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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**

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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

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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<sup>a</sup> 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<sup>b</sup> 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.<sup>c</sup> and/or ISDN<sup>d</sup>) between the Palmerston North and Albany campuses for their remote delivery in the future.

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

<sup>b</sup> Synchronous delivery allows classes to be taught simultaneously in two places at one time

<sup>c</sup> 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<sup>e</sup>, 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).

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<sup>d</sup> Integrated Services Digital Network

<sup>e</sup> One semester is 14 weeks of the University year

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***SECTION ONE***

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

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## 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<sup>f</sup>. 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<sup>g</sup>. 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.

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<sup>f</sup> Lotus Freelance '96 is a presentation graphics programme which is used to create visual documents

<sup>g</sup> Authorware 3.0 is an authoring environment for creating interactive information

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

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.

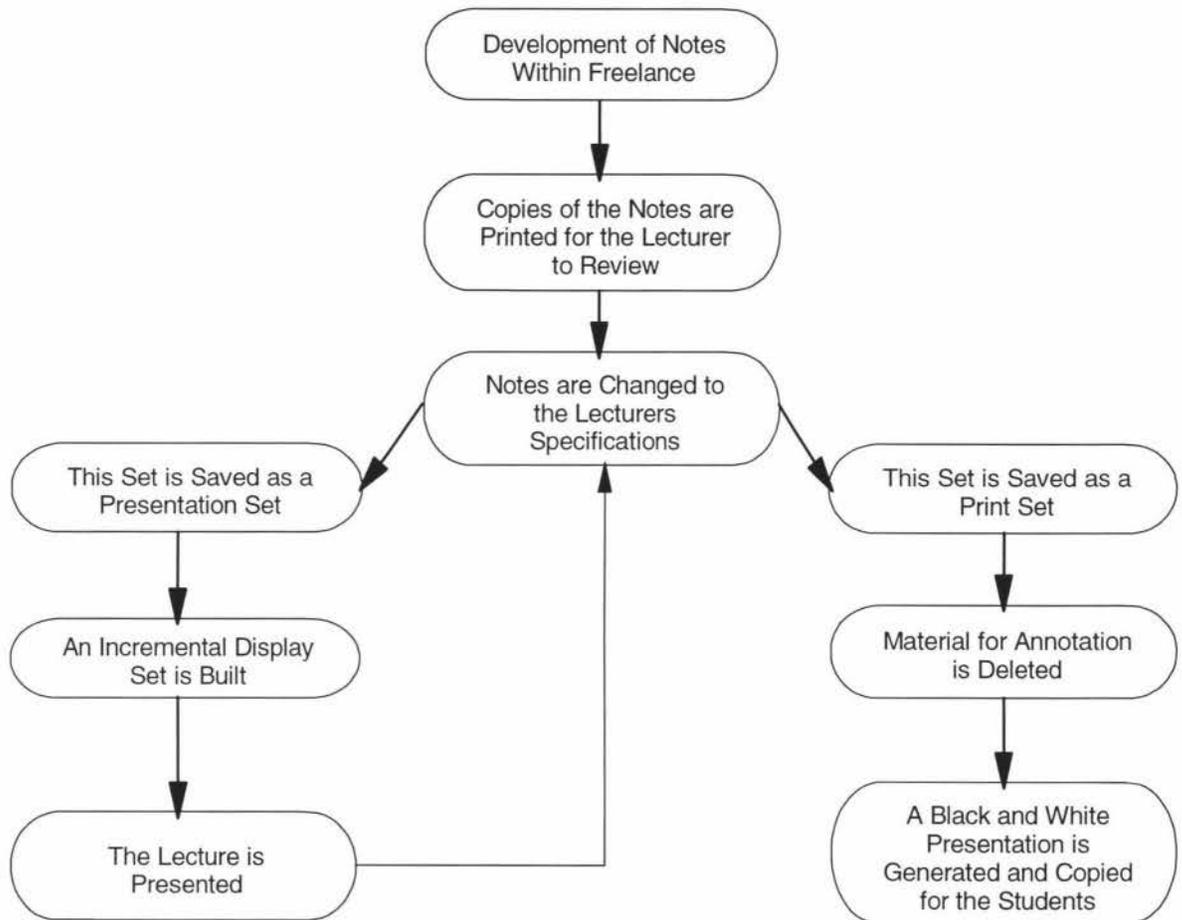


Figure 1.31: Procedure for Note Generation for the First Delivery of 43.220

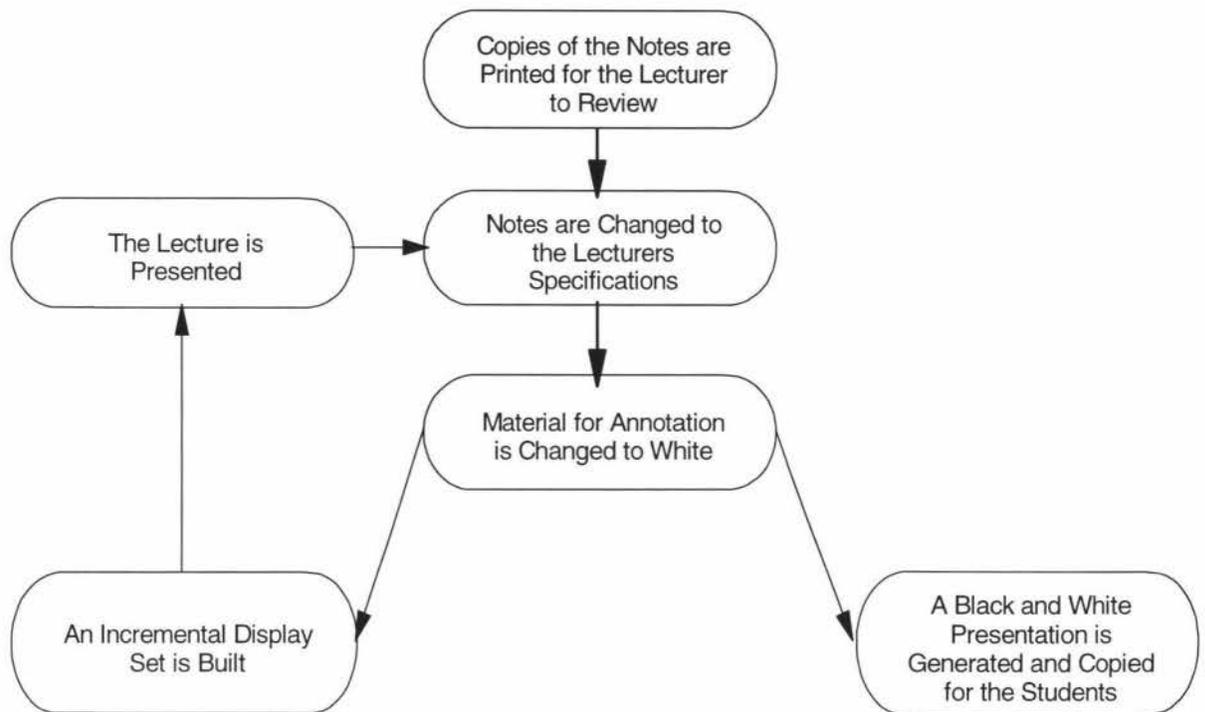


Figure 1.32: Procedure for Note Generation for the Second Delivery of 43.220

#### 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.

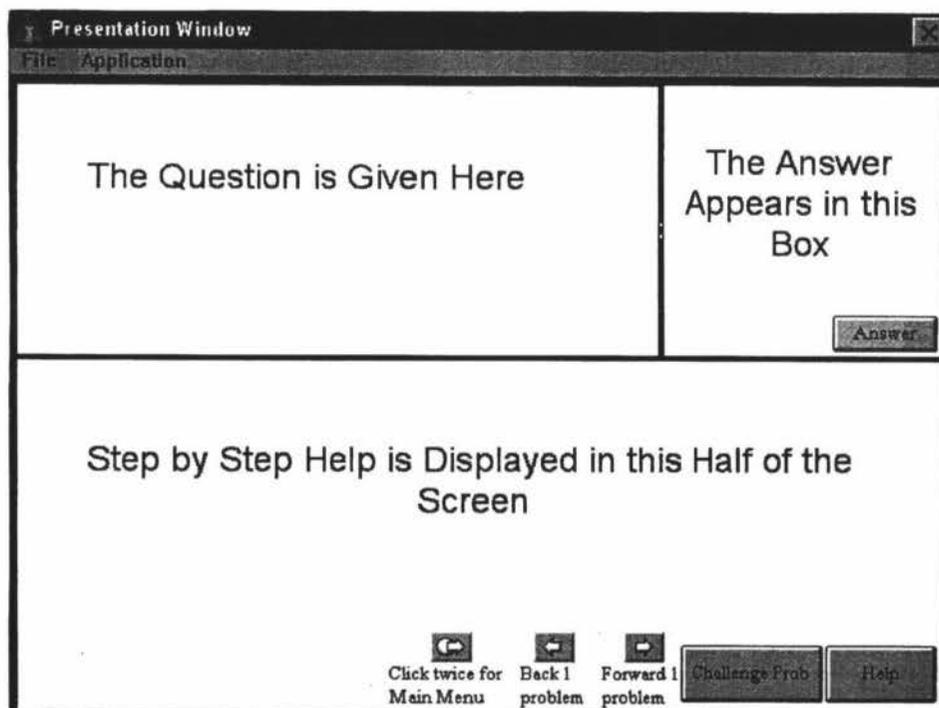


Figure 1.51: Screen Setup for a Practice Problem in a 43.220 Tutorial

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'<sup>h</sup>. 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 drive<sup>i</sup> is essential for developing programmes using Authorware 3.0 to eliminate the need for copying work to and from the computer.

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

<sup>i</sup> 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.

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***SECTION II***

**THE EVALUATION OF LECTURE AND  
TUTORIAL MATERIAL FOR 43.220**

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## 2.1 INTRODUCTION

Since the introduction of the computer into the classroom, very few researchers have investigated the responses of students and teachers to technologically based education. Such research is crucial as a student's perception of the learning environment can have a significant influence on the quality of their learning outcomes [24].

Those studies that have attempted to examine user response have typically employed a mixture of quantitative and qualitative methods using data derived from questionnaires [25]. Techniques of this sort have limited value as a questionnaire response may not correlate with the observed behaviour of the respondent [26]. In addition the response is partly dictated by the question, limiting the usefulness of questionnaires as an exploratory tool [26,27].

Another study [11] used post course interviews to assess student response to educational technology innovations. Cases of this type may neglect the possibility that the student may not be motivated to discuss the effectiveness of the delivery at the completion of the course.

Other approaches to student assessments of educational technology have employed more than one evaluative technique. For example, questionnaires, interviews and case reports may be utilized but a detailed description of the procedures followed to obtain the results of the studies is often omitted [28].

The purpose of this evaluation was to develop and apply a methodology to assess the response of participants to the computer generated lecture and tutorial material created for 43.220. The evaluation was aimed at identifying important factors that affect the quality of the delivery system, as perceived by those involved.

## **2.2 EVALUATION METHODOLOGY**

### **2.21 Overview**

To investigate the response to the delivery modes from a participant perspective a qualitative methodology was used. A more quantitative approach was discounted for three reasons. Firstly, it was unethical to assign students to experimental groups that could potentially effect their learning outcomes. Secondly, “questions of educational goals involve values, they must be removed from the realm of scientific inquiry” [5, p. 68]. Finally, the social conditions within the classroom cannot be treated as an artifact since these conditions are an essential part of the data generated [29].

The philosophy adopted here is that programme evaluation is a form of Action Research. The development, improvement and continuation of a programme within an educational setting is dependant upon research that will answer real life questions [30]. The results of this study were derived from Action Research and a collation of the qualitative data was performed using triangulation.

### **2.22 Action Research**

In order to achieve a greater understanding of an experimental investigation, it is important that the experiment, as a social process, be addressed. In the late 1940’s social psychologist Kurt Lewin shifted his focus from scientific experimentation to the study of the social dynamics which preclude social action [31]. This lead to the development of Action Research.

“The Action Researcher becomes involved in creating change not in artificial settings where effects can be studied and reported dispassionately, but in the real world of social practice. In Action Research, the intention to affect social practice stands shoulder to shoulder with the intention to understand it” [31, p. 7].

Action Research involves rigorous data collection but its goal is not to add to the general body of knowledge but to improve its application and practice [31]. French &

Bell [30, p.136] considered Action Research as an “approach to problem solving, as well as a problem solving process”. Action Research can be viewed literally as research for the improvement of the quality of action within the setting where it is to be carried out [32,33].

Methodologically, Action Research is an ongoing process which is cyclical in nature [5,31]. The strategy for its use has three distinct phases - conceptualization, implementation and interpretation [38].

Conceptualization involves an investigation of the particular system under scrutiny. This will include data collection in order to identify important inputs, and desired outcomes, in the setting where Action Research is to take place. This is essentially a planning stage where goals are set, strategies formulated for their measurement and achievement.

During the implementation phase the outcomes are measured. It is important that previous standards are clarified so that a comparison between the action strategy and any past interventions can be made. The analytic techniques for a comparison need not involve complex statistics but may include simpler numerical techniques such as means, standard deviations and graphs [38].

When interpreting findings, the Action Researcher is required to make judgments about the effectiveness of the action strategy implemented. This could include a cost/benefit summary and also reveal additional action strategies and/or variables for further investigation. These will then need to be reconceptualized and the cycle continued [38]. These ideas are summarised in Figure 2.21 [38].

The most important aspect of Action Research is that the involvement of all the participants is integral to its success. Action Research has been described as “a form of self-reflective inquiry undertaken by participants in social situations in order to improve the rationality and justice of their own practices, their understanding of these practices, and the situations in which the practices are carried out” [5, p. 162]. Participant

feedback is an essential element in all phases of the methodology as it gives greater understanding which leads to even more effective interventions.

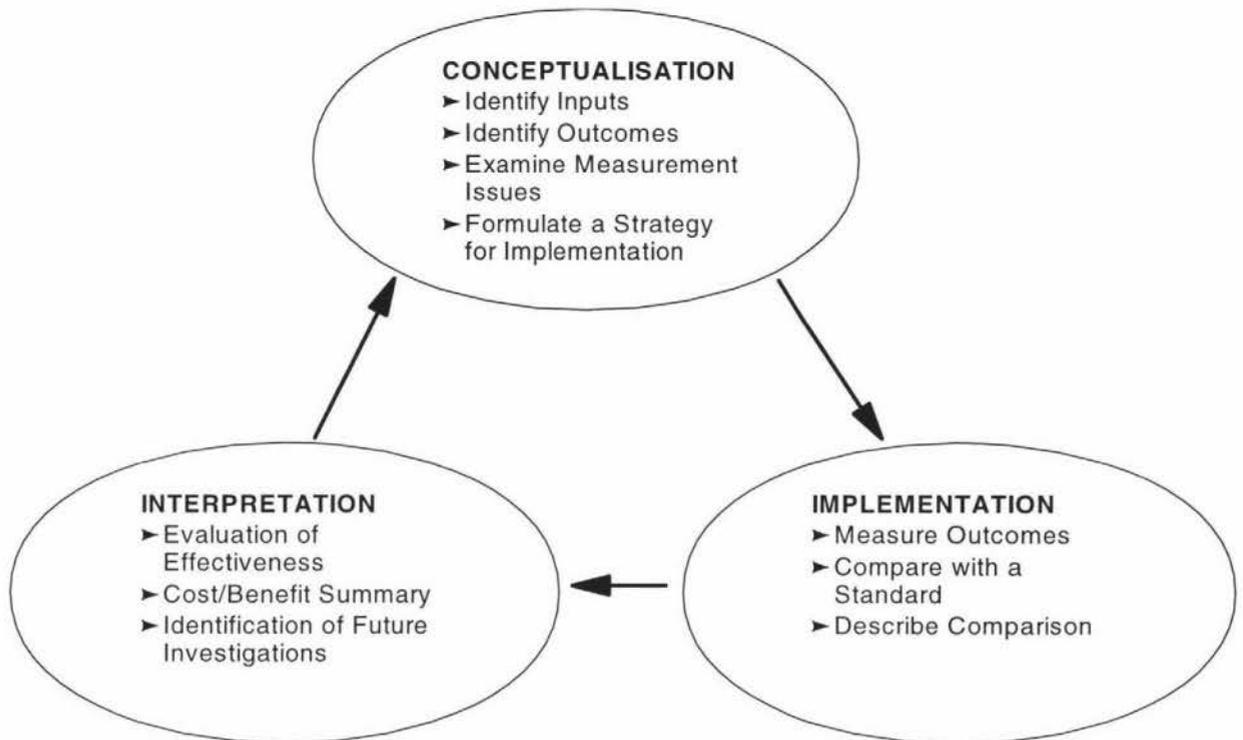


Figure 2.21: Summary of Action Research

### 2.23 Applications of Action Research

To date, Action Research has been used to solve problems, promote innovation and improve the practices of those in educational settings. In Britain, Action Research methods have been employed by Elliot and Adelman [32] in the Ford Teaching Project.

The project involved 40 teachers in primary and secondary schools and arose from the discovery that innovations in the classroom were often applied without any attempt to evaluate their effectiveness. The research was teacher-based requiring the participants to conceptualize, implement and interpret action methods for problem situations.

The teachers were required to communicate any findings to each other in an attempt to improve overall practice. As the project continued it was evident that “the teachers’ increasingly active involvement in collecting, sharing and discussing data changed the

pedagogical theories underpinning their practices” [32, p. 35] and “those who developed their capacities for Action Research displayed not only self-awareness but a considerable critical awareness of the institutional constraints on the development of their teaching” [p. 38]. In this case Action Research was successful in the promotion of action strategies, and identification of limiting factors that were previously not noted. The Ford Project paved the way for similar projects such as the Teacher-Student Interaction and Quality of Learning Project which also demonstrated the efficacy of Action Research [32].

The potential for Action Research to be applied to in-service training, job analysis, improving communication and defining prescriptive action in a research study has already been recognised [33]. It appears that Action Research need not be confined to educational practices and settings.

Action Research could also be applied to organizations for the promotion of change, innovation and improved practice. Its principles could be directly applied to experimental and social psychology, or indeed anywhere that human interaction is an important component of a study.

## **2.24 Triangulation**

Triangulation involves gathering accounts of the educational setting using two or more methods of data collection. This process increases the validity of qualitative analysis since it prevents the researcher from readily accepting isolated findings [33]. For the purposes of this study, triangulation was employed to check the consistency of findings both between methods and between sources [33].

Responses to the technology used in the delivery of 43.220 were acquired from three different sources - 79 students, two lecturers and a non-participating observer. Three different methods of data collection completed the triangulation process - observation, questionnaires and interviews.

The responses from each method of data collection were individually collated and summarised to facilitate a triangulation of the findings between methods and participant sources. The results of the study were identified from the data that appeared consistently across each method. This process is explained diagrammatically in Figure 2.22.

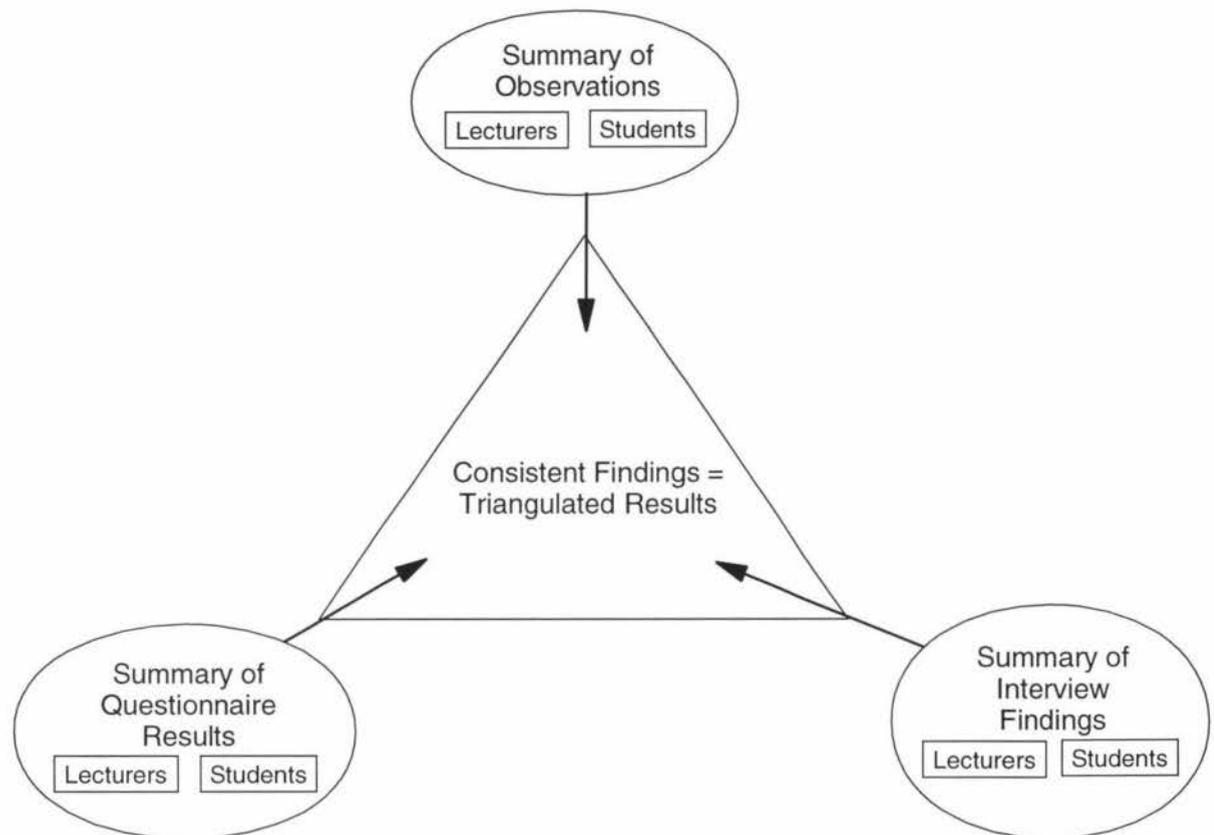


Figure 2.22: The Triangulation of 43.220 Data Collection Methods and Participant Sources. The triangulated results were derived from the data that appeared consistently across each method.

## 2.3 DATA COLLECTION

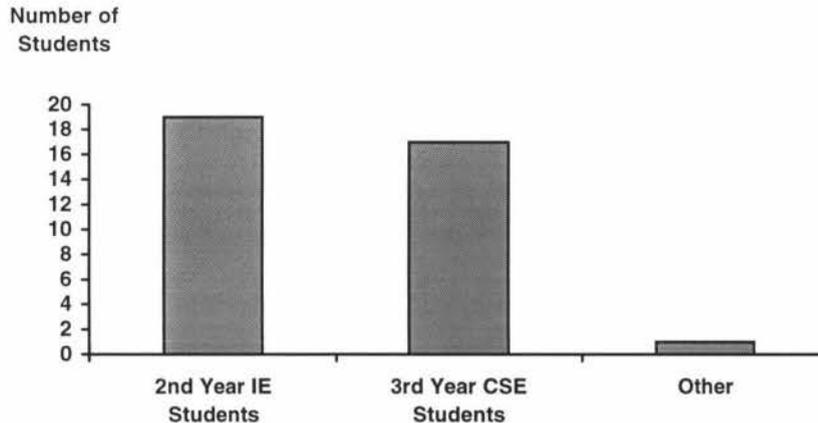
### 2.31 The Participants

Present during the lecture deliveries were one of two lecturers (depending on the lecture topic) and the researcher who acted as a non-participating observer.

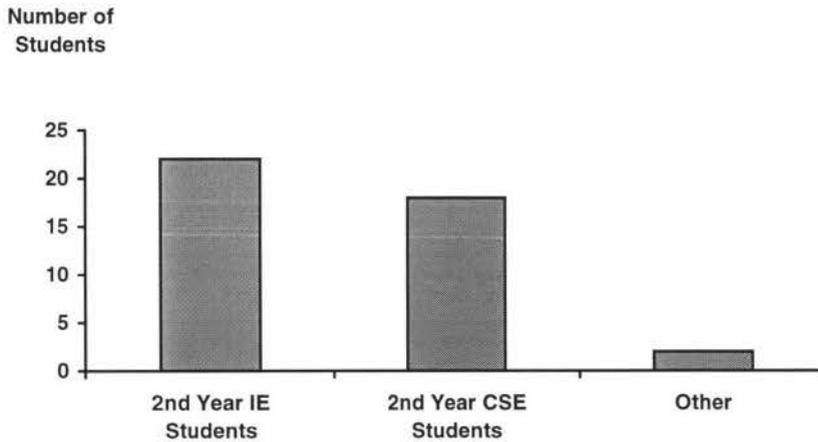
For the first delivery, 34 male and three female students attended the lectures. Nineteen students were in the second year of their degree pursuing an Information Engineering (IE) option. Seventeen students were completing the third year of a degree in Computer Systems Engineering (CSE). One student selected 43.220 as an elective for a science degree.

Forty-two students attended the second delivery of 43.220. This number included 41 males and one female. A total of 22 students had selected Information Engineering as their degree option and 18 students identified Computer Systems Engineering as their choice. Approximately 80% of the students were completing the second year of their degree.

The student information for both paper deliveries is presented in Graphs 1 and 2. It is important to note that there were very few third year students attending the second delivery of 43.220.



Graph 1: The Student Numbers, Sorted by Degree Option and Year, for the First Delivery of 43.220



Graph 2: The Student Numbers, Sorted by Degree Option and Year, for the Second Delivery of 43.220

### 2.32 Data Collection - Observation and GIFT

Data on attendance, attention and both student and lecturer responses to the delivery modes were collected by observation. Data on attention could be acquired using an operational definition [39] for measurement purposes. Increased levels of attention were identified when the students adopted a more forward-sitting position, remained quiet and followed the lecturers movements. This data was recorded at five or 10 minute intervals by the non-participating observer for all the lectures and tutorials of the course.

Midway through each course delivery, the students and lecturers were asked for written comments on the what they liked and disliked about the delivery system and to suggest improvements. This is known as the Group Informal Feedback on Teaching (GIFT) Technique (Appendix V) [34].

### 2.33 Questionnaires and Questionnaire Design

Three questionnaires were administered to the students before, during and after the course (see Appendix IV). These were devised to review attitudes to computers and

technology and determine any expectations relating to 43.220. More specifically, the questionnaires were created to identify:

- Student attitudes toward the use of computers and technology to deliver 43.220
- Student attitudes toward the use of computers and technology for learning
- Student feelings for computers and technology before, during and after the course delivery
- Important factors that may effect student perception of the course such as attention, lecturers, expectations relating to 43.220 and the pace of the material delivery

Since the majority of questionnaire responses were subjective, their validity could only be confirmed by data obtained from other means [27], in this case interviews and observation. The three questionnaires were also similar in content so that any shift in response patterns could be identified.

The validity of questionnaires can also be biased by non-responses [27]. During 43.220, completed questionnaires were not obtained from a number of students who were absent from lectures. However, it was expected that any bias arising from non-response would be compensated by the use of other data collection methods.

The question design conformed to the standards set by other survey researchers [26,27]. Each question was rephrased until:

- It could be asked exactly as it was written
- The question meant the same to everyone
- The question could be answered by all students
- The students would be willing to answer the question [26,27]

A mixture of open and closed questions were used to facilitate qualitative and quantitative analysis of the data. Closed questions require the respondent to answer from predetermined categories and are renowned for eliciting reliable and analytical answers [27]. In the 43.220 questionnaires, students were asked to respond on a seven

point Likert scale. Care was taken to reduce bias by ensuring that the response descriptions at each extreme of the scale were exactly opposite.

The questions were also open to allow the students to describe attitudes in their own words [27]. Another reason to use open questions is that they often elicit unanticipated responses [27] which can lead to new areas of inquiry. An example of the question structure used for a 43.220 questionnaire is given in Figure 2.31.

How do you feel about computers?

1	2	3	4	5	6	7
Very Boring			OK			Very Interesting

Comments

Figure 2.31: An Example of the Question Structure used in a 43.220 Questionnaire

Each questionnaire began with an introduction which contained the questionnaire objectives, instructions and overview. The questionnaires were self-administered so they needed to be self-explanatory. The questions were sectionalised into different areas of investigation. For example: General Information, Attitudes Toward Computers and Technology, Attitudes Toward the Delivery Mechanism and Course Material. Questions were unnumbered so they could be added or deleted without having to renumber the questionnaire.

The questionnaires included a tracking system that maintained student anonymity while facilitating an assessment of individual shifts in responses. This was achieved by giving each student a number between one and 50 which they placed on the first questionnaire. The students were asked to remember this number so they could write it on questionnaires two and three.

The questionnaires were kept as short, clear and uncluttered as possible to decrease confusion and increase response [26]. Finally, to ensure that all aspects of the

questionnaires were satisfactory, they were administered to a small number of students who provided useful feedback.

### **2.34 Interviews**

Throughout the paper interviews were conducted with the students. Interview times were allocated over the course of several lectures in order to gather responses from as many of the attending students as possible. During the interviews the subject was given a summary sheet from the most recently administered questionnaire (an example is given in Appendix VI) and asked to confirm whether their responses conformed to those of the class in general. If not, the student was asked to explain their response and why it was given. All students were then asked for any other comments they wished to make relating to the course delivery. This unstructured technique was used to confirm questionnaire results and identify new areas for investigation not noted on the questionnaires.

The two lecturers were interviewed after the course was delivered. They were asked for their perceptions relating to the material delivery and how they thought the students perceived the delivery mechanisms.

## **2.4 DATA COLLATION**

The qualitative and quantitative data was collated and analysed in very different ways. Any examination of qualitative data should occur simultaneously with data collection so that research instruments can be adjusted as required [35]. Throughout the data collection process for 43.220 the participant responses were searched for emerging patterns or themes that could lead to categories within the response set. This process involved assembling all comments and then arranging them into groups using keywords or phrases appearing in the content. The content analysis was inductive so that the research findings were derived from the data obtained.

At total of 1358 student comments were obtained and collated from the questionnaires and interviews. These comments were divided into the five natural groupings (Table 4).

Category	Number of Comments
Computers	323
Tutorials	203
Lectures	240
Course Notes	146
Technology	149
Lecturers	253
<b>Total</b>	<b>1 358</b>

Table 4: Number of Student Responses for each Response Category

The means, standard deviations and ranges were calculated for the Likert responses on each questionnaire. This data was visually compared in order to identify any trends that may have existed across the three questionnaires. A t-test was used to ascertain whether differences in the means of recurring questions were significant. The qualitative and quantitative data was then compared with the observations made during lectures and tutorials. A detailed guide to the data collation and analysis, as it occurred, appears in Appendix VII.

It was found that statistical differences existed between the three questionnaires but many were inconsistent. 'Richer' data which identified factors consistent with the aims of the study was obtained from the GIFT Technique and interviews. Therefore the quantitative data was used to confirm, or dismiss, the qualitative results. Responses from the lecturers were collated separately and summarized as findings.

## 2.5 RESULTS

For each category - Computers and Tutorials, Lectures and Lecturers, Course Notes and Technology, the collated responses are given along with some suggested improvements. The bracketed number appearing at the beginning, and in each result, is indicative of whether the finding was discovered during the first (1) or second (2) delivery of the paper, or whether the result was consistent across both (1) (2) paper deliveries.

## 2.51 Computers and Tutorials

(1) (2) There was a preconceived idea among students that contact with the lecturer would decrease if computers were used. In the first questionnaire students were asked to comment on their greatest concerns about the use of computers in the course. One third of those who made comments were anxious that there would be a reduction in student to lecturer interaction. This finding was confirmed in the second delivery of 43.220.

(1) (2) 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.

During the first delivery of the paper comments obtained in the second and GIFT questionnaire revealed that the majority of students found the font size used in tutorials was too small. This problem was corrected before the administration of the third questionnaire and there was a significant ( $T = -2.80$ ,  $P = 0.0037$ ) improvement in the results to the closed question “how have you found the computer based tutorials created for 43.220 to be?”. The mean of this question increased from five to six on a seven point Likert scale (1 = extremely useless, 7 = extremely useful).

Responses from the GIFT questionnaire requested more problems in each tutorial. Consequently, additional problems were created for the second delivery of the paper. Students also expressed concern that the course notes were not available during the tutorials. In future the tutorials could include hyperlinks to course notes but, in the meantime, students received prior notification of any notes that were required.

During the second delivery there were no comments made about the font size and only one request for more problems. This indicated that the fonts had been effectively resized and there was an adequate number of problems in each tutorial.

First delivery student responses on questionnaires two and three to the question “have you found the computer based tutorials created for 43.220 to be...” ranged from three to

seven and four to seven respectively (1 = extremely useless, 4 = same as other tutorials, 7 = extremely useful). For the second delivery, responses to the same question ranged from one to seven on both questionnaires.

Qualitative analysis of student comments revealed two factors that contributed to the negative responses during the second delivery. These factors were concerned with the accessibility of the tutorials outside of class time and the group size around each computer.

(1) (2) One of the reasons the computer based tutorials received positive feedback was because they were accessible to students in their own time. This result was evident when the student comments from the first and second paper deliveries were compared.

Of all the comments made about the tutorials in the first delivery only one GIFT comment requested that they be given as a printed copy. During the second delivery, hard copy tutorials were repeatedly requested in the questionnaires, GIFT and interviews by approximately one third of the 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 between the groups can be explained by examining the accessibility of the tutorials outside of class time. The first group of students were able to access the tutorials from the TEF both at home and at the Massey campus. However, due to restrictions enforced at Massey the second group of students were unable to access the TEF on campus. This meant that the tutorials were only available outside of class hours to students who could access the TEF from home.

Summary: Some students were dissatisfied with the computer based material because it could not be accessed in their own time.

(1) The main factor integral to the success of the tutorials was the group interaction that occurred around the computer. Interaction among learners promotes the acquisition of knowledge [34,36]. The GIFT questionnaire revealed that the most enjoyable and

effective learning mechanism perceived by the students was the high level of interaction that occurred around the computer. Although due in part to a lack of resources, this created a relaxed atmosphere where students openly discussed problems, deferring to the lecturer only to facilitate the problem solving process. Observations, together with subsequent lecturer and student interview comments confirmed that group interaction was perceived as a critical factor in the success of the tutorials.

A few students suggested that the quality of this environment could be enhanced if they had remained in set groups.

(2) Group interaction during the tutorials was inhibited if the group was too large. For the second paper delivery the students were encouraged to remain in the same groups. Positive feedback about group interaction was obtained but it was overshadowed by another finding.

Approximately one third of the comments from the interviews and GIFT questionnaire stated that there were “too many students per computer”. During the tutorials there were at least four students per terminal compared to a maximum of three or four students in the first delivery.

These results indicate that interaction is enhanced when groups of up to four students are around a computer. Interaction was impeded when the group numbers exceeded four. Larger classes would need to be split into tutorial streams so that the group interaction effects can be maximised.

(1) (2) The Practice Problems/Challenge Problems and step by step help were a subject of very positive feedback from the students. For both deliveries, one quarter of the GIFT comments relating to what was liked about the tutorials specified that “the help was very helpful” especially in a self-paced environment. The students were also observed to move from the practice problems to the challenge problems and back, if further assistance was needed. This was consistent with the objectives of the practice problem/challenge problem concept.

Summary: The students liked working on computers in an interactive, relaxed, self-paced environment where assistance was available.

(1) At the end of the course students felt more positive about using computers for learning than when they started. This result was revealed through qualitative analysis of the data even though it was not supported by a quantitative analysis of the questionnaire results.

On the first questionnaire six students (60% of those who commented) expressed a reluctance to use computers for learning. When presented with this finding in the first interviews, 12 students strongly disagreed with the result while six students still remained sceptical saying that it “depended on the amount of time spent on the computer” as “text is difficult to read onscreen”. 50% of those who commented on the second questionnaire expressed agreement with the use of computers for learning and this figure increased to 60% on the third questionnaire.

A number of individual response patterns to the closed question “how do you feel about computers for learning?” were tracked across the three questionnaires. Most of the traceable patterns showed a positive shift in responses, which in four cases was relatively large - two or three points on a seven point Likert scale.

(2) At the end of the course students felt less positive about using computers and technology for learning than when they started. Quantitative analysis of the questionnaire results revealed significant drops in feelings for computers ( $t = 1.05$ ,  $P = 0.15$ ), computers for learning ( $t = 2.34$ ,  $P = 0.012$ ), technology ( $t = 1.26$ ,  $P = 0.11$ ) and technology for learning ( $t = 1.45$ ,  $P = 0.077$ ). Patterns within the tracked questionnaires confirmed these trends.

Qualitative analysis of the comments made on questionnaires, GIFT and during interviews indicated that lack of interaction during lectures, along with the inhibited interaction among the students at tutorials were the main factors contributing to this result.

(2) The use of computers or technology in the classroom should not be at the expense of interaction. For this paper delivery the preconceived idea that the use of computers would result in a reduction in student to lecturer interaction was not dispelled during the course.

In future, it is essential that a decrease in student to lecturer and student to student interaction does not occur if technology in education is to be perceived by the students as an effective innovation.

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

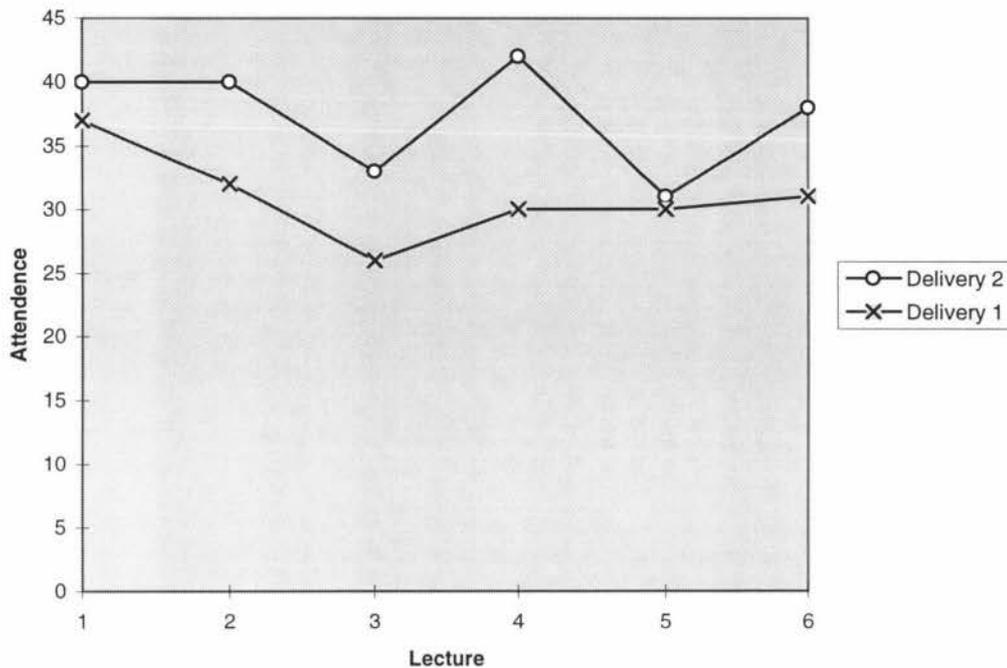
- A high level of student to lecturer and student to student interaction was maintained
- They had control over the amount of time they spent on the computer
- A hard copy of the material was available or easily obtained
- There was good support from peers and staff members

## **2.52 Lectures and Lecturers**

(1) Pre-recording the first three lectures on video tape was not received favourably by students and resulted in reduced attendance at lectures. Consistent with the results of a previous study [37] comments made on the GIFT and second questionnaires, and during the first interviews revealed that many students were extremely negative about the presentation of the pre-recorded lectures. Considering that these measures were performed eight weeks after the event, it is obvious that it is not advisable to begin a course in the manner.

An examination of the attendance at the video taped lectures (Graph 3) showed that the class number dropped by approximately one third during this time. Attendance then increased for 'live' lectures.

**Graph of Attendance at the First Six 43.220 Lectures for Two Paper Deliveries**



Graph 3: Attendance at the First Six 43.220 Lectures for Both Paper Deliveries.

There is a steady decrease in the number of students who attended the video-taped lectures (lectures 1 to 3) of delivery one. The attendance for delivery one then increases but a number of students remain absent for the following three lectures. This pattern is not evident in the attendance at delivery two which did not include the prerecorded lectures.

(1) (2) The material covered in 43.220 was seen by many students as interesting and relevant. In the third questionnaire students were asked how they felt about the course content. 77% of those who responded in the first delivery liked the material and found it to be interesting and very relevant to their chosen degree. This idea was confirmed by comments made in the second questionnaire as well as during interviews.

During the second delivery only 52% of those who responded on the third questionnaire liked the course content. 36% of the students stated that the course material was difficult and “hard to understand”. Mixed opinion on the course content was also evident at the student interviews. Of the students interviewed, nine said they enjoyed the course and the material, eight replied that they did not like the course and were confused by its content.

One possible explanation for this difference in opinion between the two groups was student maturity. The majority of students who were present at the second delivery of the paper studied 43.220 in the first semester of their second year at Massey. Many of the students who attended delivery one were in the third year of their degree. This delivery was also conducted in the second semester of the academic year. This meant that the second year students in delivery one had studied for one semester more than the second year students who attended delivery two.

Therefore, it is possible that delivery one students were more likely to describe 43.220 as interesting and relevant because they were able to link the information to material covered in previous courses.

(1) (2) When the lecture material was clearly presented and interesting in content, attention increased. In the second and third questionnaire students used a seven point Likert scale to respond to the question “compared to other courses you have taken, do you find yourself paying attention to lecture material in 43.220 ...” (1 = much less, 4 = about the same, 7 = much more). Mean response rates were 5.16 and 4.88 for the second and third questionnaires of the first delivery respectively. 50% of those who supplied comments to this question said they paid more attention as a result of clear and interesting lecture material.

Mean response rates to the same question during the second delivery were 4.13 and 4.18 for the second and third questionnaires respectively. 38% of those who gave comments to the question stated their attention was increased due to the delivery and course content. 38% of the comments also said that the course “needed to be more interactive”.

(1) (2) Realistic examples, humour and interactivity within the lecture all increased attention. The results of previous studies [24,36] were confirmed when observation of the students during the lecture deliveries clearly showed greater attention was paid to material that was 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.

Consequently, more examples and demonstrations have been planned for future deliveries. Lecturers have also been advised to facilitate a more interactive environment.

(1) (2) A lecturer's personal qualities and his lecturing ability were perceived by the students as being interdependent. Another study [25] found that students did not distinguish between teaching expertise and personality. In the third questionnaire students were asked how they felt about the lecturer as a person and then given their personal qualities, what did they think of lecturing ability. Response to these questions indicated that lecturing ability is not independent of how the lecturer is perceived as a person. For example, one third of the students gave comments about lecturing ability when asked about the lecturer as a person (2). Qualities such as being easy-going, funny and enthusiastic also correlated highly with the perception of excellent lecturing ability.

(1) (2) The lecture delivery was too fast for many students. Responses to open and closed questions on the second and third questionnaires regarding the pace of the delivery indicated that many students found the lecture delivery too fast.

All the students who made comments about the pace on the second questionnaire during the first delivery said it was a "bit fast". Likert responses on the third questionnaire ranged from four to six (1 = much too slow, 4 = about right, 7 = much too fast). During the second delivery the Likert responses ranged from one to seven. 66% of the students who commented would have enjoyed a "slower, more descriptive" delivery. A slower lecture delivery was suggested as a result of these findings.

### **2.53 Course Notes**

(1) Students perceived that clear, legible notes and screen projections were two essential ingredients that contributed to their satisfaction with 43.220. Consistent with a previous study [24] 50% of the students who participated in the GIFT questionnaire said that what they liked most about the lecture delivery was the clear handouts and screen

projections. Student comments made during interviews and on the third questionnaire reiterated that “good overheads and delivery made the material easier to understand”.

A number of improvements to the notes and projections were also identified from student responses. For example, when delivery one students were required to annotate missing information on their notes from the computer projections, they were observed to watch the screen more often thus paying more attention to the material.

However, comments obtained during interviews and on the second and third questionnaire indicated that a number of students disliked filling in the gaps on their handouts. Further investigation revealed that the students felt more time was used to scan the projections for missing data than to process the course information.

During the second delivery, the annotations were a different colour from the other material. This was intended to maintain high levels of attention during lectures while reducing the time spent hunting for missing information.

(2) The coloured annotations trialed in the second delivery of 43.220 were a resounding success. Eight of the students said they liked the annotations because they increased attention to the material. Observation of the students during lectures confirmed that their attention did increase whenever annotations appeared.

Approximately 70% of the comments obtained from the GIFT specified that the course notes were very good. However, six of the students who responded on the questionnaire said that “the notes were too brief”. This statement was echoed at the interviews.

As a result of these findings it was recommended that either the notes need to be expanded, or the students need to be informed that their notes are only a brief outline to which they are to add the detail. More annotations should be added to the course notes, maybe at the rate of one sentence per Freelance page. However, further investigation is required to identify the factors influencing the effectiveness of annotations.

## 2.54 Technology

(1) (2) The technology used to deliver a lecture did not alter students' perception of the material or the lecturer. Throughout the questionnaires and interviews students were given ample opportunity to comment on the technology used in the delivery of 43.220. Yet at no time throughout both 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 lecture content and lecturers that contributed to student satisfaction with the course.

Over the three questionnaires of the first delivery, students were asked "given the technologically based delivery, how do you think this course will compare (has compared) to other courses you have taken?". Of those who commented on the first questionnaire 50% said it would not be any different. Two thirds of the comments on the second questionnaire stated that "it doesn't matter what technology is used - it's the interesting material that counts". Comments on the third and final questionnaire confirmed this trend when they stated "43.220 was better than other courses because the material and lecturers were better".

At the interviews during the second delivery, five students said that technology had not made any difference to the course and six others restated that lecturers and course material were the most important elements in a course delivery. These comments were confirmed in the three questionnaires.

## 2.55 Lecturer Comments

From the perspective of the lecturer, the GIFT Technique revealed that interacting with the students during a lecture coupled with the ease of material delivery were significant factors identified during the study. It was also found that prepared material reduced the opportunity for spontaneous digression during the lecture. Importance was also placed

on the level of interaction with colleagues and support personnel during material development and delivery.

Annotating electronic material with a mouse also proved to be a problem. In order for the lecturer to digress from the pre-prepared material it is thought that a graphics tablet would be an ideal remedy. This will be trialed in a future paper delivery.

During the lecturer interviews further comments suggested that the tutorials may have been ineffective in motivating some students to learn information theory. This may have been due to the perceived shift in control - from the lecturer to student - for the facilitation of the learning process. Other comments were made relating to the large amount of time and ongoing effort required to produce the material.

## **2.6 Critique of the Methodology**

As a proposed alternative to scientific methodology, Action Research has always been a matter of controversy. For example, according to Hodgkinson [31, p. 14] "if students and teachers became interested and involved in 'professional' research, there would soon be no need for Action Research". However, the main assumption underlying such a criticism is that the fixed purpose and design utilized in experimentation can be readily applied to a dynamic human system. Many researchers now feel that this is not strictly true because human values and beliefs impose on the experiment, rendering a scientific investigation insufficient.

One of the strengths of Action Research lies in its recognition of the social factors effecting an investigation and the incorporation of these factors in an attempt to promote more effective practice. This is achieved through the shared participation of subject and researcher and the fact that the general focus is allowed to 'shift' [32] as new findings are revealed.

The Action Researcher is also free to admit limitations while given the opportunity and encouragement to create and try out new strategies [31]. For action to take place, Neff [30, p. 142] stated that three things must occur:

- “The participants and decision makers must accept the data presented as valid.
- They must accept responsibility for the part they play in the programme and its success and failures.
- They must commit themselves to solving problems.”

Since each of these factors is crucial for the success of Action Research it is important to examine the implications of each one for this study.

The acceptance of the data as valid is normally unquestioned since it is collected in the arena in which it is to be applied [38]. However, the qualitative techniques employed for data collection (questionnaire comments, interviews, observation) are often criticised by quantitative advocates. Arguments along this line are refuted since Action Research seeks to improve practice through understanding and quantitative data very rarely reveals additional information that is not incorporated in the original hypothesis.

For participants to accept responsibility for the success or failure of a programme they must be clear as to their position within the study as well as any contributions they are expected to make. These issues were explained to the participants at the beginning of the study but considering the student workload outside of 43.220 motivation to participate fully in an Action Research approach may have been less than one hundred percent.

Ideally, a commitment to solving problems will rise from the action goal of improving practice. However, in light of the finding that over half of the students just wanted “to pass the paper”, commitment to solving the problems associated with material delivery in 43.220 was questionable as a high priority.

One of the major criticisms of Action Research is that even though it may prove to have high internal validity it cannot be seen to exhibit reliability. Fortunately, it has never claimed to. Action interventions are setting specific, only the methodology itself is generalizable.

Considering the nature of the study, evaluation apprehension (the tendency to present oneself as favourably as possible [29]) and the Hawthorne Effect (the tendency for performance to improve simply because changes are made or observers are present [40]) are factors that may have influenced the results.

Evaluation apprehension would have been most apparent during interviews but since anonymity was maintained in the other forms of data collection, and all comments were pooled to obtain the results, it is expected that bias arising from evaluation apprehension was significantly reduced.

The Hawthorne Effect has always been a problem for researchers in social situations and the presence of a non-participating observer throughout this study undoubtedly effected the findings. Fortunately the technology used to display and present the material for 43.220 was not entirely new to the students and as many as a third had received similar instruction in other papers.

## **2.7 SUMMARY**

The open-ended nature of the data collection methods facilitated the identification of many factors effecting the perceived quality of the delivery modes. For example, from the perspective of the student, the mechanism of material delivery was not as important as how it was delivered by the lecturer. Factors such as enthusiasm for, and knowledge of the subject matter, as well as ability to inject humour and 'real life' applications of the material into a standard lecture, were considered to be of great value. Classroom interaction was also an important factor that effected student satisfaction with the paper delivery.

Given that peer-group interaction was a key factor in the success of the tutorials there are implications for computer-based distance delivery. Perhaps computer aided instruction is misdirected if packages are created to teach the user on a one on one basis. If one of the most effective uses for a computer in an educational setting is the

promotion of discussion that facilitates peer teaching, then any inclination towards single user computer-based learning packages could be counterproductive.

---

***SECTION 3***

**DISCUSSION**

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The pressure to integrate technology and education is increasing and it will not be an easy process. One of the greatest problems is the variety of technology available for educational purposes [37] with the majority of software being unsuitable or too expensive to be included in an existing teaching programme. There is also opposition to using 'out of house' products so teachers must be given the opportunity to create their own multimedia presentations. However, until the authoring programmes become easier to use this is not considered a viable option [4].

Draper stated that "what performs more or less well is not some material or medium (a lecture, a book, a computer programme) but the whole teaching and learning episode managed by the teacher who employs the educational innovation as one element" [2, p. 3]. The results of this study confirmed Draper's statement. Computer based tutorials, course notes and Freelance presentations were 43.220 course components. Yet without the instruction of a skilful lecturer who could inject relevance and realism to the course material, the educational technology did not increase the quality of the learning experience as perceived by the students.

In view of this finding, one might ask: why spend a lot of time developing computer-based material for a paper, when the students will not think it makes any difference to the quality of the course? The answer is that the generation of computer based material can increase the accessibility of a course by facilitating a flexible delivery.

If the use of a computerized delivery means that a lecturer can simultaneously deliver a lesson to students in different locations, then educational technology can benefit everyone. As long as there is no perceived decrease in the quality of a technologically delivered course, then there is every reason to continue developing computer based material.

This study has shown that interaction, lecturers and course content were the most important aspects of the paper delivery. Therefore, it is possible that educators should focus on the improvement of these elements for the betterment of their courses. For a computer based remote delivery, the implications of this study are that classroom interaction needs to be maintained to preserve the perceived quality of the course.

It must also be realised that technology is not the solution to the educational problems and burdens faced now and in the future. Technology simply increases the options available [6] and future educational technology should focus on the development of an interactive classroom environment with multimedia products to support the current teaching practices. The goal is not to 're-invent the wheel' but to use the technology available to increase the quality of the classroom environment.

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## REFERENCES

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- [1] Adamson-Macedo, C. (1996). PCs, the bandwidth revolution and engineering curricula. *Computing and Control Engineering Journal*. June 1996, pp. 129-135.
- [2] Lockwood, F. (1996). *What can multimedia do for us in terms of instructional design - the role of media*. Seminar given at Massey University, 9 December 1996.
- [3] Mizell, A. P. & Lever, J. C. (1990). *Accommodating Learning styles through Hypermedia*. Paper presented at the Technology in Teacher Education Conference, Orlando, Florida, April 1990.
- [4] Norman, K. L. (1990). The Electronic Teaching Theater: Interactive Hypermedia and Mental Models of the Classroom. *Current Psychology: Research and Reviews*, **9** (2), pp. 141-161.
- [5] Carr, W. & Kemmis S. (1986). *Becoming Critical - Education, Knowledge and Action Research*. Falmer Press: London.
- [6] Harris, D. A. & DiPaolo, A. (1996). Advancing Asynchronous Distance Education Using High-Speed Networks. *IEEE Transactions on Education*, **39** (3), pp. 444-449.
- [7] URL: <http://tef.massey.ac.nz/>
- [8] Breen, V. R. & Barnes, D. J. (1996). Facilitating Multi-campus Tertiary Education in a Distributed Environment. *Proceedings of the Third New Zealand Conference of Postgraduate Students in Engineering and Technology*, (July 1-2), pp. 423-428. School of Engineering, University of Canterbury: Christchurch, New Zealand.

- [9] Hodgson, R. M. (1991). Production Technology - A Department with a Mission. *Paper presented at the Association for Engineering Education in South East Asia and The Pacific Conference*. Department of Production Technology, Massey University: Palmerston North, New Zealand.
- [10] Atkins, M. (1993). Evaluating interactive technologies for learning. *Journal of Curriculum Studies*, **25** (4), pp. 333-342.
- [11] Lee, P. & Sullivan, W. G. (1996). Developing and Implementing Interactive Multimedia in Education. *IEEE Transactions on Education*, **39** (3), pp. 430-435.
- [12] Mengel, S. A. & Adams, W. J. (1996) The Need for a Hypertext Instructional Design Methodology. *IEEE Transactions on Education*, **39** (3), pp. 375-380.
- [13] Cain, L. (1995) *Using Technology To Enhance Student Learning Outcomes*. PhD Thesis, Nova Southeastern University.
- [14] Hartel, H. (1994) COLOS: Conceptual Learning of Science. In *Design and Production of Multimedia and Simulation-Based Learning Material* ( J. deJong & L. Sarti, eds.), pp. 189-217. Kluwer Academic Publishers: Netherlands.
- [15] Penton, H. (1993). Teacher in a Box - The Debate Over Multimedia Learning. *PC World*, (October 1993), pp. M62-M73.
- [16] O'Shea, P. (1996). Undergraduate Signal Processing Education and Its Evaluation. *International Symposium on Signal Processing and its Applications, ISSPA, Gold Coast, Australia, (25-30 August 1996)*, p. 796.

- [17] Chabay, R. W. & Sherwood, B. A. (1992). A Practical guide for the Creation of Educational Software. In *Computer-Assisted Instruction and Intelligent Tutoring Systems: Shared Goals and Complementary Approaches* (Larkin, J. H. & Chabay, R. W. eds.), pp. 151-186. Lawrence Erlbaum Associates: Hillsdale, New Jersey.
- [18] Silverman, K., Lindlsey, O. R. & Porter, K. L. (1990). Overt Responding in Computer-Based Training. *Current Psychology: Research and Reviews*, **9** (4), (Winter 1990-1991), pp. 373-384.
- [19] Bengu, G. & Swart, W. (1996). A Computer-Aided, Total Quality Approach to Manufacturing Education in Engineering. *IEEE Transactions On Education*, **39** (3), pp. 415-422.
- [20] Wood, S. L. (1996). A New Approach to Interactive Tutorial Software for Engineering Education. *IEEE Transactions On Education*, **39** (3), pp. 399-408.
- [21] Nordy, K. (1991). Human Factors. In *A Window To The Future* (Kristiansen, T. ed.), pp. 66-76. Norwegian Telecom Research Department, Norway: Byraservice, Stavanger.
- [22] Oakley II, B. (1996). A Virtual Classroom Approach to Teaching Circuit Analysis. *IEEE Transactions On Education*, **39** (3), pp. 287-296.
- [23] Harger, R. O. (1996). Teaching in a Computer Classroom with a Hyperlinked, Interactive Book. *IEEE Transactions On Education*, **39** (3), pp. 327-335.
- [24] Clarke, J. A. (1995). Tertiary Students' Perceptions of their Learning Environments: A New Procedure and Some Outcomes. *Higher Education Research and Development*, **14** (1), pp. 1-12.

- [25] Jones, J. (1983). Students' Assessments of Instruction as a Basis for Teaching Improvement and Promotions Decisions: A Case-Study. *Higher Education Research and Development*, **2** (1) pp. 3-15.
- [26] Fowler Jr, F. J. (1984). *Survey Research Methods*. Sage 1984, pp. 74-106.
- [27] Sinclair, M. A. (1975). Questionnaire design. *Applied Ergonomics*, **6** (2), pp. 73-80.
- [28] Hiltz, S. R. (1993). Correlates of learning in a virtual classroom. *International Journal of Man-Machine Studies*, **39**, pp. 71-98.
- [29] Brenner, M. & Bungard, W. (1981). What to Do with Social Reactivity in Psychological Experimentation?. In *Social Method and Social Life* (Brenner, M. ed.), pp. 89-114. Academic Press.
- [30] Midkiff Jr, R. M. & Burke, J. P. (1987). An Action Research Strategy For Selecting And Conducting Program Evaluations. *Psychology in the Schools*, **24**, pp. 135-144.
- [31] McTaggart, R. (1991). *Action Research - A Short Modern History*. Deakin University Press: Victoria, Australia.
- [32] Elliot, J. (1991). *Action Research for Educational Change*. Open University Press: Philadelphia.
- [33] Burns, R. B. (1994). *An Introduction to Research Methods*. Longman Cheshire Pty Ltd: Australia.

- [34] Angelo, T. A. (1996). *A "Teacher's Dozen" - Fourteen General Findings from Research that can Inform and Improve Teaching Assessment and Learning Quality*. Workshop held at Massey University, (Wednesday 10 July) Palmerston North, New Zealand.
- [35] Brymen, A. and Burgess, R. G. (1994). *Analyzing Qualitative Data*. Routledge: London.
- [36] Angelo, T. A. (1995). Improving Classroom Assessment to Improve Learning: Guidelines from Research and Practice. *Progress, Trends, and Practices in Higher Education*, 7 (6), pp. 1-13.
- [37] Harpham, P. (1990). Technology For Better Teaching. *New Zealand Interface*, pp. 51-53.
- [38] McLean, J. E. (1995). *Improving Education Through Action Research - A Guide for Administrators and Teachers*. Corwin Press Ltd: California.
- [39] Kerlinger, F. N. (1973). *Foundations of Behavioural Research*. Holt, Rinehart & Winston, Inc.: Sydney.
- [40] Kalat, J. W. (1990). *Introduction to Psychology*. Wadsworth: California.

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# ***APPENDIX I***

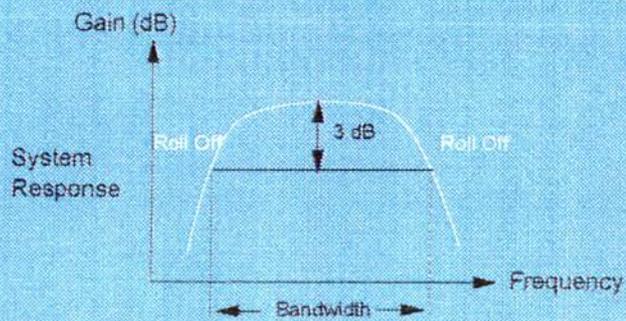
## **Lecture Notes for 43.220**

The following pages contain examples of the lecture notes generated for 43.220. The colour copy appears as it did when projected onto the screen. By simply changing the background colour to white, the notes could be printed for the students to annotate.

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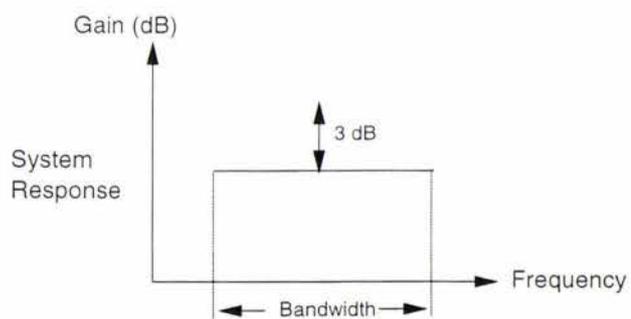
## Bandwidth and how its defined



- The bandwidth is the range of frequencies at the 3dB level

$$\text{Gain in dB: } = 20 \log\left(\frac{V_{\text{out}}}{V_{\text{in}}}\right)$$

## Bandwidth and how its defined

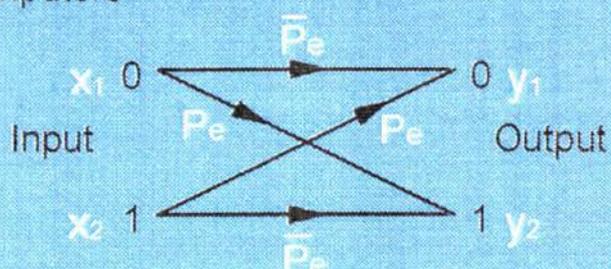


The bandwidth is the range of frequencies at the 3dB level

$$\text{Gain in dB: } = 20 \log\left(\frac{V_{\text{out}}}{V_{\text{in}}}\right)$$

## Binary symmetric channel (BSC)

- ✗ Assume the channel is memoryless - each message emitted is independent of the previous messages
- ✗ The simplest type of source alphabet  $(0, 1)$  - used by computers

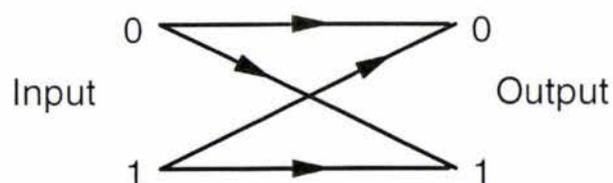


- ✗ Note this is symmetrical with respect to  $(0, 1)$

## Binary symmetric channel (BSC)

Assume the channel is memoryless - each message emitted is independent of the previous messages

The simplest type of source alphabet  $(0, 1)$  - used by computers



Note this is symmetrical with respect to  $(0, 1)$

## The average information per message

The mean or average information per message emitted by the source is given by:

$$\sum_{i=1}^n P_i I_i \quad (\text{Entropy of the source } H(m))$$

$$= \sum P_i \log\left(\frac{1}{P_i}\right)$$

$$= -\sum P_i \log P_i$$

eg

Prod Tech has 980 male and 20 female students. The surprise caused by seeing:

A male is  $-\log 0.98 = 0.03$  bits

A female is  $-\log 0.02 = 5.64$  bits

Gender entropy

$$= (0.98)(0.03) + (0.02)(5.64)$$

$$= 0.141 \text{ bits}$$

## The average information per message

The mean or average information per message emitted by the source is given by:

$$\sum_{i=1}^n P_i I_i \quad (\text{Entropy of the source } H(m))$$

$$= \sum P_i \log\left(\frac{1}{P_i}\right)$$

$$= -\sum P_i \log P_i$$

---

## ***APPENDIX II***

### **Cyclic Redundancy Check Code (CRC) Example**

The following screen dumps are taken from the asynchronous version of the CRC example. In the example used during lectures the paragraphs immediately above, and immediately below the shift register were absent thereby allowing the lecturer to describe the CRC code demonstration.

---

Presentation Window

File

# Generating Cyclic Redundancy Check (CRC) Codes using a shift register and exclusive OR (XOR) gates

Continue

Screen 1: Title Page

Presentation Window

File

The generator:  $g(x) = x^3 + x^2 + 1 = (1010)$

Is a polynomial of the order  $M = 3$ , therefore a 3 bit shift register is required. Ignoring the MSB, whenever a 1 occurs in the generator, the output of the shift register is XORed with the contents of the register

Initially assume the shift register has been cleared, so all bits are set to 0. The dataword  $d = (1010)$  will now be shifted, one bit at a time into the register

Continue

Screen 2

Presentation Window

File

The generator:  $g(x) = x^3 + x^2 + 1 = (1010)$   
 Is a polynomial of the order  $M = 3$   
 The first bit of the dataword is placed into the shift register, and recorded in the bottom left corner of the screen

When a zero is output from the shift register, it has no effect on the XOR gates (switch open)

**1**

Continue

Screen 3

Presentation Window

File

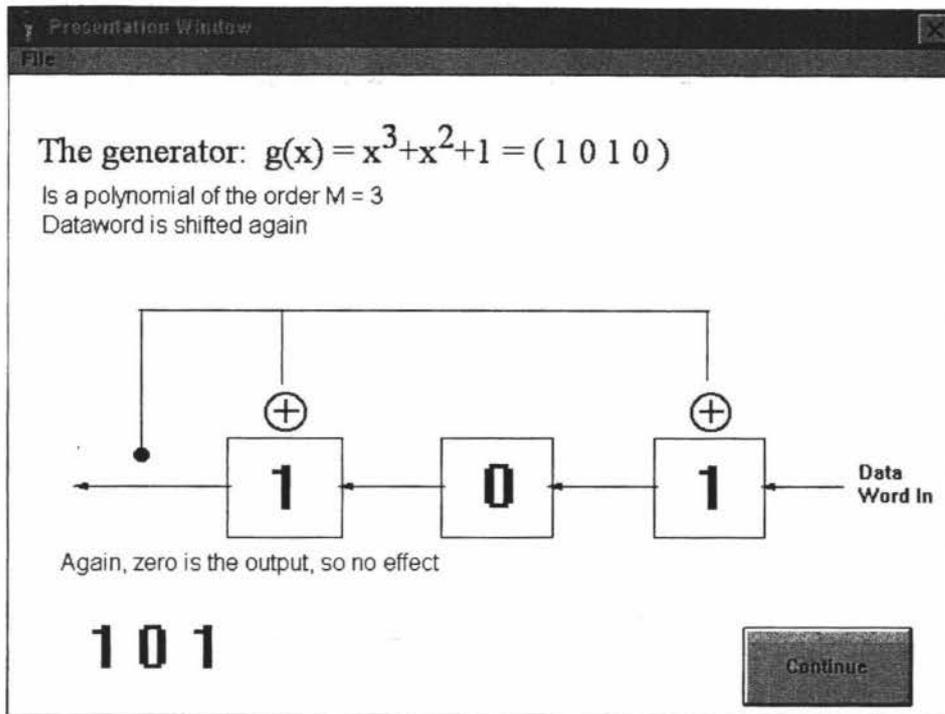
The generator:  $g(x) = x^3 + x^2 + 1 = (1010)$   
 Is a polynomial of the order  $M = 3$   
 The dataword is shifted left to right, and the next bit appears

Again, zero is the output, so no effect

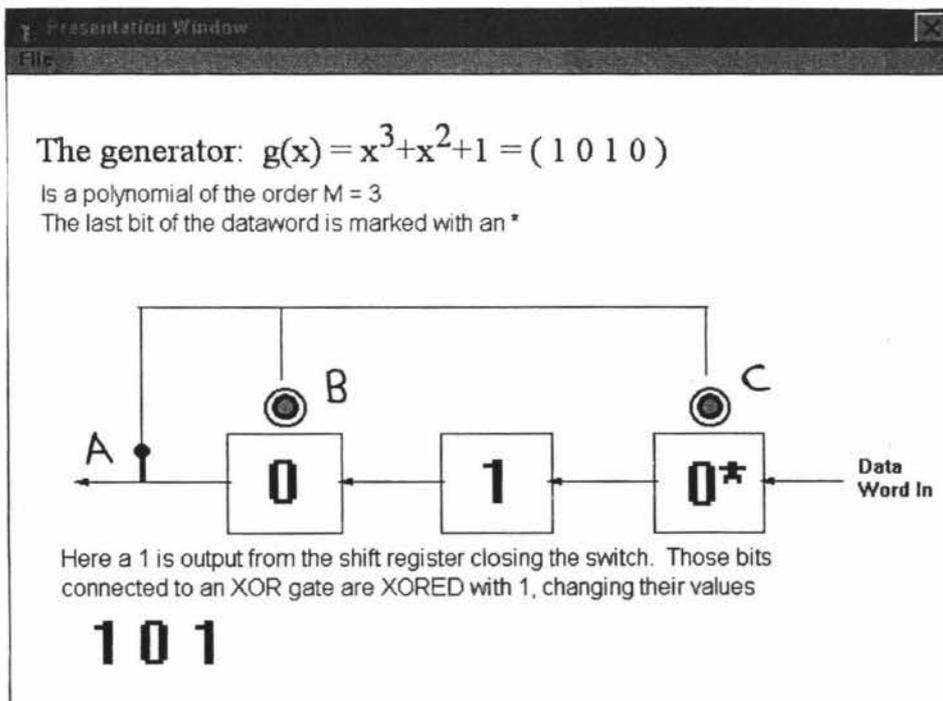
**10**

Continue

Screen 4



Screen 5



Screen 6: (XOR Animation) As the 1 passes through the gate (marked A) the gate is closed and a pulse is sent to the XOR gates (marked B and C)



Presentation Window

The generator:  $g(x) = x^3 + x^2 + 1 = (1010)$   
 Is a polynomial of the order  $M = 3$   
 Once the dataword has been entered, continue to pad with zeros (\* indicates last bit last bit)

Another 1 is output so the switch is closed and another XOR happens

**1 0 1 0**

Continue

Screen 7: XOR animation continues

Presentation Window

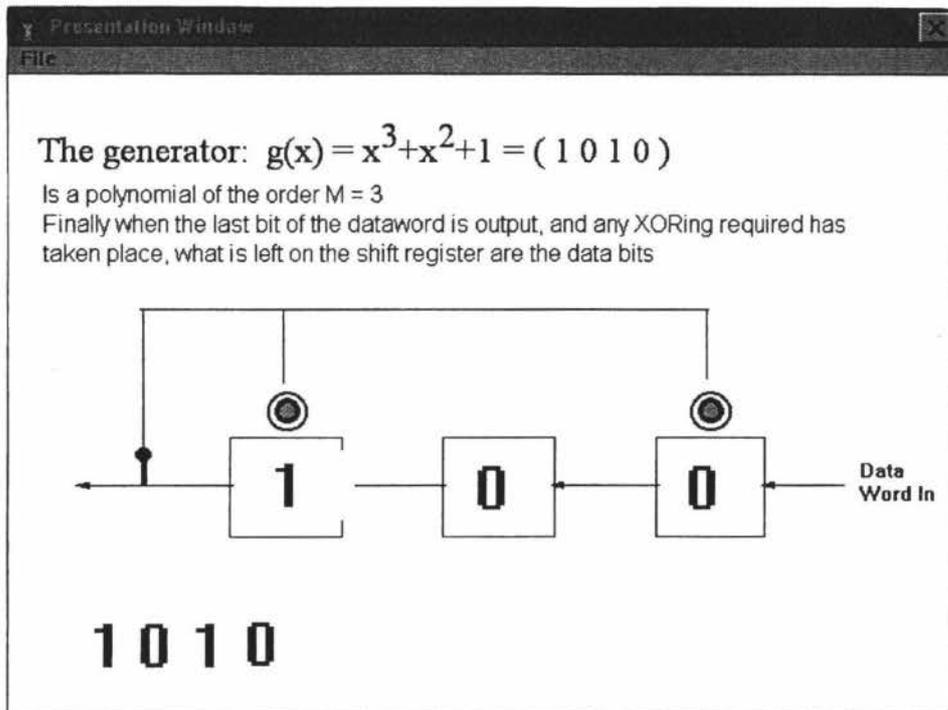
The generator:  $g(x) = x^3 + x^2 + 1 = (1010)$   
 Is a polynomial of the order  $M = 3$   
 Data continues to move left to right

A zero is output so no effect

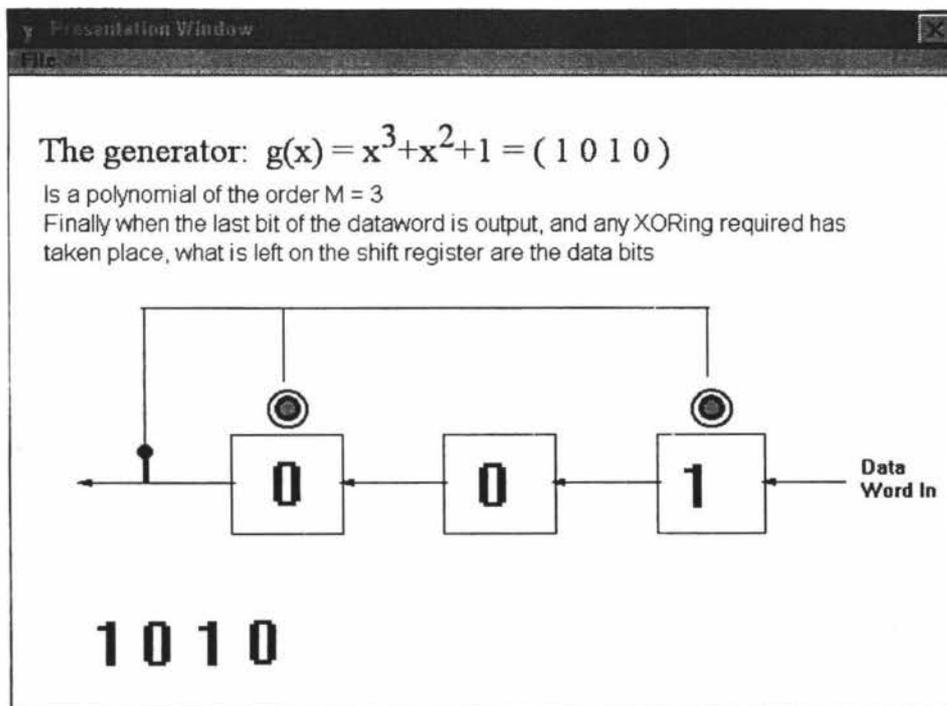
**1 0 1 0**

Continue

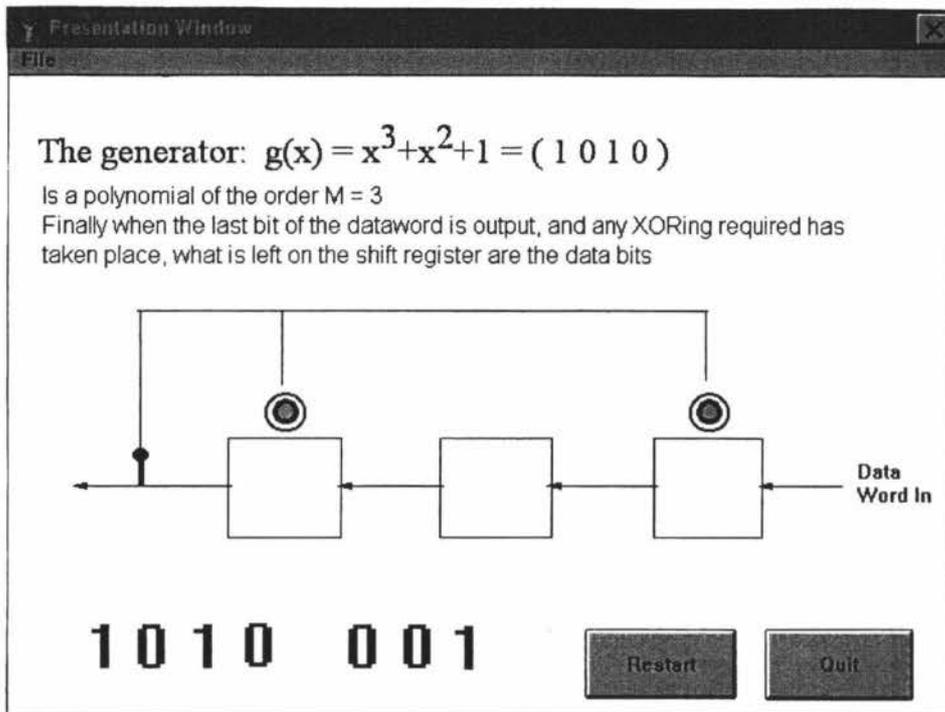
Screen 8



Screen 9: The XOR animation is repeated



Screen 9: XOR animation continues



Screen 9: The data bits move to the bottom of the screen and the user has the option to review the example or quit the programme

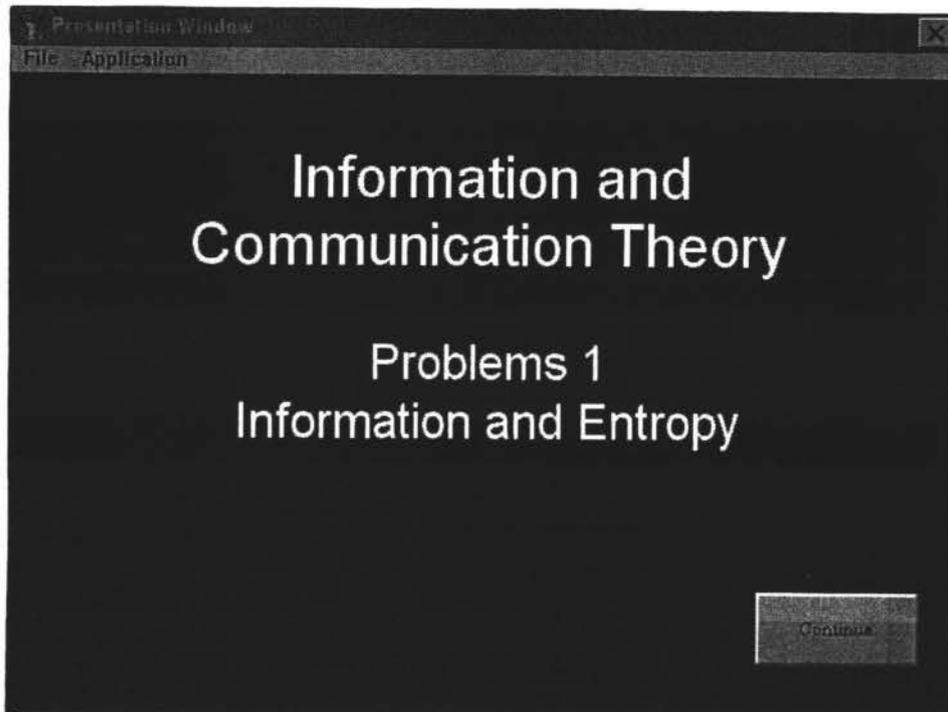
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## ***APPENDIX III***

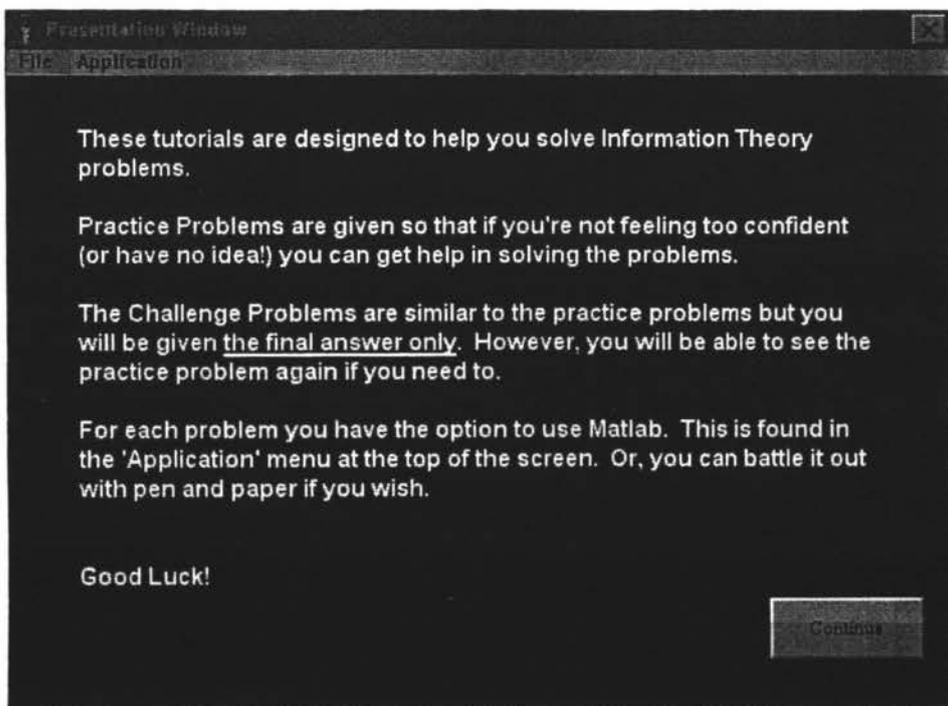
### **43.220 Tutorial Example**

The option screens and an example of a Practice and Challenge Problem are given in the following pages.

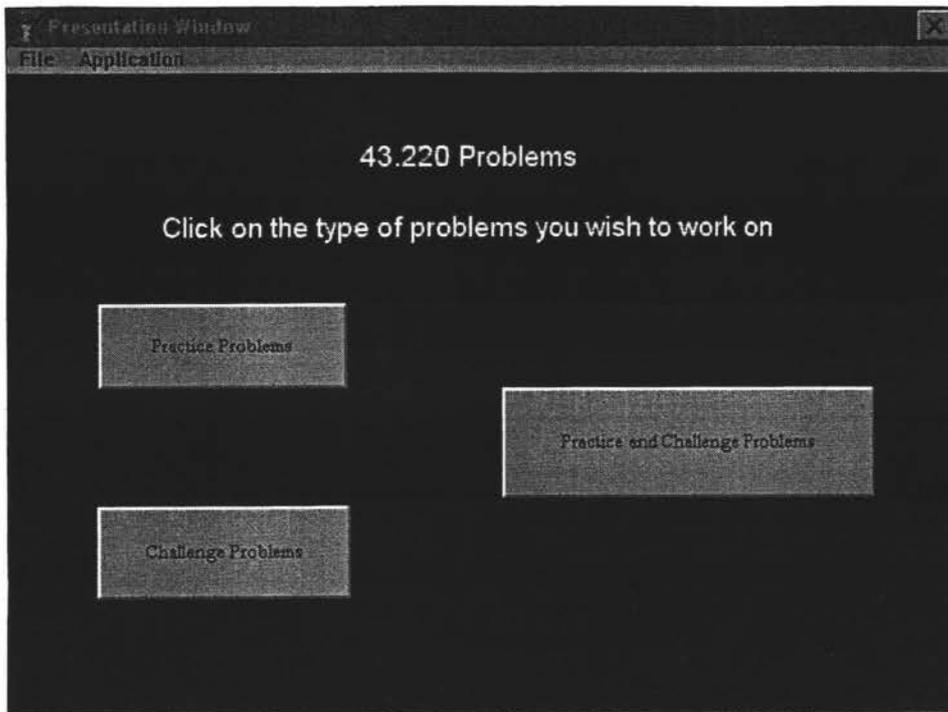
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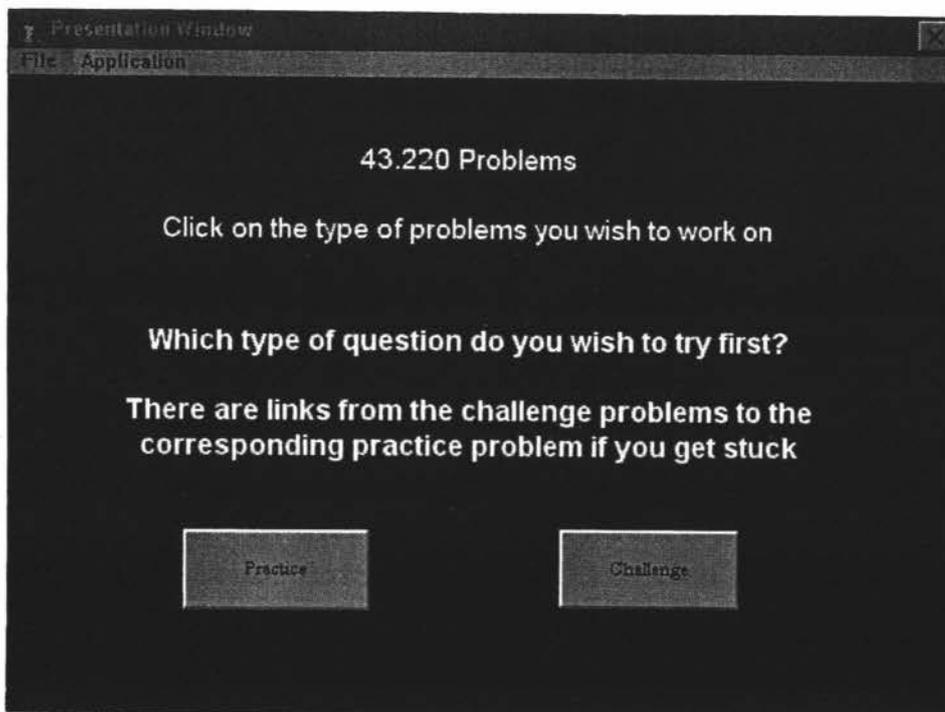
1. Title Screen - Select Continue.



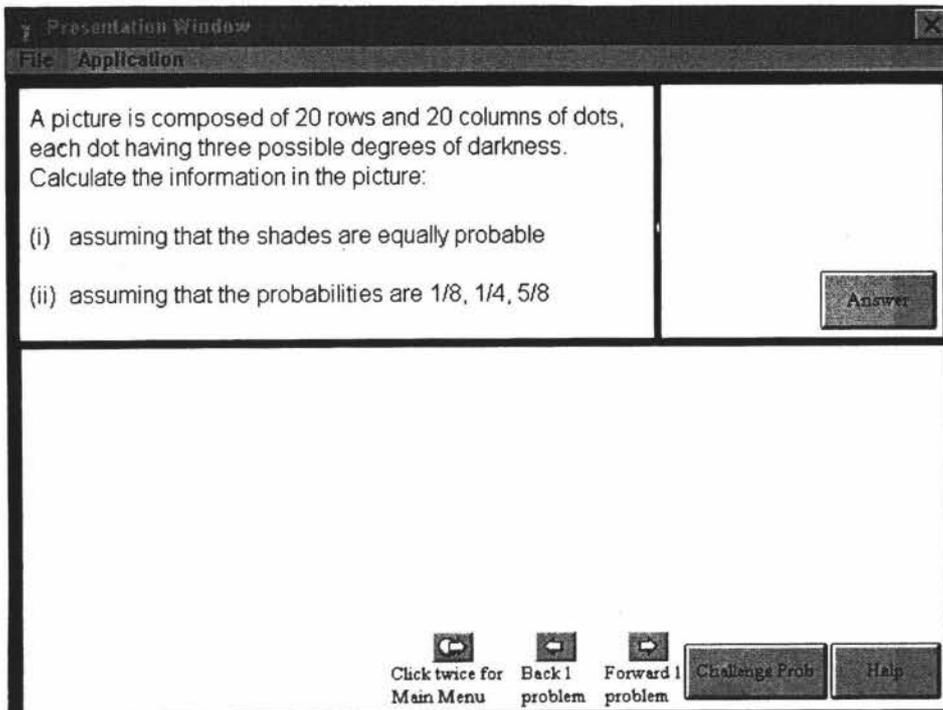
2. Instructions - Select Continue.



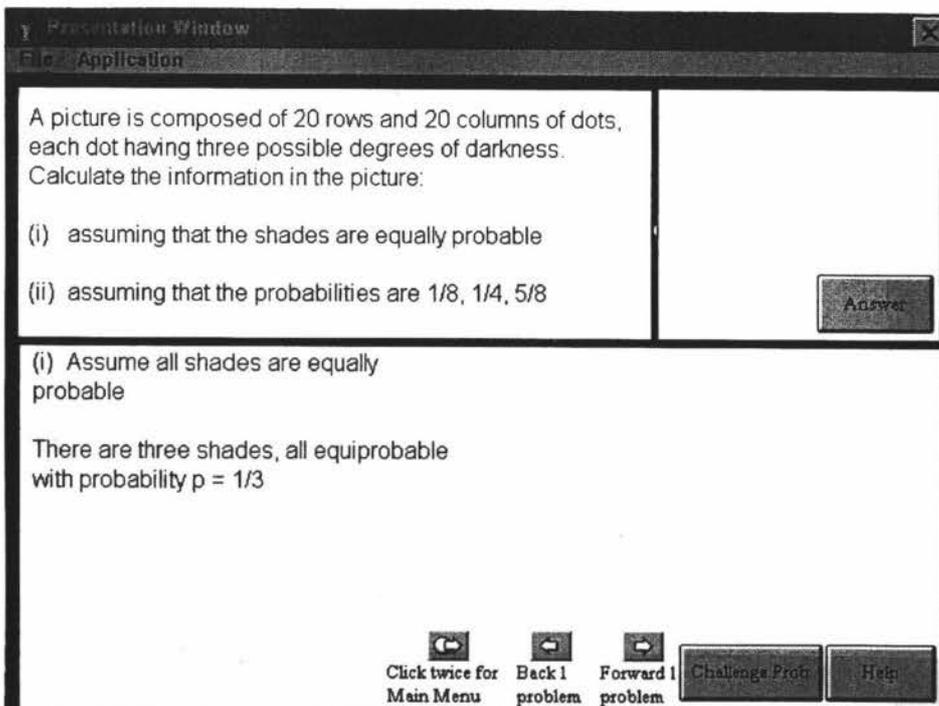
3. **Main Menu** - The user can select “Practice Problems” or “Challenge Problems” to cycle through the questions. The “Practice and Challenge Problems” button leads the user to an environment where the problems are linked. **Select Practice and Challenge Problems.**



4. **Sub Menu - Practice and Challenge Problems.**



5. **Practice Problem 1:** The screen is divided into three segments. The question appears in the top left hand corner and help is given in the bottom half of the screen. The answer can be obtained at any stage during the problem. Navigation aids appear at the bottom on the display. Two pull down menus are present on the Task Bar. The user can “Quit” from the File menu or launch Matlab from the “Application” menu. **Select Help.**



6. The first stage of the Help appears in the bottom half of the display. **Select Help.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

Answer

(i) Assume all shades are equally probable

There are three shades, all equiprobable with probability  $p = 1/3$

$$I = \log_2 \frac{1}{P_i} \text{ bits}$$

Click twice for Main Menu   Back 1 problem   Forward 1 problem   Challenge Prob   Help

7. Stage two Help. **Select Help.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

Answer

(i) Assume all shades are equally probable

There are three shades, all equiprobable with probability  $p = 1/3$

$$I = \log_2 \frac{1}{P_i} \text{ bits}$$

$$= \log_2 3$$

$$= 1.58 \text{ bits for each dot}$$

Click twice for Main Menu   Back 1 problem   Forward 1 problem   Challenge Prob   Help

8. Stage three Help. **Select Help.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

Answer

(i) Assume all shades are equally probable Therefore the total information is:

There are three shades, all equiprobable with probability  $p = 1/3$

$$I = \log_2 \frac{1}{P_i} \text{ bits}$$

$$= \log_2 3$$

$$= 1.58 \text{ bits for each dot}$$

Click twice for Main Menu Back 1 problem Forward 1 problem Challenge Prob Help

9. Stage four Help. **Select Help.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

Answer

(i) Assume all shades are equally probable Therefore the total information is:

$$I = 20 \times 20 \times 1.58$$

$$= 632 \text{ bits}$$

There are three shades, all equiprobable with probability  $p = 1/3$

$$I = \log_2 \frac{1}{P_i} \text{ bits}$$

$$= \log_2 3$$

$$= 1.58 \text{ bits for each dot}$$

Click twice for Main Menu Back 1 problem Forward 1 problem Challenge Prob Help

10. Stage five Help. **Select Answer.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

(i) 632 bits

(ii) 519 bits

Answer

(i) Assume all shades are equally probable

Therefore the total information is:

$$I = 20 \times 20 \times 1.58$$

= 632 bits

There are three shades, all equiprobable with probability  $p = 1/3$

$$I = \log_2 \frac{1}{P_i} \text{ bits}$$

$$= \log_2 3$$

$$= 1.58 \text{ bits for each dot}$$

Click twice for Main Menu    Back 1 problem    Forward 1 problem    Challenge Prob    Help

11. The answer appears in the top right hand portion of the screen.

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

Answer

(ii) Assuming the probabilities are 1/8, 1/4, 5/8, the average information per dot is given by:

$$H(x) = \sum_i P_i \log_2 \frac{1}{P_i}$$

Click twice for Main Menu    Back 1 problem    Forward 1 problem    Challenge Prob    Help

12. Stage six Help. **Select Help.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

Answer

(ii) Assuming the probabilities are 1/8, 1/4, 5/8, Therefore the total information is: 1/4, 5/8, the average information per dot is given by:

$$H(\mathbf{x}) = \sum_i P_i \log_2 \frac{1}{P_i}$$

$$= -\left(\frac{1}{8} \log \frac{1}{8} + \frac{1}{4} \log \frac{1}{4} + \frac{5}{8} \log \frac{5}{8}\right)$$

$$= 1.30 \text{ bits}$$

Click twice for Main Menu    Back 1 problem    Forward 1 problem    Challenge Prob    Help

13. Stage seven Help. **Select Help.**

Presentation Window

File Application

A picture is composed of 20 rows and 20 columns of dots, each dot having three possible degrees of darkness. Calculate the information in the picture:

(i) assuming that the shades are equally probable

(ii) assuming that the probabilities are 1/8, 1/4, 5/8

(ii) Assuming the probabilities are 1/8, 1/4, 5/8, Therefore the total information is: 1/4, 5/8, the average information per dot is given by: 519 Bits

$$H(\mathbf{x}) = \sum_i P_i \log_2 \frac{1}{P_i}$$

$$= -\left(\frac{1}{8} \log \frac{1}{8} + \frac{1}{4} \log \frac{1}{4} + \frac{5}{8} \log \frac{5}{8}\right)$$

$$= 1.30 \text{ bits}$$

Click twice for Main Menu    Back 1 problem    Forward 1 problem    Challenge Prob

14. Stage eight Help. The user may then progress to Challenge Problem 1 while retaining the option to view the Practice Problem if difficulties arise. **Select Challenge Problem.**

Presentation Window

File Application

In facsimile transmission,  $2.25 \times 10^6$  square picture elements are needed to provide proper picture resolution. (This corresponds to 1,500 lines in each dimension).

Find the maximum information content if 12 brightness levels are required for good reproduction.

Answer

Hint: See Practice Problem 1

Click once for Main Menu    Back 1 problem    Forward 1 problem    Practice Prob

15. Challenge Problem 1. **Select Answer.**

Presentation Window

File Application

In facsimile transmission,  $2.25 \times 10^6$  square picture elements are needed to provide proper picture resolution. (This corresponds to 1,500 lines in each dimension).

Find the maximum information content if 12 brightness levels are required for good reproduction.

$8.07 \times 10^6$  Bits

Hint: See Practice Problem 1

Click once for Main Menu    Back 1 problem    Forward 1 problem    Practice Prob

16. The answer has been obtained and the user can continue through the programme.

---

## *APPENDIX IV*

### **Questionnaires**

The following three questionnaires were administered to students before, during and at the conclusion of the 43.220 course.

---

## Student Questionnaire Number 1 for 43.220 - Information and Communication Theory

This is the first of three questionnaires you will be asked to complete. The aim of this questionnaire is to provide me with some background information about you and your attitudes towards computers and technology.

The latter questionnaires will be concerned with your attitudes towards a technologically based course delivery and will give you the opportunity to offer suggestions as to improvements or changes you might make.

There are 3 sections in this questionnaire and a total of 18 questions. There is a space for comments following each question. Please feel free to note any thoughts or insights down as they come to mind.

Your responses are completely anonymous but will be collated and summarised for research purposes.

Please indicate your opinions by circling one of the numbers on the scales or ticking the appropriate box provided.

### Section 1 - General Information

Are you:

Male

Female

How many years (including this one) have you attended Massey University?

1	2	3	4	5	More

Comments

What is your Option?

Do you own a computer?

Yes

No

If Yes, what is the resolution of your computer screen?

640 x 480 pixels

800 x 600 pixels

1024 x 768 pixels

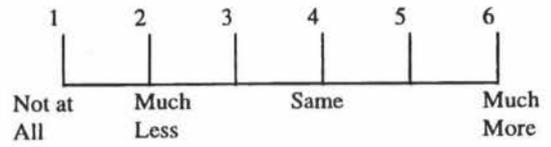
Other

How many hours, on average, do you use a computer per week?

Hours

Comments

How often would you like to use computers?

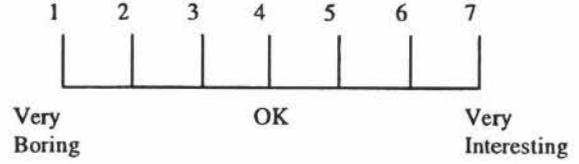


Why?

Comments

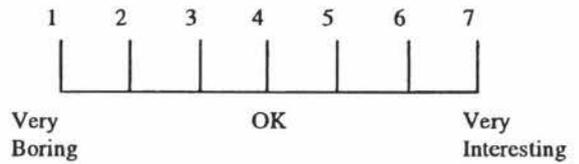
**Section 2 - Attitudes towards Computers and Technology**

How do you feel about computers?



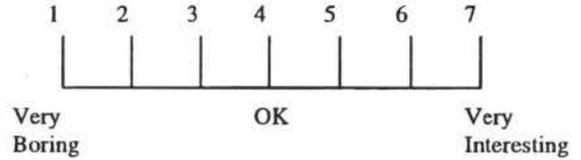
Comments

How do you feel about using computers for learning?



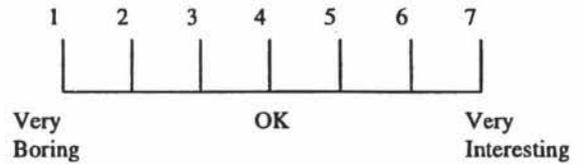
Comments

How do you feel about technology?



Comments

How do you feel about using technology for learning?



Comments

**Section 3 - Attitudes toward delivery mechanism for 43.220**

Have you ever participated in a computer based delivery before?

Yes   
No

If Yes, how would you rate the experience overall?

1 2 3 4 5 6 7  
| | | | | | |  
-----  
A waste of time OK An excellent experience

Comments

Do you think that the use of technology to deliver course material will make 43.220

1 2 3 4 5 6 7  
| | | | | | |  
-----  
A waste of time Just the same An excellent experience

Comments

Given the technologically based delivery, how do you think this course will compare to other courses you have taken? Will it be

1 2 3 4 5 6 7  
| | | | | | |  
-----  
Much less Interesting Much more Interesting

Comments

What are your greatest concerns about the use of computers in this course?

Comments

Why did you enroll in 43.220?

Comments

What is your main objective in this course?

Comments

Thank you for your time

## Student Questionnaire Number 2 for 43.220 - Information and Communication Theory

This is the second of three questionnaires you will be asked to complete. The aim of this questionnaire is to provide me with information I can compare to the previous responses, and also, to get some idea of how you think the course is going.

There are 4 sections in this questionnaire and a total of 14 questions. There is a space for comments following each question. Please feel free to note any thoughts or insights down as they come to mind.

Your responses are completely anonymous but will be collated and summarised for research purposes.

Please indicate your opinions by **circling one of the numbers on the scales** or **ticking the appropriate box** provided.

### **Section 1 - General Information**

How many years (including this one) have you attended Massey University?

1	2	3	4

What is your Option?

Do you have access to a computer at home?

Yes	
No	

How many hours per week, on average, do you use a computer?

	Hours
--	-------

Comments

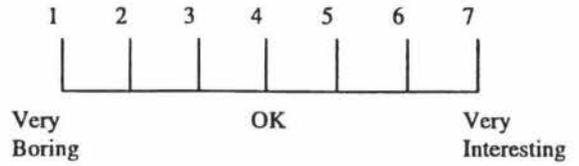
How often would you like to use computers?

1	2	3	4	5	6
Not at All	Much Less		Same		Much More

Comments

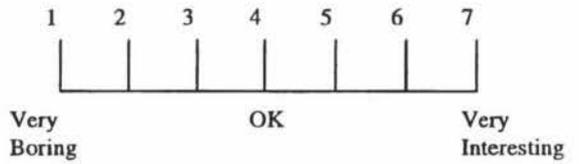
## Section 2 - Attitudes towards Computers and Technology

How do you feel about computers?



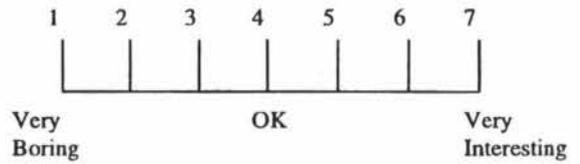
Comments

How do you feel about using computers for learning?



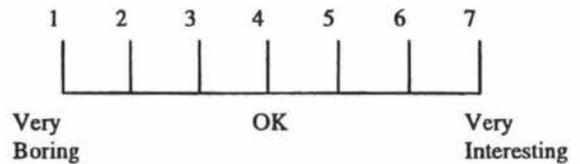
Comments

How do you feel about technology?



Comments

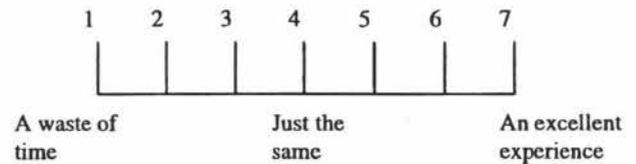
How do you feel about using technology for learning?



Comments

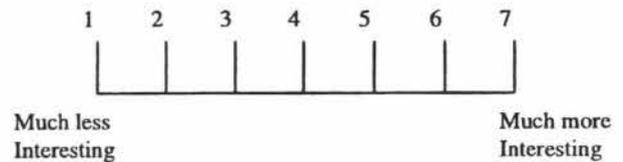
### Section 3 - Attitudes toward delivery mechanism for 43.208

Do you think that the use of technology to deliver course material has made 43.220



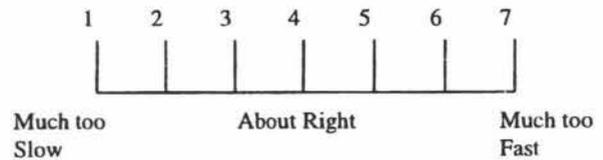
Comments

Given the technologically based delivery, how do you think this course compares to other courses you are taking?  
Is it:



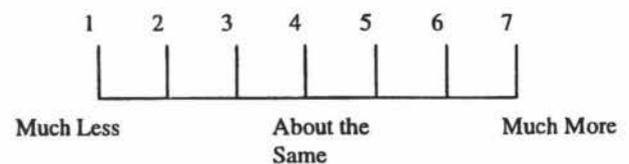
Comments

How do you find the pace of the material delivery in the lectures?



Comments

Compared to other courses you have taken, do you find yourself paying attention to lecture material in 43.220



Comments

**Section 4 - Course Material**

Have you found the computer based tutorials created for 43.220 to be

1	2	3	4	5	6	7
Extremely Useless		Same as other Tutorials			Extremely Useful	

Comments:

Thank you for your time

## Student Questionnaire Number 3 for 43.220 - Information and Communication Theory

This is the last questionnaire you will be asked to complete. The aim of this questionnaire is to provide me with information I can compare to the previous responses.

There are 5 sections in this questionnaire and a total of 21 questions. There is a space for comments following each question. Please feel free to note any thoughts or insights down as they come to mind.

Your responses are completely anonymous but will be collated and summarised for research purposes.

Please indicate your opinions by **circling one of the numbers on the scales** or **ticking the appropriate box** provided.

### Section 1 - General Information

How many years (including this one) have you attended Massey University?

1	2	3	4

What is your Option?

Do you have access to a computer at home?

Yes	<input type="checkbox"/>
No	<input type="checkbox"/>

How many hours per week, on average, do you use a computer?

	Hours
--	-------

Comments

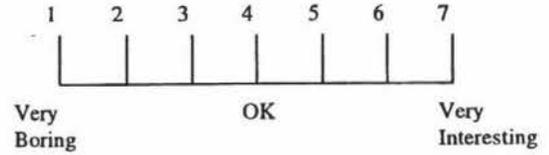
How often would you like to use computers?

1	2	3	4	5	6
Not at All	Much Less		Same		Much More

Why?

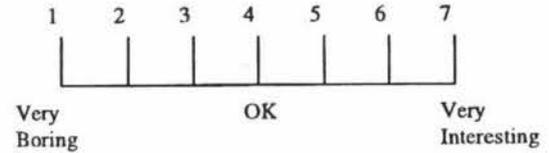
## Section 2 - Attitudes towards Computers and Technology

How do you feel about computers?



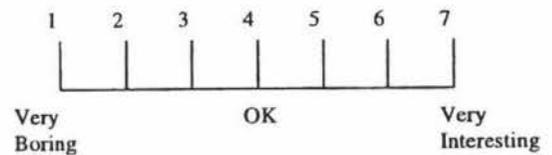
Comments

How do you feel about using computers for learning?



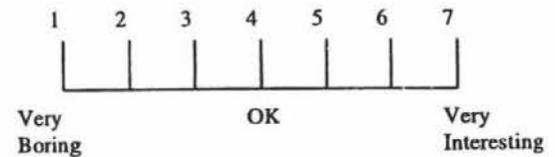
Comments

How do you feel about technology?



Comments

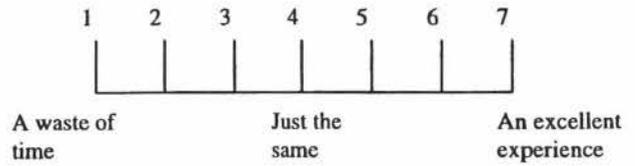
How do you feel about using technology for learning?



Comments

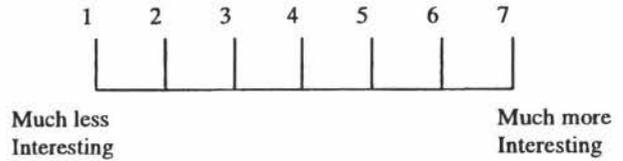
**Section 3 - Attitudes toward delivery mechanism for 43.208**

Do you think that the use of technology to deliver course material made 43.220



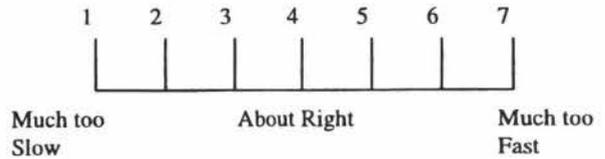
Comments

Given the technologically based delivery, how do you think this course compared to other courses you took?  
Was it:



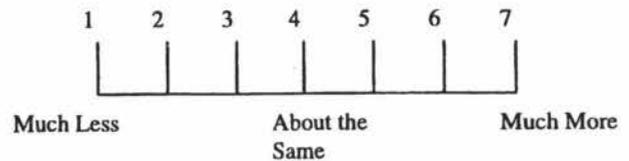
Comments

How did you find the pace of the material delivery in the lectures?



Comments

Compared to other courses you have taken, did you find yourself paying attention to lecture material in 43.220



Comments

## Section 4 - Course Material

Notes for the course were given out in lectures

Did you annotate these notes any more than was required?

1	2	3	4	5	6	7	
Not at all							A Lot

Comments:

Have you found the computer based tutorials created for 43.220 to be

1	2	3	4	5	6	7
Extremely Useless		Same as other Tutorials			Extremely Useful	

Comments:

Did you use the computer-based tutorials at home?

Yes

No

Comments:

**Section 5**

How do you feel about the course content?

Comments:

How do you feel about Dr Adrian Evans as a person?

Comments:

Given Dr Adrian Evans' personal qualities and the course content, how good a job do you think he made of teaching it?

Comments:

How do you feel about Professor Bob Hodgson as a person?

Comments:

Given Professor Bob Hodgson's personal qualities and the course content, how good a job do you think he made of teaching it?

Comments

Thank you for your time

---

## ***APPENDIX V***

**The Group Informal Feedback on Teaching (GIFT)**

**Technique**

---

- 
- What are 1 or 2 specific things you have liked about the lecture delivery in this course
  - What are 1 or 2 specific things you have disliked about the lecture delivery in this course
  - Please give 1 or 2 specific, practical suggestions on ways to improve the lecture delivery in this course

- 
- What are 1 or 2 specific things you have liked about the computer based tutorials in this course
  - What are 1 or 2 specific things you have disliked about the computer based tutorials in this course
  - Please give 1 or 2 specific, practical suggestions on ways to improve the computer based tutorials in this course

Directions: Please write brief, honest - and legible - answers to the questions asked. (Do not write your name on this paper)

1

2

3

---

## ***APPENDIX VI***

### **Sample Summary Sheet**

The following questionnaire data summary sheet was examined by the students during interviews.

---

## Data Summary - Student Questionnaire Number 1 for 43.220

WHAT IS YOUR OPTION?

IE = 22

CSE = 18

DO YOU OWN A COMPUTER?

Yes = 33

No = 7

HOW MANY HOURS, ON AVERAGE, DO YOU USE A COMPUTER PER WEEK?

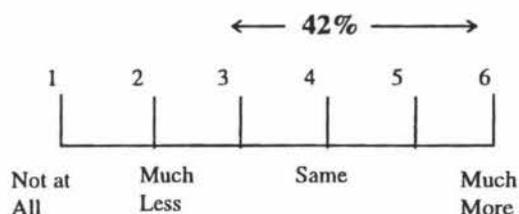
Average = 9 Hours

Range = 1 to 21 Hours

COMMENTS

64% Depends on workload

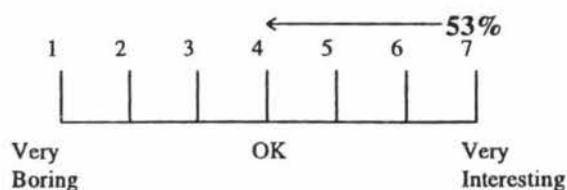
HOW OFTEN WOULD YOU LIKE TO USE COMPUTERS?



WHY?

60% Happy with their usage. Feel they have reached a good balance of work and recreation

HOW DO YOU FEEL ABOUT COMPUTERS?

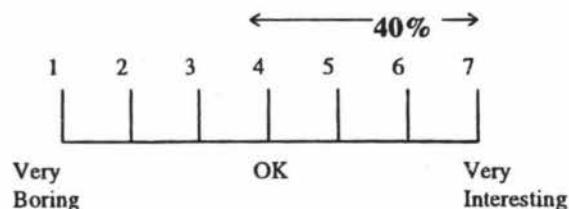


COMMENTS

50% Find them very interesting

50% Find them useful tools

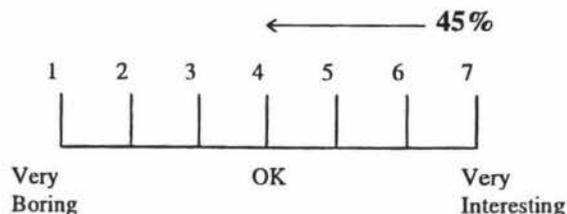
HOW DO YOU FEEL ABOUT USING COMPUTERS FOR LEARNING?



COMMENTS

63% OK. Inevitable, only as good as material, human interaction is important

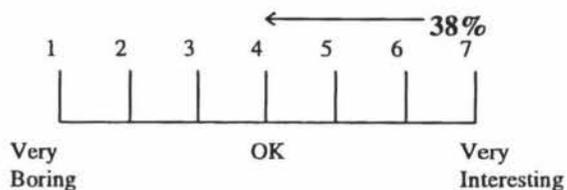
HOW DO YOU FEEL ABOUT TECHNOLOGY?



COMMENTS

67% Very positive toward technology

HOW DO YOU FEEL ABOUT USING TECHNOLOGY FOR LEARNING?



COMMENTS

50% Are positive toward using technology for learning

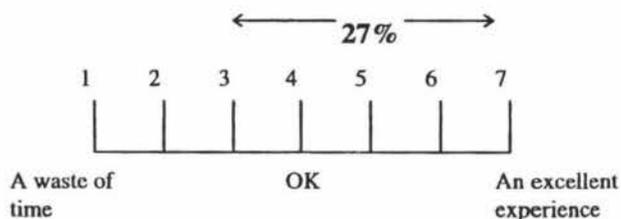
50% Can't rely on it, people and material are important

HAVE YOU EVER PARTICIPATED IN A COMPUTER BASED DELIVERY BEFORE?

Yes = 19

No = 21

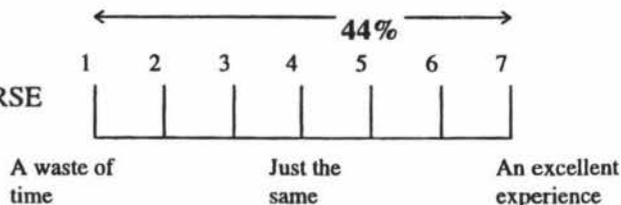
IF YES, HOW WOULD YOU RATE THE EXPERIENCE OVERALL?



COMMENTS

38% Bit monotonous

DO YOU THINK THAT THE USE OF TECHNOLOGY TO DELIVER COURSE MATERIAL WILL MAKE 43.220

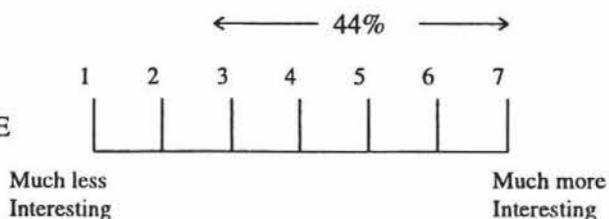


COMMENTS

30% Don't know

30% Hope it will be good

GIVEN THE TECHNOLOGICALLY BASED DELIVERY, HOW DO YOU THINK THIS COURSE WILL COMPARE TO OTHER COURSES YOU HAVE TAKEN? WILL IT BE



#### COMMENTS

**36% It will be more interesting**

**36% Don't know**

WHAT ARE YOUR GREATEST CONCERNS ABOUT THE USE OF COMPUTERS IN THIS COURSE?

**31% Reduction in human/social interactions**

**17% Technical problems**

**17% None**

WHY DID YOU ENROLL IN 43.220?

**85% Because they had no choice**

**15% Had to, but it did sound interesting**

WHAT IS YOUR MAIN OBJECTIVE IN THIS COURSE?

**54% To pass**

**43% To learn about information and communications**

---

## ***APPENDIX VII***

### **Data Collation and Analysis**

---

**Lecture 1:** Brief introduction to HMR-EM given to students. The Action Research study is described and the students are informed as to what can be expected, and what is expected of them, over the course of the study. Questionnaire one is given. For the first delivery of the course the lecture is pre-recorded on video tape.

**Lecture 2:** First delivery - lecture material pre-recorded on video tape.

**Lecture 3:** First delivery - lecture material pre-recorded on video tape.

Comments from questionnaire one are transferred to Microsoft Word 7.0 where the responses are grouped according to content. Likert responses are entered in Minitab 10.5. The mean, median, standard deviation and range are calculated for each question. A comparison is made between the responses of Information Engineers (IEs)/Computer Systems Engineers (CSEs), first/second/third year students, those who have/do not have their own computer, and those who have/have not participated in computer based instruction previously. Finally a summary sheet of the questionnaire is compiled for interviews (Appendix VI).

**Lecture 8-14:** GIFT questionnaires and questionnaire two are administered. Interview times are allocated and interviews conducted.

GIFT and questionnaire two responses are collated and grouped. Statistical analysis on the data from questionnaire two is carried out with Minitab 10.5. Comparisons are made between the responses given in questionnaire two and those obtained from questionnaire one. A summary sheet is compiled for questionnaire two that includes any significant differences between the responses of questionnaire two as compared with questionnaire one. Interviews are conducted over two weeks using the summary sheet from questionnaire one. Interview comments are collated using Microsoft Word 7.0. Comments are grouped by content.

**Lecture 21-23:** Questionnaire three is administered. Group interviews are conducted with the students.

Responses from questionnaire three are collated using Microsoft word 7.0 and Minitab 10.5. The responses are then compared with those of questionnaires two and one. Statistical differences are identified and examined. Interview comments are entered into Microsoft Word 7.0 and categorised.

All questionnaire, GIFT and interview comments are pooled and sorted according to content. Five natural groupings result - Computers, Tutorials, Lectures and Lecturers, Course Notes and Technology. Results of the observations are then compiled in point-form and added to the groupings.

Attendance plots are produced from the observational data. Separate plots are made for lectures and tutorials. Graphs of attendance versus lecturer are also examined.

The overall collation is compared with the individual method summaries and statistical results. Inconsistent findings are discarded. Results that appear consistently across the individual method summaries and overall collation are drafted for final copy.

Finally, individual responses are tracked across the three questionnaires and used to support or disprove the finalised results.

Lecturers are interviewed and their comments are pooled and summarised as results.