one month and ongoing improvements and changes totalled more than 60 hours. Examples of the lecture notes and annotations can be found in Appendix I.

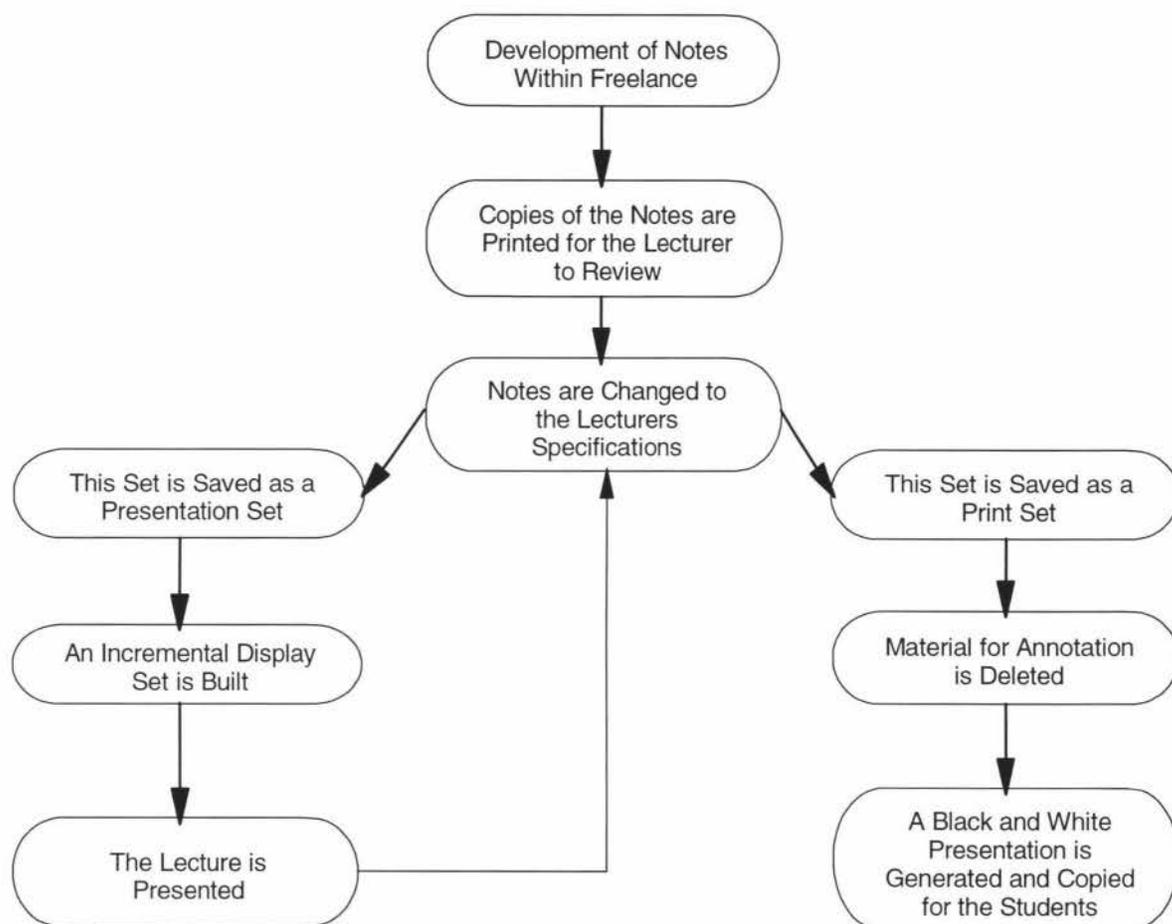


Figure 1.31: Procedure for Note Generation for the First Delivery of 43.220

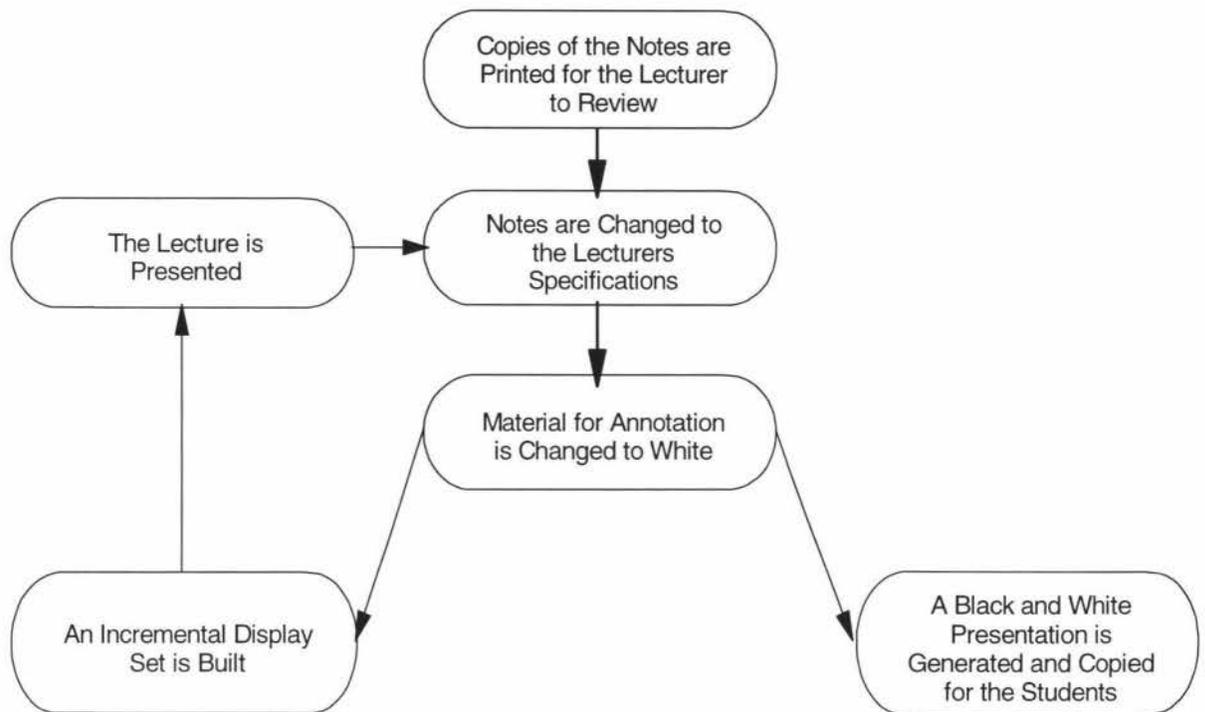


Figure 1.32: Procedure for Note Generation for the Second Delivery of 43.220

1.4 THE DEVELOPMENT OF LECTURE DEMONSTRATIONS

The creation of lecture demonstrations was essential in providing varied and interesting course material. The demonstrations developed for 43.220 were typically of a few minutes duration and were either a video, Freelance or Authorware 3.0 animation.

The lecturers identified a suitable demonstration for each 43.220 frame. Demonstrations were selected to provide students with practical examples that could easily be related to information and communication theory. Consistent with the principles of multimedia it was expected that the demonstrations would promote interest and enliven the lectures.

Once such demonstration was produced to illustrate the concept of 'noise' in a communications system. A video taped segment of a post graduate student operating a telephone network simulator allowed students to hear the effect of noise at varying levels using equipment not available in the classroom.

Another demonstration utilized Macromedia's Authorware 3.0 to create a computer animation. This effectively illustrated the movement of data bits through a 'shift register'. After each movement the animation was paused for lecturer comment before proceeding by clicking the "Continue" button. The asynchronous version of this demonstration included an accompanying explanation that appeared onscreen with each movement. This example appears in Appendix II.

1.5 THE DEVELOPMENT OF TUTORIALS

The objective of the computer based tutorials was to teach students how to solve information theory and coding problems in a self paced and interactive environment. Computer aided instruction should establish an environment where the learner can control the time and pace of material delivery in a non-threatening setting [4,15,19]. It is essential that any computer based learning package requires no training to use [20] and is navigable [17]. In other words, when creating interactive software "make sure the user can figure out what to do and make sure the user can tell what's going on" [21, p. 71]. Consistent screen layouts, navigation functions that were always visible and instructions appearing throughout the programme were the elements employed to make the programmes user 'friendly'.

Authorware 3.0 was used to create six tutorials for information theory, communication and coding problems (Table 2). Authorware was chosen for this task because it can be run on any computer. The tutorials produced also functioned as standalone programmes which allowed the students to obtain their own copies to work through in their own time.

| | |
|----------------|------------------------------|
| Tutorial One | Information and Entropy |
| Tutorial Two | Huffman Coding |
| Tutorial Three | Mutual Information |
| Tutorial Four | Arithmetic Coding |
| Tutorial Five | Basic Coding |
| Tutorial Six | Cyclic and Convolution Codes |

Table 2: Information Theory Tutorials

Many of the problems presented to the students were of a mathematical nature. Problems of this type are best learnt from example by working through the solutions to similar problems [22]. Each 43.220 tutorial contained a set of practice and challenge problems. Practice problems offered a help function that gave a step by step guide to the solutions. These were included in order to make 'the obscure apparent'. If students were unable to begin a problem they could acquire the first step by clicking the "Help" button. This process could be repeated until the final answer was reached. The help process utilized in the tutorials provided a full worked solution in a series of stages so that students could focus on each step.

Challenge problems were presented to enable the user to apply the knowledge gained from the practice problems. Challenge problems were similar in content to practice problems but lacked the help function. Instead, hints were available if the problem required any additional knowledge that did not appear in the practice problem. Links between the practice and challenge problems were established so that students could move from one to the other. Students were encouraged to use MATLAB for numerical assistance and could launch it from within the Authorware programme. Excerpts from Tutorial One can be found in Appendix III and an example of the tutorial screen setup appears in Figure 1.51.

The tutorials were first presented to the students in a semi-formal one hour tutorial, during which the lecturer was present. Eight IBM PS2 computers were used, each with two to six students attending. Once the tutorial was finished, a copy of the Authorware programme was made available on the TEF.

Difficulties with the tutorials arose from file size and screen resolution. The programmes created and packaged using Authorware ranged from two megabytes to 11 megabytes in size. This meant that the tutorials were not easily copied for presentation during class, or distribution to the students.

For the first delivery of the paper the tutorials were copied to a network drive from which they could be copied onto each IBM PS2 computer (space permitting). This procedure lasted approximately twenty minutes. During the second delivery the

tutorials were run directly from the network drive in order to promote a more efficient administration of the tutorial programmes. Utilizing the departmental network meant that the tutorials could be copied to the 'server' computer where they would be immediately visible to the IBM PS2s which were part of the network. It was thought that this would eliminate the 'double copying' carried out previously.

However, each week that the tutorials were run, at least one of the IBM PS2 computers was disconnected from the network so a copy was manually put in place. On two occasions when the network was down, the tutorials were hurriedly copied onto the computers as the students waited. The response time for each of the tutorial functions was also greatly increased when the network was utilized. During the latter stages of the second delivery the double copying method was the preferred procedure. Even though it was more time consuming to manually copy the tutorials to each computer, once the programmes were in place their availability was assured and not susceptible to the instability of a computer network.

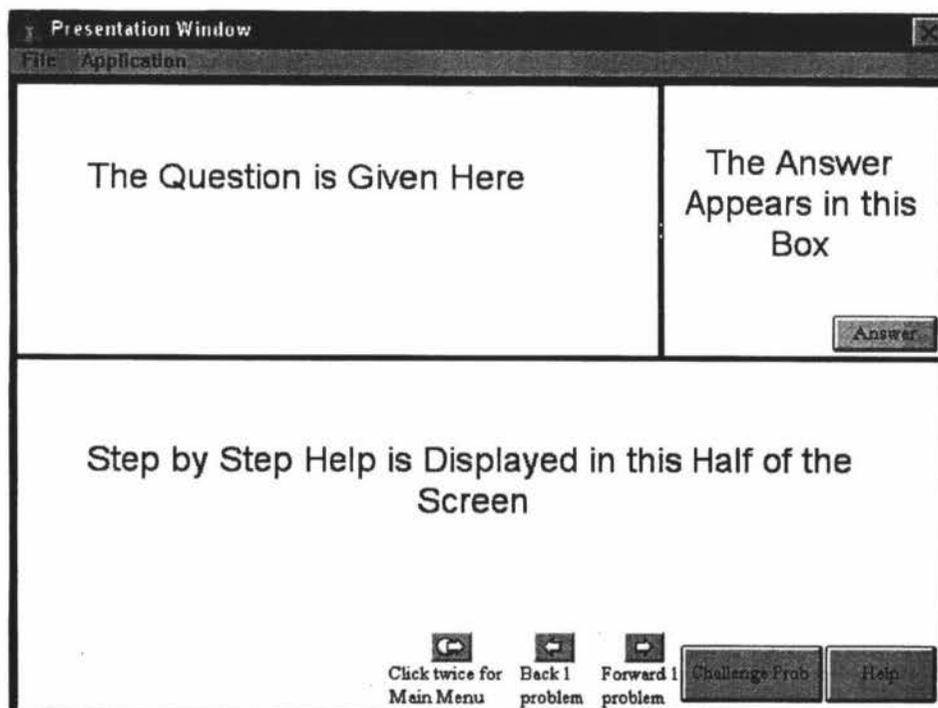


Figure 1.51: Screen Setup for a Practice Problem in a 43.220 Tutorial

It was also found that the screen resolution of the host computer adversely effected the clarity of the tutorials if it was less than that specified within the Authorware programme. If a tutorial was created for a 640 x 480 pixel screen the text would appear too small if viewed at a 1024 x 768 resolution. A student survey revealed that both high and low resolution versions of the tutorials were required so an additional six tutorials were recreated for a 1024 x 768 pixel screen.

There were a number of unforeseen problems that hindered any further tutorial development after the high resolution versions were created. Given the numbers and cumulative size of the tutorial programmes (Table 3) they could no longer be stored on the computer and had to be transferred to a 'zip disk'^h. From this point onward, the files on zip disk had to be copied back to the computer to perform any alterations using Authorware 3.0. Copying files from the zip disk to computer and vice versa took up a significant amount of development time, but it was unavoidable.

In order for a computer to run Authorware a 'hardware key' is required to be inserted into one of the ports at the back of the machine. Unfortunately the zip drive is also connected at the same port and will not work if both are plugged in simultaneously. This seemed to be the result of an inability of the zip drive to communicate with the computer through the Authorware hardware key. It has been noted that an internal zip driveⁱ is essential for developing programmes using Authorware 3.0 to eliminate the need for copying work to and from the computer.

^h A zip disk has a capacity of 100 megabytes and is used in a zip drive that can be plugged into a computer

ⁱ An internal zip drive is installed in the computer

| Tutorial | File Type/Size | | | |
|------------|---|--|---|--|
| | Original Authorware Files, 640 x 480 Resolution (Megabytes) | Original Authorware Files, 1024 x 768 Resolution (Megabytes) | Files Packaged as Executable Programs, 640 x 480 Resolution (Megabytes) | Files Packaged as Executable Programs, 1024 x 768 Resolution (Megabytes) |
| Tutorial 1 | 6.62 | 16.90 | 1.810 | 9.100 |
| Tutorial 2 | 7.25 | 15.30 | 1.700 | 2.720 |
| Tutorial 3 | 6.78 | 18.90 | 1.270 | 7.330 |
| Tutorial 4 | 5.99 | 15.30 | 0.935 | 0.940 |
| Tutorial 5 | 7.20 | 22.70 | 1.890 | 10.90 |
| Tutorial 6 | 9.30 | 37.30 | 2.420 | 11.00 |

Table 3: 43.220 Tutorials and File Sizes for High and Low Resolution, Original and Packaged Versions

1.6 FUTURE RECOMMENDATIONS FOR 43.220 TUTORIAL DELIVERY

Within the tutorial programmes three sets of problems contained common material - “Practice Problems”, “Challenge Problems” and “Practice and Challenge Problems”. The “Practice Problems” and “Challenge Problems” menus enabled the user to cycle through either the practice problems or the challenge problems. The navigation available in these items needs to be improved by adding “Forward One Problem”, “Back One Problem” buttons.

Alternatively, these menus could be deleted so the user can work through the “Practice and Challenge Problems”. This set has improved navigation and renders the existing “Practice Problems” and “Challenge Problems” menus redundant.

When the tutorials are run there should be no more than three, and a maximum of four students per computer. When larger groups were formed many students were observed to ‘opt out’ since the motivation to participate appeared to decline as group numbers

increased (see Section 2.51). For larger classes, tutorial streams may need to be organized so that each student can gain the maximum benefit of computer based instruction.

The creation of six high and six low resolution tutorials meant that minor changes to the material had to be made in 12 programmes. This laborious process took over three weeks of development time so the advantages and disadvantages of high and low resolution versions required consideration.

Even though the higher resolution tutorials appeared clearer on high resolution monitors the file sizes limited their portability. The programmes created for the lower 640 x 480 resolution screen were significantly smaller. Therefore, they were copied faster and did not take up as much space on the host computer. For these reasons, any further interactive programmes created using Authorware would ideally be developed for a 640 x 480 resolution. However care must be taken to ensure that the programmes can be clearly viewed on a high resolution screen.

Unfortunately the available screen space using the lower resolution is significantly reduced. Nevertheless, considering that material prepared at a low resolution can be viewed on all higher resolution screens, time invested on finding innovative ways to use the space available would be time well spent.

1.7 RECOMMENDATIONS FOR A REMOTE DELIVERY - LESSONS LEARNED FROM 43.220 MATERIAL DEVELOPMENT AND DELIVERY

The development and delivery of the 43.220 course has provided insight for the requirements of a remote delivery. Equipment setup, monitoring delivery mechanisms, and working with lecturers to improve the paper delivery were processes used in 43.220 that have application to remote courses. Lessons learned during the 43.220 delivery have included many factors that need to be considered before, during and after a computerized, or remote delivery. These factors are summarised below.

1.71 Factors to be Considered Before Delivery

The presentation software selected for material development is dependant on available resources. Lectures and tutorials should be prepared well in advance of delivery. This allows time for a 'practice' run that would reveal any alterations needed.

The lecturer must be familiar with the technology used during delivery. For example, instruction should be offered on the use of computers, video recorders and projectors. Experience with 43.220 has shown that even though equipment may appear easy to operate before a lecture, it becomes very difficult to use during the lecture. A practice run would reveal potential problems with the delivery mechanisms and areas where instruction is required.

Any notes or handouts to be distributed to the audience should be produced during material development. They could comprise a printed copy of the computer presentations or a more comprehensive set could be compiled using word processing software.

1.72 Factors to be Considered During Delivery

For the first few deliveries, and on any subsequent occasion where there is variation in the delivery tools, support personnel should be present before, during and after the lecture. Before the lecture, instructions for equipment setup and use are given to the presenter. As the lecture progresses, the lecturer is more inclined to relax knowing that support is near. Following the presentation, support personnel may need to pack up the equipment and answer any questions relating to the delivery.

Very few lecturers remain stationary throughout a lecture. Therefore, in a remote delivery the lecturer must have freedom of movement.

Computer generated course notes can result in a lack of flexibility during the lecture. The lecturer should be able to digress from the prepared material to answer student

questions and address matters arising from the lecture. This leads to the following requirements:

- A whiteboard that can be annotated online.
- The opportunity for the lecturer to insert examples, quizzes, demonstrations (some may include other computer packages) etc, easily, spontaneously, and without hassle.

The lecturer also needs to control what the class 'sees' during the lecture. There are three essential media for information transfer - the lecturer, prepared notes and whiteboard. To deliver these remotely, using one projector, would require constant cutting between media with an audio lecture in the background. An alternative window type arrangement could be used but both options result in 'screen watching' which is not likely to promote an interactive learning environment.

A more effective arrangement could be achieved with two projectors - one for the lecturer, and one that can project a whiteboard or notes at the lecturer's will. This scenario is preferable since the class will have to monitor two screens, and their own notes, thereby increasing their interaction with the course material.

In order for the lecturer to interact with a remote class, the ability to see and ask questions of the audience, in addition to receiving verbal and non-verbal feedback is essential.

1.73 Factors to be Considered After Delivery

It is important that the audience is satisfied with the material taken away from the lecture. A smooth remote delivery is of little value if the material covered cannot be referred to at any other time. This is especially true for a delivery system where the lecturer is not readily available. Therefore, study guides may be required or the lectures could be video taped for reference from the campus library.

Any queries that the audience may have relating to the lecture could be addressed via e-mail, newsgroups or some other mailbox system.

Finally, the lecturer should elicit feedback from the students about the course delivery. They may suggest some viable improvements.

1.8 SUMMARY

This section has detailed the first step toward a remote delivery of 43.220 considering that the paper was delivered without recourse to the traditional lecture and tutorial format. The exemplary paper showed that existing technology could be used successfully in a classroom environment.

However, the generation of computer based material for lectures and tutorials is very time consuming and a clear understanding of material presentation, coupled with a detailed agenda for its preparation are required. The 43.220 lecture notes were created over a period of one month and tutorial development exceeded two months. In addition to this, a great deal of time was spent on changes and improvements.

The development of computer based lecture and tutorial material facilitated an asynchronous course delivery. The material was copied to the TEF where it could be accessed at any time from the Internet. In future, material could also be transferred to a CD-ROM if a demand for this format existed.

Future improvements to the delivery of 43.220 include more lecture demonstrations that show the 'real life' applications of information theory. Also, the tutorials could include hyperlinks or pull down menus for access to the relevant course notes.

Changes in delivery format require that an evaluation of the delivery modes is conducted from a participant perspective - that of the student and lecturer - if real improvements are to be identified and implemented [20,23]. The evaluation of, and improvements to the delivery mechanisms for 43.220 are detailed in Section II of this thesis.