COMPUTER ASSISTED EDUCATION: DESIGN, DEVELOPMENT AND EVALUATION.

(An investigation into the potential use and development of Computer Assisted Education at the University of Natal.)

by

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PREFACE

The research described in this dissertation was carried out in the School of Geology and Computer Science, University of Natal, Durban, from January 1997 to October 2001, under the supervision of Professor Jane Meyerowitz.

This study represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any tertiary institution. Where use has been made of the work of others it is duly acknowledged in the text.

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Katharine Murrell
October 2001.

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ABSTRACT

Educational institutions throughout the world are increasingly facing classes of educationally, culturally and linguistically diverse student groups. At the same time economic constraints require these institutions to expand their student base and they are therefore looking to distance education and continuing education modules to meet these challenges. Simultaneously rapid advances in desktop computing capabilities and Internet delivered information have revived interest in Computer Assisted Education (CAE).

The University of Natal is no exception to these trends; schools, departments and individual members of staff are increasingly exploring the possibility of using the University's computer infrastructure to assist in delivering quality education, maintaining current standards, and addressing the multiple needs of the students.

To investigate these issues a CAE program was developed for use in the Nelson R. Mandela School of Medicine to investigate how students would make use of the technology, and to report on the development and evaluation processes of such a development. In doing so various lessons could be learnt which could inform the further development of such software at the University.

In order to support the development of the CAE program an extensive literature survey into current educational theory was conducted. Its objectives were to explore and understand all the factors affecting the development and use of computer based systems as an educational tool. Particular aspects considered were

- the debate between constructivist and instructivist theory in their applicability to both the medium and the subject material.
- instructional styles, and with them the learning styles, that could be used to support the educational goals of the diverse student population.
- instructional design methodologies that are currently used as well as media production methodologies. The goal of this aspect of the research was to advise both the development of the case study and to gain a broader understanding of the methodology that could be used for other developments. Included in this phase of the research are methods and criteria for selection of authoring systems and interface design issues in a multi-cultural multi-lingual environment.
- the review of different evaluation strategies in order to incorporate appropriate evaluation in the CAE case study.
- the investigation of broader sociological and historical factors that may influence the way in which CAE can be used effectively in a South African context.

The presumption was that students from historically disadvantaged backgrounds and those with English as a second language would be less willing to use technological interventions than those who were more likely to have had access to computers earlier in their education. The case study set out to investigate if this presumption was valid, and if so what elements of design and delivery could facilitate these students' usage of such systems. However, these presumptions were not validated by the case study, showing the exact opposite of expectations, with more historically disadvantaged students showing a willingness to use the module.

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF FIGURES

LIST OF ACRONYMS

AIDS	Acquired Immune Deficiency Syndrome
ANC	African National Congress
BODMAS	Brackets of Division Multiplication Addition and Subtraction
CAE	Computer Assisted Education
CAL	Computer Aided Learning
CBE	Computer Based Education
CBT	Computer Based Training
CD	Compact Disk.
CMC	Computer Mediated Communication
DOS	Disk Operating System
HCI	Human Computer Interface
HIV	Human Immunodeficiency Virus
HTML	Hypertext Markup Language
ID	Instructional Design
ISD	Instructional systems design
LAN	Local Area Network
NQF	National Qualifications Framework
OBE	Outcomes Based Education
PBL	Problem Based Learning
PC	Personal Computer (usually in reference to IBM compatibles)
R2D2	Recursive, Reflective, Design and Development
RAM	Random Access Memory
SAARDHE	South African Association for Research and Development in Higher Education
UNAIDS	United Nations Aids Program
W3C	World Wide Web Consortium
WAI	Web Accessibility Initiative
WWW	World Wide Web
ZPD	Zone of Proximal Development

CHAPTER ONE
INTRODUCTION

1.1 Overview

Educational institutions throughout the world are increasingly facing classes of educationally, culturally and linguistically diverse student groups. At the same time economic constraints require these institutions to expand their student base and many South African institutions are looking to distance education and continuing education modules to meet these challenges.

Rapid advances in desktop computing capabilities, in particular multimedia capabilities and the Internet, have revived interest in Computer Assisted Education (CAE). Educators across the globe are reviewing these media and the University of Natal is no exception to these trends. Increasingly academic staff members are exploring the possibility of using the existing computer infrastructure to assist in delivering quality education, maintaining current standards, and addressing the multiple needs of the diverse student body (Greaves, 1997). More recent suggestions from the University's executive propose, "that the University of Natal establishes a sufficient infrastructure ... to operate as a digital university" (Bawa, 1999).

1.2 Objectives

The primary objective of this research was to investigate the potential to develop and use CAE at the University of Natal. Given the diversity of the student population one of the major concerns was to ensure that all students regardless of ethnic, language and educational background would have equal intellectual and physical access to the resources. Subject to these findings a secondary goal was to make recommendations to the University regarding such developments.

To investigate these issues a CAE program was developed for use in the Nelson R. Mandela School of Medicine to investigate how students would make use of the technology, and to report on the development and evaluation processes of such a development. In doing so various lessons could be learnt which could inform the further development of such software at the University.

In order to support the development of the CAE program an extensive literature survey into current educational theory was conducted. Its objectives were to explore and understand all the factors affecting the development and use of computer based systems as an educational tool. Particular aspects considered were

- the debate between constructivist and instructivist theory in their applicability to both the medium and the subject material.
- instructional styles, and with them the learning styles, that could be used to support the educational goals of the diverse student population.
- instructional design methodologies that are currently used as well as media production methodologies. The goal of this aspect of the research was to advise both the development of the case study and to gain a broader understanding of the methodology that could be used for other developments. Included in this phase of the research are methods and criteria for selection of authoring systems and interface design issues in a multi-cultural multi-lingual environment.
- the review of different evaluation strategies in order to incorporate appropriate evaluation in the CAE case study.
- the investigation of broader sociological and historical factors that may influence the way in which CAE can be used effectively in a South African context.

1.3 Methodology

1.3.1 Literature review

This study is complementary to a number of ongoing research projects around the world. It also includes diverse subjects such as educational management and assessment, cultural and sociological perceptions of technology and technological literacy, computer delivery methods and the cost effectiveness of such delivery. As globalisation trends and technological innovations and developments take place at such a rapid pace the literature reviewed includes information reported via the World Wide Web (WWW), listserv discussion groups, as well as research published in books and journal articles.

Furthermore, as the topic requires an understanding of a variety of disciplines, the literature reviewed draws information from a myriad of subject areas, including education, educational psychology, cognitive sciences and computer studies. These were broadly categorised into educational issues, including educational theory, learning styles, instructional design models and instructional strategies; media production, with particular emphasis on interface design applicable to a multi-cultural multi-lingual audience; practical issues such as implementation and evaluation, and finally an overview of the particular changes facing tertiary educational institutions and South African institutions in particular.

As educational technology and educational philosophy change over time, some of the more current debates were reported in the literature review even if they did not inform the development of the case study; for example, constructivist and socio-constructivist educational theory, situated learning, and computer mediated communication. These may inform other CAE developments as technology develops and thus it was considered important to reflect on the myriad aspects that should be considered in developing CAE for use in tertiary education.

1.3.2 Case study

The case study was predominantly developed to investigate if there were any discernable and significant differences in the use of the program when correlating the students' usage patterns with ethnic, educational and language backgrounds. Furthermore, if such differences were found, what conclusions could be reached for further development of educational software.

To entice students to use the system there had to be perceivable benefits to them individually, thus the development of the system had to be meaningful and of particular relevance to the subject matter being learnt. The Department of Human Anatomy had identified a need to use technology to supplement traditionally delivered course material and were willing, if largely silent, participants in the research. They chose to have a program developed to support the learning of the anatomy of the leg and contributed valuable information about the subject matter. In order for the program to be meaningful for the students the program had to be developed within the educational paradigm used at the time which was primarily instructivist in nature, it also had to be seen to support the students' primary objective which was to pass a multiple choice exam at the end of the year. The CAE development thus focused on factual information as prescribed by the subject experts and supported the students' strategies to master the information presented by offering self-testing mechanisms.

Once developed the program was demonstrated to the students and loaded on to the University Local Area Network (LAN) for optional use by any student. The program stored data via an on-line tracking system that recorded each student's movement through the program. Subsequently an open-ended questionnaire was administered to obtained students' perceptions of the program. Where possible the two were correlated to ensure validation of the data.

The presumption was that students from historically disadvantaged backgrounds and those with English as a second language would be less willing to use technological interventions than those who were more likely to have had access to computers earlier in their education. The case study set out to investigate if this presumption was valid, and if so what elements of design and delivery could facilitate these students' usage of such systems.

1.4 Overview of thesis

The dissertation reports on the whole research process and is divided into four major sections. The first is the literature review as discussed in section 1.3.1 above. The next discusses the development of the case study and instructional design methodologies employed in the development of the CAE module. It includes each area of major import including:

- Choice of study project;
- Design principles for a multi-cultural, multi-lingual, educationally diverse student group, and, where applicable, for students with physical limitations;
- Software choice and development difficulties;
- Delivery method;
- Record keeping and evaluation methods;
- Analysis methods.

The results section of the dissertation reports on the results obtained from the questionnaire and on-line tracking system. It attempts to identify predictors or factors that may influence the successful inclusion of CAE in the learning process and in particular the way in which the software was used and perceived by the second year medical school students in 1999. It is, however, necessary to consider these results in the light of the teaching methodologies employed at the time of conducting the case study, and to understand that a change in educational methodology may have radical implications on these findings. Furthermore, the student demographics change with each year's intake and these findings can simply point to issues of current concern.

Although initial responses from students show a positive attitude to the program developed, these results need to be viewed in a more systemic manner, particularly in the light of new curriculum developments at the medical school. The final section of the dissertation discusses topics from the literature review that were important in the development and analysis of the case study and looks specifically at the issues of design and implementation issues pertinent to the University of Natal. It closes with some comments and recommendations to the University of Natal whilst also noting that further research is required to validate some presumptions bearing in mind the need for continual re-evaluation as our national education system evolves.

1.5 Summation

A case study, by necessity, selects the most pertinent aspects of a theory to test the validity of ideas in a given setting. To limit this dissertation to those areas only applicable to the case study itself would deny much of the validity of the debates in an evolving educational medium. The literature reviewed here is far broader than the case study, but could be used to inform future CAE developments depending on the needs of each specific case. However it cannot be viewed as a complete work as the area of study is undergoing continual development and reassessment and the research reported here should be seen in this light.

CHAPTER TWO
LITERATURE REVIEW

2.1 Introduction

Educational institutions, departments and individuals all over the globe are researching and developing CAE modules. The research area covered by this dissertation is reflective of these developments, and looks more specifically at the potential of computer delivered and mediated instruction to assist with the educational process at universities in South Africa and the University of Natal in particular. Much of the research is published in current research journals, web sites, and listserv discussion groups. Whilst cognisance is taken of the lack of academic refereeing in web page publishing, the technology is developing at such a rapid rate that it was necessary to explore all media available to researchers in this field, and published material is quickly outdated.

A literature review was conducted in the following areas:

- Definition of Terms
- Educational issues:
  - Educational philosophy;
  - Educational theory;
  - Learning styles;
  - Instructional design;
  - Instructional strategies;
- Media production:
  - Delivery technology;
  - Development systems;
  - Media production;
  - Interface design.
- Implementation issues:
  - Accessibility;
  - Organisational culture;
  - Maintenance and sustainability.
- Evaluating Computer Assisted Education:
  - Research question;
  - Methodology;
  - Research tools;
  - Research ethics.
- Changing face of university education:
  - Global issues;
  - Historical context of education in South Africa;
  - Historical background to CAE in South Africa;
  - Organisational and implementation issues at the University and its Medical School.

2.2 Definition of terms

Many of the terms used in this dissertation vary in meaning depending on the context and time frame in which they are used. It is, therefore, necessary to state emphatically their particular meanings in this context.

Assessment: In this dissertation the term assessment is used to refer to assessing student performance as apposed to evaluation as defined below.

CAE: Most current research refers to the terms Computer Aided/Assisted Learning (CAL), Computer Based Teaching (CBT), Computer Assisted

Education (CAE) synonymously, with minor variation in emphasis on the terms 'learning', 'teaching', 'education', 'aided' and 'based'. For the purposes of this research the term Computer Assisted Education (CAE) is used, as the emphasis of the research is on the assistance this medium can offer to the full spectrum of education including both the teaching and learning processes. However, the literature reviewed is not limited to CAE, it includes all variations of computer usage in the educational and training process.

Culture: The term 'culture' is not a euphemism for 'race'. Race has more to do with physical appearance than with culture, many people of the same 'race' have different cultures. Hulmes (1989: 16) states, "the word culture is one of those words which it is difficult to define". He points out that T.S. Eliot argued that the term 'culture' has different associations according to whether we have in mind the development of an individual, or a group, or of a whole society. Eliot maintained that the culture of the individual is dependent upon the culture of a group or class, and that the culture of the group or class is dependent upon the culture of the whole society to which that group or class belongs. For Eliot, therefore, the culture of the society is fundamental. Culture in this context is taken to mean the way in which individuals experience life, view the world, and behave in relation to their particular group norms.

Much of the literature reviewed refers to 'culture' in terms of the organisational culture and societal influences within the dominant culture. Although these influences are correctly termed, for the purposes of this dissertation these influences will be distinguished from personal multi-culturalism including religious and traditional influences by using the term 'organisational culture'.

Curriculum: The knowledge and skills required by students in order to gain a qualification or level within a degree.

Educator: Used in the context of this dissertation the word 'educator' means a person employed to teach or facilitate the learning of students and test the knowledge of students in order that the students may obtain a degree at a university. Educators are often, but not necessarily, involved in setting the curriculum for students.

Evaluation: In this dissertation the term evaluation is usually used to refer to evaluation of curriculum or CAE interventions, as apposed to assessment as described above.

HCI: The computer interface otherwise known as 'Human Computer Interface' (HCI) refers to the way the information is presented to the end user. This includes both the screen design and interactive features written into the program. It also includes such tangibles as the room in which the computer user works, the response time of the system, lighting and seating arrangements, all of which will have bearing on the way a system is used.

Hypermedia: Hypermedia is generally used to incorporate the definition of multimedia as defined below, but extends this definition to include the use of hyperlinks allowing the user to define their own path through the material. (Fouchè, 1998)

Listserv: A computer mediated communication tool using email to facilitate online discussion groups.

Multimedia: There is some debate on the specific meaning of the term multimedia. In the past this would refer to a number of different media being used such as video, slides and print. The term mixed media is now more common for that environment. Multimedia is now generally used to mean a computer interface that incorporates two or more media including still or animated graphics, video, audio and text (ibid).

Program/programme: The word 'program' is used to represent computer software, usually a series of coded computer instructions. 'Programme' on the other hand, is used to represent a series of events. In direct quotations these terms take their meaning from the context as they are used differently in various countries.

Students: People who have registered for a course with the view to passing a set of criteria that would award them a degree.

University: The term 'University' with a capital letter refers to the University of Natal as defined below, whilst 'university' in lower case refers to tertiary educational institutions that award degrees in general.

University of Natal: This term refers to the three campuses – Howard College, Medical School and Pietermaritzburg, unless otherwise stated.

2.3 Educational issues

Concepts and theories of education are, of course, imperative in a study such as this. This section outlines the current issues and debates in educational theory and then relates them to university education and the University of Natal in particular.

2.3.1 Educational philosophy

Philosophical questions by definition do not have any 'right' or 'wrong' answer, they pose a question for exploration in order to help us clarify our thinking and ideological position on certain topics. This thesis has no intention of exploring all the philosophical questions surrounding knowledge, truth and education. Suffice to say that these matters are open to interpretation and debate as discussed by Plato, Socrates, Russell, Popper and others, that these interpretations do not remain static over time, and cultural attitudes and beliefs will influence the outcome of such a debate (Hulmes, 1989).

A university, whose business it is to peddle such items, should continually, across faculties, schools, and departments, review such questions as:

- What is knowledge?
- What do we mean by education?
- What is the role of knowledge in society?
- Is there a relationship between training and education?
- What constitutes learning and is learning the same as education?
- Is there a relationship between data, information and knowledge?
- Do answers to the above questions change with the dawning of the 'information age' and the technological revolution?
- What are the effects of the proliferation of information on education as we know it?

Finally, universities should ask if the answers to the above questions change the role of the university in the 21st century. This dissertation will highlight some of the areas in which the changing needs of society that should be reflected in analogous changes at educational institutions can be addressed with the use of CAE.

2.3.2 Educational theory

"Theories are meant to explain something, or to help us understand the way things are within a certain domain. ... [They] include a cluster of concepts organised to form a whole. ... The key is how the concepts relate to each other." (Wilson, 1997: 22). Generally they do not ask 'what is something?', but 'how is something achieved?'.

Current debate in educational theory and instructional design revolves around behaviourism and its 'instructivist' style of teaching led by the behaviourist theoreticians such as Skinner, Watson and Thorndike, and 'constructivist' approaches as outlined by researchers such as Bruner and Goodman. However, renewed interest in elements of Vygotsky's 'social constructivist' theory from his concepts of the social origins of thought and his theory of the Zone of Proximal Development (ZPD) are again coming to the forefront of the debate.

Instructivist educational theory

Instructivist teaching takes as its premise the behavioural psychologists' theory of learning. Pavlov proved in his classical conditioning that behaviour can be modified by the association of two unrelated stimuli, whilst Skinner's operant conditioning claims that behaviour can also be modified by positive and negative reinforcement.

Taking this position into the classroom means that given the correct link between stimulant and reinforcement, 'instructors' can change the behaviour of a child. With practise the child's ability improves. Early computer delivered lessons based their instructional design principles on Thorndike's idea that repetition leads to mastery (Gardner, Kornhaber and Wake, 1996), thus developing 'drill and practice' exercises to reinforce the rote learning of skills, specifically in language and arithmetic exercises. Harper (1987) points out that in the late 80s the primary mode of CAE was still in the area of drill and practice exercises.

Schools have traditionally focused on ensuring their learners memorise and subsequently regurgitate content with the predictable result that "schools world over have not produced a population that thinks well and deeply" (Gardner et al, 1996: 259).

Traditional university teaching follows a similar model. Students sit in lectures and tutorials taking instruction from academic staff in the form of 'chalk and talk' lectures or discussion in tutorials. Small groups may be convened for remedial exercises where staff members may attempt to address some of the issues related to second language learners or different educational backgrounds, however, these tend to follow the instructivist style of teaching and learning as well. The staff member is considered the 'subject expert' and the students the 'empty vessel' into which knowledge must be poured. Operant conditioning is used by means of rewarding 'good' work with high marks and 'punishing' poor work with failure grades.

The subject material is usually considered to be an entity in itself that can be contained and handed out in doses and small-step procedures to make learning easier. Students are deemed successful when they are able to reproduce the taught material.

These theories tend to equate learning with behaviour modifications and base their assumption on the fact that changes in behaviour take place under certain conditions. However, they fail to take account of transferability and critical analysis as part of the educational process.

Unfortunately, this style of teaching is an extension of most of the teaching that takes place in South African schools, and to a greater or lesser extent has resulted in many first year students being considered virtually illiterate (Ivala, 1998).

Constructivist educational theory

The constructivist approach to education is based on the cognitive psychological approach to learning. It bases its theory on the philosophy that "there is no unique 'real world' that pre-exists and is independent of human mental activity and human symbolic language; that what we call the world is a product of some mind whose symbolic procedures construct the world" (Goodman cited by Bruner, 1986: 95); that "the idea of mind as an instrument of construction is (or should be) congenial to the developmental psychologist who observes different meanings being assigned to the same 'event' at different ages" (Bruner, 1986: 97). The constructivist believes that humans construct their own understanding of reality by interacting with the world around them, and knowledge is gained through experiencing that world.

Constructivist teaching, therefore, can generally be said to place priority on participatory, active, group, and co-operative learning among faculty and students. It would encourage the "active participation of students and instructors in an environment that facilitates peer interaction, evaluation and co-operation" (Hiltz and Wellman, 1997: 46 - 47).

Jonassen, Hennon, Ondrusek, Samouilova and Spaling separate the instructivists from the constructivists into the 'logical positivists' whose theory of science and instructional design are derived from the 'Aristotelian logic' and the 'relativists' who challenge these 'scientific' assumptions. They suggest that there are five major arguments outlined by Cziko (cited by Jonassen et al, 1997: 28) for indeterminism in human behaviour: "individual differences, the evolutionary nature of learning and development, the role of consciousness in human behaviour, quantum mechanics, and chaos". Table 2.1 summarises the difference outlined by Jonassen et al (ibid).

The constructivist teaching method suits some students better than others, however, even students who are naturally inclined to this method will have difficulties when they come from an instructivist background such as that in most of South African schools.

Socio-constructivist educational theory

Vygotsky's theory of the social construction of knowledge varies slightly from that of the constructivist theory in that he placed emphasis on the dialectical relationship in humans between history, culture, society, and nature. He looks specifically at the tools one uses to make sense of this relationship and sees language, including both spoken and written forms, as being one of the most important tools in doing this. The tools and aids available to one within one's culture will influence one's thoughts and one's thoughts will act or influence the tools one uses (Vygotsky, 1978). This is of particular importance to the educational process at the University as many of the students are learning in a language that is not their mother tongue, as well as learning a discipline that has a language and culture foreign to them. Medical school students are required not only to learn in English, but understand Latin and Greek terms in relation to their subject. This is further compounded in that they are learning what is essentially a western concept of medical practice that is quite different to the indigenous practise of holistic medicine carried out by *sangomas*.

Vygotsky is also responsible for coining the term 'Zone of Proximal Development' (ZPD). He maintained that it was irrelevant to measure one's current problem solving capabilities as a measure of ability. He noted that some people would measure the same as other people on solving a problem independently, but they would vary in capability when solving a problem co-operatively, or with the aid of a more experienced person. Thus, it is important to measure the persons potential at solving a problem. The ZPD is "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance in collaboration with more capable peers" (Bruner, 1986: 73).

Table 2.1
Summary of differences between logical positivists and relativists.

'Logical Positivists'	'Relativists'
Instructional systems are closed systems, which are the sum of their parts (learners, curriculum, technology, teachers etc.). By controlling these parts, we can regulate the performance of the whole system, which will then achieve a state of equilibrium. Instructional systems design is the process of regulating these closed systems.	Learning systems are necessarily open. The myriad components of learning systems are not even known to the teacher or designer and so cannot be controlled. And every identifiable component of learning systems is subject to random fluctuations and perturbations and is affected by forces that we do not know. While research into instructional systems has identified a very few fairly reliable cause-effect relationships between instructional activity and learning performance, whether they will be operable in any learning situation is probabilistic at best.
Knowledge is an external, quantifiable object that can be transmitted to and acquired by learners. The effectiveness of instructional systems, in fact, is a function of the effectiveness and efficiency of this transmission process.	Knowledge is an elusive phenomenon that can be represented only in complex, interacting forms in the world as well as in the learner's head. It is the interaction of knowledge in the head with knowledge in other peoples' heads and knowledge in the world that makes humans flexible, effective and problem solvers. Knowledge is not something which is possessed entirely by one person and transmitted passively to another. Rather, knowledge is distributed among society, history, and the community of practitioners with whom we interact, as well as the tools and artefacts that we create and use to interact with the world.
Human behaviour and performance are predictable, that is, they are reliable, knowable, and predictable in known circumstances. This enables patterns of behaviour to be analysed and used to make judgements about how learners are thinking or what they have learnt.	Human thinking and behaviour are incredibly complex and dynamic. We are ill-equipped to adequately describe human thinking, let alone regulate it.
A change in the state of one entity causes a predictable change in the state of another because of a linear relationship between the two (linear causality). Instruction predictably causes learning.	Quantum physics has shown that any effort to measure phenomena can never be certain, that the act of observation intervenes and changes that which is being observed. So, if it is impossible to be an objective observer of reality because we participate in that reality, we can never know with certainty if or why students learn. We do not doubt that they do learn, only that we can control and predict the process with any degree of certainty. Therefore, we can never be certain of what will happen when we intervene in any process. Reality is contingent – it can only be described probabilistically, which is the major lesson of fuzzy logic.
Interventions in the learning process deterministically predict the effects of those interventions. The design of an instructional system will effect predictable changes in learners' performance.	Systems are non-linear and so causes and effects tend to be unpredictable. We have no way of accurately predicting the effects of any interventions in learning system. (sic) This is supported by a rich history of no significant differences in our research.

Adapted from Jonassen et al (1997)

Albert Bandura (Nevid, Rathus and Greene, 1997) was another proponent of the social theory of learning and one of the key elements of his theory for instructional designers is his focus on how expectations can influence behaviour. Expectancies are perceived as 'predictions' about the outcomes of particular responses. He distinguished between two types of expectancies; outcome expectations and self-efficacy expectations. For Bandura, outcome expectations are anticipations that certain behaviour patterns will have certain effects, whilst self-efficacy expectations are based on beliefs that one will be able to execute the required behaviour successfully. According to Bandura, people are more likely to tackle a task if they believe they will succeed; people who have positive self-efficacy expectancies are likely to persevere (ibid). According to McCombs (1988), Bandura highlights four principle sources for self-efficacy judgements:

1. **Enactive attainments** – by performing the task.
2. **Vicarious experience** – by watching others perform the task.
3. **Verbal persuasion** – hearing and believing in one's capabilities to perform the task.
4. **Physiological state** – being able to adequately assess one's stress level, fatigue or other types of arousal in order to adequately perform the task.

To do this people need to adopt personal standards against which to evaluate their performance. These standards are acquired by perceiving and integrating self-evaluation standards modelled on one's perception of the standards of one's professional and peer groups.

2.3.3 Learning styles

Educational theory focuses on how people acquire knowledge; learning styles look at how individuals approach specific tasks of learning and recognise that individuals may vary their style of learning to suit different tasks or circumstances.

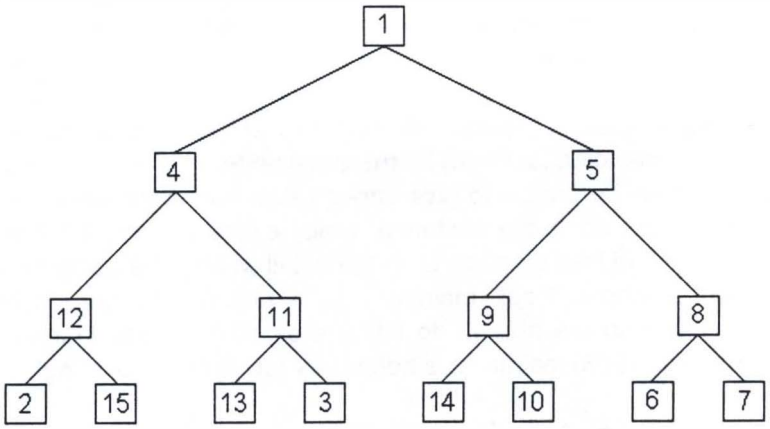
It is generally accepted that students do not apply the same strategies in their learning tasks. Numerous theoreticians (Bruner, Gregorc, and Pask amongst many others) have suggested various "learning styles" as guides to both students and faculty to use in the educational process. Claxton and Murrell (1987) hypothesise that academic staff who are informed about learning styles can design experiences appropriate for students (in both the matching and mismatching of styles) to enhance the learning of individual students. However, they go on to say that instruments that take cultural differences into account still need to be developed.

There are a large number of documented learning styles some of which are discussed here, with the criterion for selection being the way in which they informed the design of the case study as well as their relevance to current educational debate.

Gordon Pask: holistic and serialistic strategies

Of particular interest to instructional designers developing a hypertext medium is Gordon Pask's theory discussed by Claxton & Murrell (ibid). Pask described two learning strategies. The first he called 'holists', stating that these types of learners use a global approach to learning and develop a broad framework of understanding into which they can then fit more detailed information. They typically look at several aspects of a topic at the same time, constantly make connections between the theoretical aspects and practical applications as they learn, and make substantial use of analogies. Holists, according to Pask, examine parts of the topic at the higher level of complexity and make connections between them, jumping from one subsection to another to establish an over-reaching understanding as demonstrated by Figure 2.1.

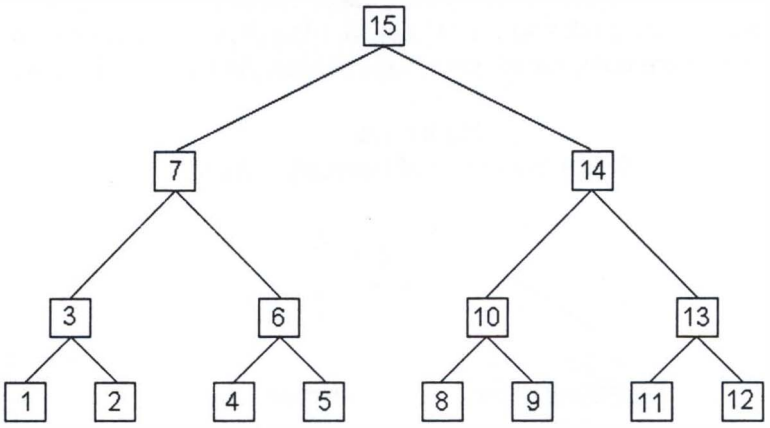
Figure 2.1
Pask's view of a holistic strategy to learning.



Adapted from Ford, N. (1985) "Styles and strategies of processing information: implications for professional education." Education for information 3: 115-32. Cited by Claxton & Murrell (1987) page 22.

The second type described by Pask are the 'serialists', who focus their attention more narrowly on pieces of information low in the hierarchical structure and develop their understanding through logical, sequential, and well-defined steps. Figure 2.2 shows how they use simple links to relate different aspects of the subject, thus working in a 'bottom up' approach so that the overall picture is developed slowly, sequentially, and logically in what Schmeck (1988: 186) describes as "an 'additive' approach to comprehension".

Figure 2.2
Pask's view of serialistic strategy to learning.



Adapted from Ford, N. (1985) "Styles and strategies of processing information: implications for professional education." Education for information 3: 115-32. Cited by Claxton & Murrell (1987) page 22.

Theoretical and practical aspects are learned separately, rather like separate strands. Serialists, according to Pask, use logical links rather than analogies to relate different parts of a subject. The numerical sequences displayed in each node of learning in Figures 2.1 and 2.2 show the different movement through the information of a 'holist' and 'serialist' learner respectively. It appears from Pask's theory, that learners create their own hyperlinks through the material depending on their learning style.

According to Pask there are two important components of understanding, description building and procedure building. Description building requires the creation of a conceptual map of a topic to provide an overview of how topics relate to one another. Procedure building focuses on the evidence and procedures that create the foundation of a broad overview. Pask believes both are essential to the process of learning.

He maintains that comprehension (holistic) learners are better at descriptive building than procedure building, whilst operation (serialist) learners are better at procedure building. Extreme comprehension learners may be unable to give enough attention to detailed evidence, leading to over-generalisation without adequate evidence, whilst extreme operation learners lack the skill in descriptive building, and lose themselves in the detail without the ability to draw the detail together into a cohesive whole. Pask maintains both procedures are necessary for full understanding and people who are able to do this are called 'versatile' learners (ibid), which Entwistle (cited in Schmeck, 1988) maintains is necessary for 'deep processing'.

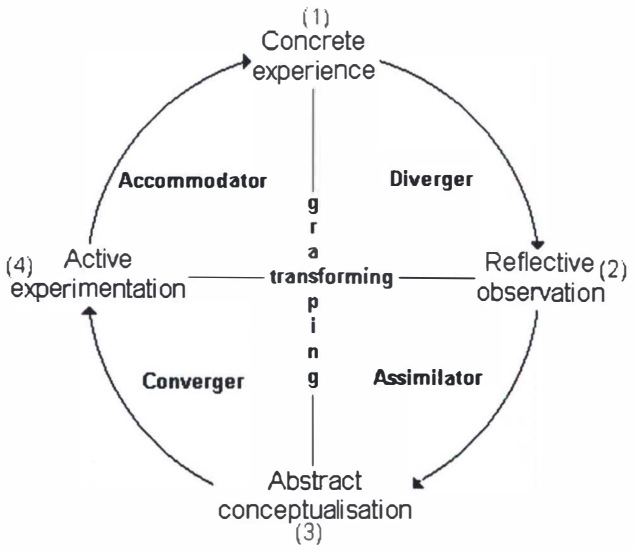
These styles have direct implications for navigational issues discussed in the section on interface design. With careful construction of indexes and navigation aides, a skilled instructional designer should be able to accommodate both styles of learning whilst giving adequate guidance to non-versatile learners.

David Kolb: inventory of learning

Kolb was a proponent of 'experiential learning', furthering Dewey's theory that learning needs to be grounded in experience, Lewin's theory that the learner needs to be actively involved in the process and Piaget's proposition that intelligence is a result of the interaction of the learner and the environment (Claxton & Murrell, 1987). He sees learning as a four step process.

(1) Learners have immediate concrete experience, involving themselves fully in the experience and then (2) reflecting on the experience from different perspectives. From these reflective observations, they (3) engage in abstract conceptualisation, creating generalisations or principles that integrate their observations into sound theories. Finally, learners use these generalisations or theories as guides to further action, (4) active experimentation, testing what they have learnt in new, more complex concrete experiences, as shown in Figure 2.3.

Figure 2.3
Kolb's inventory of learning styles



Adapted from Claxton & Murrell (1987: 26 - 28).

Kolb is careful to point out that the starting point may differ for different types of learners. Some learners may prefer to grasp a concrete experience whilst others would tackle a more abstract concept. They would then choose to transform it with either reflective observation, reviewing the information essentially as it is, or they may choose to transform the experience through active experimentation, changing the information to fit their thinking. From this approach he developed the concept of four learning styles, which he named as follows:

Divergers: people who grasp experience through concrete experience and transform it through reflective observation. According to Kolb these learners have imaginative ability.

Assimilators: who grasp the experience through abstract conceptualisation and transform it through reflective observation. These learners are said to have the ability to create theoretical models and assimilate diverse data into an integrated whole.

Convergers: use abstract conceptualisation to grasp experience and transform it through experimentation. They move quickly to find the correct answer when presented with a task or question.

Accommodators: who grasp the experience through concrete experience and transform it through active experimentation. They tend to prefer active participation and new experiences.

Kolb suggests that as people mature they move to a convergence of these styles. Claxton & Murrell (ibid) advise that teaching practices should ensure that learners engage systematically in all four modes. Problem based learning discussed under the heading 'instructional strategies' is an ideal method to accommodate these styles.

Anthony Gregorc: style delineator

According to the American Education Network Corporation's web pages (1999) Gregorc's theory is premised on the understanding that students require unique skills for each stage of learning. The suggestion is that although all skills are required for comprehensive learning some learners will develop a preference for one stage-skill over another. The two major skills identified by Gregorc are perceiving and ordering.

According to Gregorc perceiving takes place through either concrete physical sensory abilities or through abstract non-physical mental construction. Organising, he suggests, is done either sequentially in one or two dimensions or randomly in a non-linear multi-dimensional manner. Thus he proposes four distinct skill styles:

- Concrete sequential
- Concrete random
- Abstract sequential
- Abstract random

Taylor (1999) summarises the preferences of people with dominance in these skill styles as follows:

Concrete sequential learners prefer direct hands-on experience. They develop their five senses, like touchable concrete materials and orderly presentations. They do not oppose

tradition and are adverse to change. Taylor suggests they are likely to be habitual, organised, punctual, and desire perfection.

Concrete random learners like to experiment using trial and error approaches. They tend to jump to conclusions and prefer to work independently or in small groups. Generally they are risk takers and tend to arrive late for meetings. They thrive in a competitive atmosphere and like to take charge. They are not overtly concerned with other peoples' impressions.

Abstract sequential learners have strong linguistic strengths with written, verbal and image symbols. They prefer a sequential presentation that is rational and substantive. Taylor suggests they are 'fence-sitters' and highly sceptical.

Abstract random learners are highly intuitive and sensitive to moods. They prefer learning in an unstructured environment such as group discussions and activities, preferring not to be restricted by unnecessary rules and guidelines. They dislike routine and discharge enormous energy.

Gregorc suggests that there is a strong correlation between the individual's disposition, the preferred teaching medium, and teaching strategies (ibid). He is quoted as having said

> "Individuals with clear-cut dispositions toward concrete and sequential reality chose approaches such as ditto sheets, workbooks, computer-assisted instruction, and kits. Individuals with strong abstract and random dispositions opted for television, movies, and group discussion. Individuals with dominant abstract and sequential leanings preferred lectures, audio tapes and extensive reading assignments. Those with concrete and random dispositions were drawn to independent study, games and simulations. Individuals who demonstrated strength in multiple dispositions selected multiple forms of media and classroom approaches. It must be noted, however, that despite strong preferences, most individuals in the sample indicated a desire for a variety of approaches in order to avoid boredom."
>
> *Gregorc (1984) "Style as a symptom: a phenomenological perspective". Theory into Practice, 23(1), 51-55. cited by Taylor (1999).*

Gregorc's suggestions should be of particular concern when developing the entire instructional system, including support materials and class structures. Creative ways should be developed to ensure that any CAE developments juxtapose these elements in the instructional process.

Howard Gardner: multiple intelligences

Gardner's claims his theory of 'multiple intelligences' is a description or new way of looking at the concept of intelligence. He suggests that traditional measures of intelligence that result in a single IQ score are artificial, culturally exclusive and fail to take into consideration the possibility of other measurements (Gardner et al, 1996). Many psychologists and cognitive scientists agree with this criticism. Gardener argues that a prima ballerina and a master chess player could be equally 'intelligent' within his theory. However, in justification of his theory he uses examples of autistic people and savants who display great skill or 'intelligence' in one area alone, without the mental capacity to incorporate that knowledge into a complex whole. It is in this area that his theory of 'intelligence' is open to the most criticism. Anderson (cited by Gardner et al, 1996: 214) believes that Gardner's multiple intelligences are "sometimes a behavior, sometimes a cognitive process and sometimes a structure in the brain", others have claimed that he describes talents or skills, not intelligence. Gardner counter claims that the concept of human intellect encompasses several mental abilities and that his theory is concerned with "accounting for the variety of adult roles (or 'end-states') that exist across cultures" (Gardner et al, 1996: 203).

The philosophical question of what constitutes intelligence is not relevant to this dissertation; however, Gardner's theory has great value to education in terms of exploring ways to exploit learners' various talents, skills or 'intelligences' to enhance the learning process, and is thus included here under the heading of learning styles.

Gardner uses the term intelligence to organise and describe human capabilities. It is a potential that allows an individual access to forms of thinking appropriate to specific kinds of content. He defines intelligence as the "ability to solve problems or fashion products that are of consequence in a particular cultural setting or community" (ibid: 205). As a result he suggests that there are several 'relatively autonomous intelligences' of which he identifies seven, allowing for the possibility of more. Gardner et al (1996) summarise these intelligences as follows:

1. **Linguistic intelligence** – manifests itself amongst 'normal individuals', usually displaying itself as a "universal, rapidly developing capacity for speech." Gardner claims this intelligence can develop to a high degree across cultures without formal instruction. He suggests that poets, journalists, copywriters and lawyers typically display a good command of this intelligence.

2. **Musical intelligence** – allows people to create, communicate and understand meanings made out of sound. Studies of savants indicate that this intelligence is autonomous from other capabilities. Great skill in this area, according to Garner et al generally requires years of training, and is evident in composers, conductors, instrumentalists as well as acousticians and audio engineers.

3. **Logical-mathematical intelligence** – involves the use and appreciation of abstract relations. This type of intelligence follows Piaget's theory that abstract reasoning begins with exploring and ordering objects, progresses to manipulating objects and appreciating actions that can be performed on objects, then making propositions about real or possible actions and their interrelationships. It culminates into the appreciation of relationships in the absence of action or objects; pure, abstract thought. Gardner claims that one of the core operations of this intelligence is the concept of numbering, or assigning numeric values to objects in a series of objects. People who manifest strengths in logical-mathematical intelligence include mathematicians, computer programmers, financial analysts, accountants, engineers and scientists.

4. **Spatial intelligence** – deals with the ability to perceive visual or spatial information, to transform and modify this information and to recreate visual images in the absence of the original physical stimuli. Abilities evidenced in this intelligence include the ability to construct, move and rotate images in three dimensions, and create graphic representation of physical data. Geographers, cartographers, surgeons, navigators and artists would require this intelligence.

5. **Bodily-kinesthetic intelligence** – involves the use of all or part of one's body to solve problems or fashion products. It involves operations that require numerous motor actions and the ability to manipulate external objects. Dancers, rock climbers, gymnasts, jugglers or people who manipulate tools with delicate precision would show high levels of this intelligence.

6. **Intrapersonal intelligence** – enables people to distinguish among their own feelings and act on them. "At its highest level, discrimination among one's own feelings, intentions and motivations yield a deep self-knowledge of the sort elders draw on when making a crucial decision when advising others in their community" (ibid: 209). This type of intelligence allows people to know their own abilities and perceive how best to use them.

7. **Interpersonal intelligence** – enables people to distinguish among others' feelings, beliefs, and intentions, and manifests itself in the ability to understand, act on, and shape others' feelings and attitudes. Examples of people who display this type of intelligence, according to Gardner et al., (1996) are Mother Teresa and Martin Luther King. People would need this kind of intelligence if they were to be good therapists, parents and teachers.

A combination of these intelligences is required for the full functioning of any one of the examples listed above. Gardner (ibid) claims that although most normal people are able to draw on all the intelligences, they would have different strengths and weaknesses in using them, and this would account for individual differences.

The importance of Gardner's theory is its application in the teaching and learning strategies that can be employed to enhance individual student's ability to master various knowledge domains. In justification of his theory Gardner (1983) outlines how these intelligences have been dominant in different educational settings. He hypothesises that in 'non-literate' societies and tribal societies "most forms of knowledge were widely shared" (ibid: 338) and transmitted by imitation and observation. When complex and elaborate skills were necessary they were acquired by a select few members of the community and transmission occurred through 'off site' oral communication, memorisation and mental modelling of the circumstance in which the knowledge would be used. Learning these skills required linguistic, sensory, spatial and bodily-kinaesthetic knowledge. Some specialist tasks required linguistic and musical abilities.

Using Muslim religious education as an example, Gardner goes on to show how these educational systems often prized memorisation and recitation. Rote learning of this nature did not always require that the learner understand the material being learnt. He suggests that linguistic skills are the most dominant in this type of learning.

Middle Age education in Europe followed a similar pattern. "The method of teaching, even at higher levels of learning, was largely memorization, through set questions-and-answer formats, formalized definitions, or even whole lectures" (ibid: 349). Gardner suggests that criticism of this system by Holofernes, Bacon and others was one-sided. He states "medieval scholastic schooling was in many ways appropriate to the goals of the society of its time and allowed the transmission of the most important skills and knowledge in an effective way" (ibid: 351).

According to Gardner (ibid), the development of modern science, its acceptance in Europe and North America, and other changes that occurred in the period 1400 to 1800, created a need for more formal education: education orientated towards science and technology and less orientated toward the learning of sacred texts and reading of classical literature. Gardner (ibid: 351) views what he terms "the great industrial revolutions" of textiles and heavy machinery in the eighteenth century, the chemical, electrical engineering, and steel revolutions in the nineteenth century, and the computer information technology of the twentieth century, as being largely responsible for further changes in the educational system.

Modern state-funded education is no longer based on religious texts and theoretically all knowledge is granted equal treatment. Educational institutions are no longer staffed by members of the clergy but rather by state employed teachers whose employment is reputedly based on intellectual credentials rather than moral character. Families contribute in whatever ways they can to the education of their young. The goals of education are now supposedly to foster productive labour and proper citizenship within one's own country, stimulate personal development and ensure skills in individuals to use as they wish (ibid).

Gardner argues that "the relative importance of interpersonal intelligence has been reduced" (ibid: 352) whilst intrapersonal skills are pertinent as "the individual must monitor his own reactions and plan his future course of study, and ... the rest of his life" (ibid: 352). Linguistic

skills requirements are reduced as memorisation become less important and reading skills take a greater emphasis. However, a combination of linguistic skills and logical skills have been brought to the fore as individuals are expected to "abstract, synthesize and criticize the texts they read, and to devise new arguments and positions to replace the contemporary wisdom" (ibid: 352). He suggests that with the advent of computers and technologies much of the work in education becomes the manipulation of logical and numerical symbols.

Gardner's model of modern education does not translate well into the local situation. Many South African schools are reflective of early European and even Middle Age educational systems. The majority of schools have few textbooks and educators are often under-qualified in the subject material, teaching in a language that is not their mother tongue and in some cases a language that is only partially mastered. Rote learning and memorisation is prized in these institutions, model answers are given to likely questions and students who can reproduce the answers verbatim score higher marks than those that show an intrinsic understanding of the material. When these learners move into a tertiary educational system at undergraduate levels they are ill equipped to make the change to a western scientific model of learning. If the learning that takes place in these institutions has a dialectical relationship with the society as suggested by Vygotsky, and if learning "tends to occur in a particular cultural context" as suggested by Gardner (ibid: 336), then it should be of no surprise to the Minister of Education, Kadar Asmal, that "our whole method of teaching, of education and training, is still redolent of the teaching of 100 years ago" (Brand, 1999).

It would be extremely difficult for educators to adjust their methods for all preferred intelligences within their student population, but with a carefully designed instructional program the students should be able to select their preferred mode. In addition when educating professionals for a discipline, such as medicine, which requires it's practitioners to evident a number of intelligences the teaching methods should encourage the development of these within their student population. Thus intelligences may need to be taught as well as used for effective learning.

2.3.4 Instructional design

Instructional design (ID) is a systematic approach to designing, developing, implementing and evaluating instruction (Armitech, 1999). It is a discipline that is pragmatic and goal orientated, the assessment criterion being the amount of learning that results from the design (Richey, 1990).

Instructional design models

Literature that refers to ID typically looks at various models that have been proposed as processes that lead to the successful development of instructional systems. Many of these were developed at the time when behaviourism was the predominant educational influence, and as a result they follow a prescriptive linear cause and effect flow chart. Typically an ID model will address the following topics

1. An analysis of needs, tasks and learning objectives.
2. The design of increasingly more detailed blueprints that specify the requirements of the instructional material to be constructed.
3. The construction and implementation of the instructional material.
4. The evaluation of the material in both a formative and summative sense.
5. The maintenance of the instructional material.

Adapted from Gros, Elen, Kerres, Merriënboer and Spector, (1997: 48)

Some authors distinguish between ID and Instructional Systems Design (ISD) where ID relates to instruction on a micro level and ISD at a macro level. Gagné and Briggs warn that the term 'system' in ISD is relative and will mean different things depending on the context in which it is

used (Gagné & Briggs, 1979: 19). For them designing an instructional system is "the construction of an over-arching variety of learned outcomes the course (or curriculum) intends" (ibid: 18). They summarise the instructional systems design process into fourteen stages but emphasis that although the steps are given sequentially, each is part of an iterative process where the findings in one step may influence a previous choice and adaptations would need to be made accordingly.

Systems Level

1. Analysis of needs, goals and priorities
2. Analysis of resources, constraints and alternate delivery systems
3. Determination of scope and sequence of curriculum and courses, including delivery system design.

Course Level

4. Determining course structure and sequence
5. Analysis of course objectives

Lesson Level

6. Definition of performance objectives
7. Preparing lesson plans or modules
8. Developing, selecting materials, media
9. Assessing student performance and performance measures.

Systems Level

10. Teacher preparation
11. Formative evaluation
12. Field testing, revision
13. Summative evaluation
14. Installation and diffusion.

Adapted from Gagné & Briggs (1979: 23)

Armitech (1999) state that there are over forty ID models available to instructional designers. It thus makes sense to some authors to classify these.

Classification of instructional design models

Reeves (1996) outlines four paradigms of instructional design which he named and described as follows:

1. Analytic-empirical-positivist-quantitative paradigm, where
   - analytic reflects a belief in a mechanistic, deterministic reality and cause and effect relationships can be revealed;
   - empirical states that the goals of inquiry are the definition, prediction, control and explanation of physical phenomena as revealed through experience (inductive reasoning) and experiments (deductive reasoning),
   - positivist represents a faith in scientific progress;
   - quantitative stems from a reliance on measuring variables and analysing the relationship among them with descriptive and inferential statistics.

2. Constructivist-hermeneutic-interpretivist-qualitative paradigm, where
   - constructivist reflects the belief that humans individually and collectively construct reality;
   - hermeneutic is used to mean the analysis of curriculum in the broadest sense and instructional programs and products in a more focused sense, including attempts to expose the values underlying these phenomena;
   - interpretivist stresses the need to put analyses in context, presenting the interpretations of many, sometimes competing, groups;

- qualitative represents the emphasis on the human being as the primary research instrument, rejecting the mathematical modelling of phenomena upon which the quantitative paradigm depends.

3. Critical theory-neomarxist-postmodern-praxis paradigm, where
   - critical theory relates to a concern with the questions of power, control, and epistemology as social constructions with benefits to some and not to others;
   - neomarxist refers to evaluators who seek to expose the 'hidden curriculum' underlying instructional technology and other educational reforms;
   - postmodernists question the conception of instructional technology "as neutral or as leading inevitably to progress" (Hyunka & Yeaman cited by Reeves, 1996);
   - praxis represents a desire to abandon the search for truth as sought by empiricists or understanding as desired by interpretivists in favour of seeking situationally appropriate realities.

4. Eclectic-mixed methods-pragmatic paradigm, where
   - eclectic refers to its openness to borrowing the methods of the other three paradigms to collect information and solve a problem;
   - mixed-methods relates to the recognition that multiple perspectives are necessary to 'triangulate' or 'bracket' information and conclusions regarding complex phenomena;
   - pragmatic aspect reflects the practical orientation that although ultimate prediction and control may never be achieved in education and training through instructional design or any other approach, things can get better.

Reeves' analysis is directly related to educational theory. His supposition is that instructional designers will use a paradigm that best suits their educational theoretical predilection. This section will look briefly at Reeve's (1996) "analytic-empirical-positivist-quantitative paradigm" under the heading 'behaviourism and instructional design', and his "constructivist-hermeneutic-interpretivist-qualitative paradigm" under the heading 'constructivism and instructional design' and then offer an alternative paradigm, not discussed by Reeves, under the heading 'chaos theory and instructional design'. Finally the section will explore Richey's categorisation of instructional design.

Behaviourism and instructional design

The discipline of ID and programmed instruction developed out of the behaviourists' view of knowledge and knowledge acquisition. Cooper (1993) states that early technology-based instructional systems were task-based, developed around stimulus-response chains of behaviour and that they were developed to shape a desired identifiable final behaviour. Typically behaviourist technology based instruction programmes were self-paced and individualised. Feedback to the learner was perceived as the necessary positive reinforcement required for sustained behavioural changes.

Generally behaviourists use a reductionalist approach to the delivery of information. Information is 'chunked' into small components that relate to a single skill that must be mastered before the learner gains access to the next step. According to Chase (cited by Cooper, 1993: 13) this meant they focused primarily on "low-level skills" rather than the more "complex, conceptual behaviours".

Jelden (cited by Cooper, 1993: 13) identifies four major components of behaviourist ID systems:

1. A student information module with learner characteristics and capabilities assessment.
2. Instructional analysis module to analyse and order the instruction.
3. A learning activity module that identifies the support mechanisms and media required, and suggests a learning sequence for each student.

4. A systems evaluation module which performs a statistical analysis of the effectiveness of the overall system.

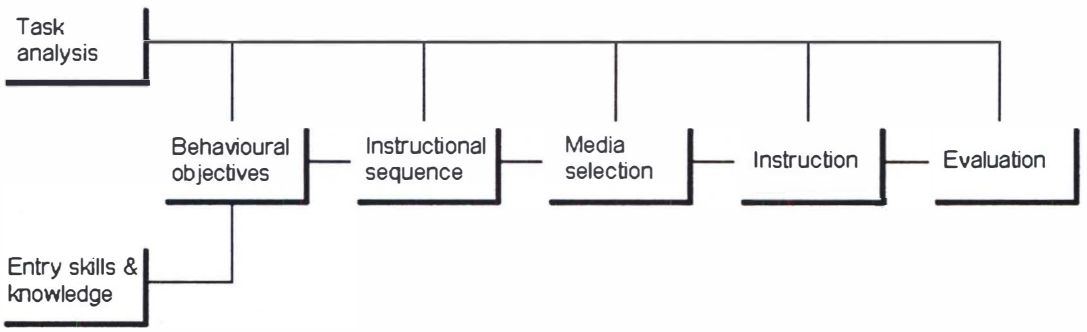
Within this model, behaviourists look at the specification of goals, objectives and tasks. They then develop a continuum of tasks from elementary entry level to conceptual relationships, analyse the content and develop an evaluation method including the assessment of learner entry skills, "changes that occur as a result of instruction", and a "calibration of the collected data" (Chase cited by Cooper, 1993: 13).

Cognitivists refined the objectivists' philosophy by adding a theory describing the way humans process information. However, they still perceived knowledge as an external verifiable reality. This view of learning and ID requires more complex processes as it needs to take into account individual differences. The remedial branches typically built into the instructivist models are considered insufficient to cater for learner differences.

According to Lebow, Heinich identified traditional educational technology values applicable to the objectivist models, which he lists as "replicability, reliability, communication and control" (Lebow, 1993: 5). Another common theme running through these ID systems is the belief that it is possible to measure learning achievement against predefined goals.

The Dick and Carey ISD model was initially designed in 1968 to support the framework of "Skinnerian programmed instruction" (Dick, 1993: 55). In his paper Dick clearly outlines the criticisms levelled at the model as well as his view of its deficiencies. He states that he presumed users would know what the goals were so did not include a goal identification step and had omitted steps for criterion-reference assessment and development of instructional strategies. According to Dick, educators at the time rejected "Gagné's hierarchical analysis as a means of identifying the content of instruction, ... [disregarded] concerns for selecting appropriate media, ... [and rejected the] notion of formative evaluation" (ibid: 56). He states that the clients were educators because at the time "there were no instructional designers, per se" (ibid: 55), with the implied suggestion that the responses may have been different if there had been. Figure 2.4 is a reproduction of Dick's 1968 ID model.

Figure 2.4
Dick and Carey's first edition of an ISD model.

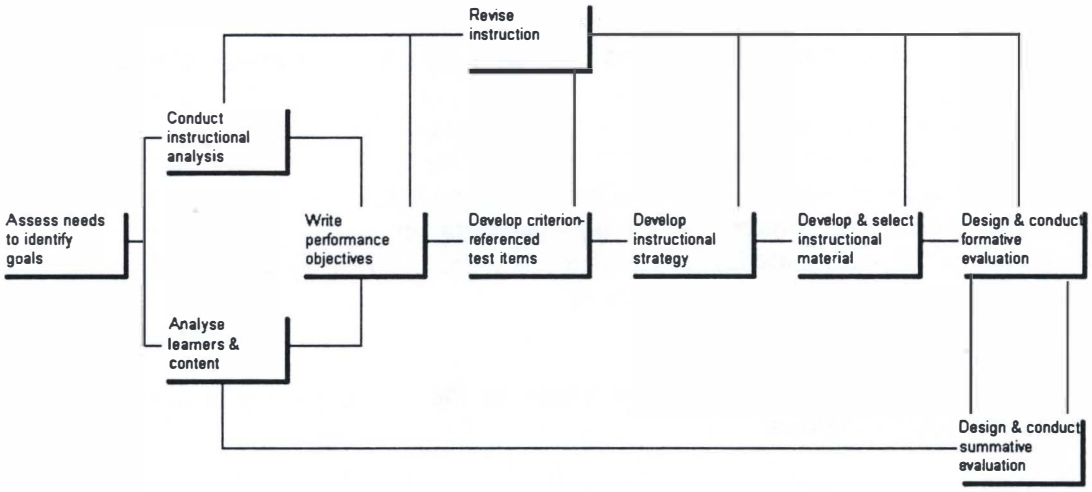


Redrawn from Dick, (1996: 56)

Dick claims that in 1974 he concluded "computers would never play an important role in education because they were much too expensive, and educators found them dehumanizing" (Dick, 1996: 56). As a result he turned his attention to "the design of instruction rather than the delivery of instruction" (ibid: 56). This statement highlights the confusion between the perceived roles of the instructional designer, the materials developer, and the instructional deliverer that permeates the literature reviewed.

Dick modified the 1996 design model to accommodate what he terms "several important concepts and procedures" (ibid: 56), such as performance technology, context analysis, multi-level evaluation models and total quality management. He maintains that the "evolution ... seems both inevitable and appropriate for design models" (ibid: 56). The changes between the 1968 model and the 1996 model include some transitory steps including the addition of a goal identification step, the merger of media selection and instructional strategy and the separation of formative and summative evaluation. His 1996 model, depicted in Figure 2.5, includes more systemic issues such as his belief that instructional goals should be developed "through an analysis of the current status of the organization's mission, goals and objectives" (ibid: 57) and his belief in "the importance of understanding the contexts in which students will learn and use the skills" (ibid: 57) taught and how the transference of the knowledge or skills learnt into the work place will be accomplished. In his text he emphasises "the importance of planning instruction that will facilitate the transfer of learning to the performance environment, and conducting formative evaluations in the workplace after training has been completed" (ibid: 58).

Figure 2.5
Dick and Carey's 1996 ISD model



Redrawn from Dick (1996: 58)

Limitations of the model, according to Dick (ibid: 58 - 59), include the fact that it is not a complete model as it does not include procedures for a total performance systems analysis, and for implementing and maintaining instruction. In response to the criticism that practitioners do not follow all the steps in sequence, he counter claims that the model "was never intended to be a reflection of what practitioners actually do ... it is recognized that many factors determine what practitioners do and do not do on any given project in any given organization" (ibid: 58). He dismisses Willis' argument that the model is a fixed, linear approach as a "straw man" (ibid: 59) and that although the model is a systems model, practitioners will move back and forth and not always start at the beginning. However, he continues by saying "novice designers are encouraged to learn the process by beginning at the beginning and working through the model in an orderly fashion" (ibid: 59).

There is a certain irony in the fact that Dick clearly sees the model as a means of teaching a systematic approach to designing instructional material, not a precise model to be used in practice.

Constructivism and instructional design

Lebow (1993) states that for some educational technologists, ID is the antithesis of a constructivist's view of the world. 'Instruction' denotes the passing on of knowledge rather than the individual construction of knowledge through experience, whilst design creates images of the artificial development of limited blocks of knowledge (or information) to be passed on outside of the real-world experiences of the learner. However, he continues to say, some of the more pragmatic theorists suggest that the time has come for a shift in ID theory to accommodate constructivist principles (Jonassen, cited by Lebow, 1993). In Lebow's opinion this view comes from a misunderstanding, whereby constructivism is treated as a method when it is a philosophy and ISD being treated as a philosophy when it is a method, thus "appearing to project the world view of the tool maker onto the tool" (Lebow, 1993: 5).

Lebow suggests that constructivists should offer designers an alternative set of values with which to influence the emphasis of the ISD methods "without undermining the coherence and consistency of the ISD model". (ibid: 5). In his view these would be "the seven primary constructivist values of collaboration, personal autonomy, generativity, reflectivity, active engagement, personal relevance and pluralism" (ibid: 5). This leads him to his five principles of constructivist ISD listed as follows:

1. Maintain a buffer between the learner and the potentially damaging effects of instructional practices.
2. Provide a context for learning that supports both autonomy and relatedness.
3. Embed the reason for learning into the learning activity itself.
4. Support self-regulation through the promotion of skills and attitudes that enable the learner to assume increasing responsibility for the developmental restructuring process.
5. Strengthen the learners' tendency to engage in intentional learning processes, especially by encouraging the strategic exploration of errors.

(Lebow, 1993: 5)

Willis (1995) on the other hand names and describes the characteristics of constructivist-interpretivist ID models as follows:

1. The ID process is recursive, non-linear and sometimes chaotic in that:
   - the same issues will be addressed many times;
   - the tasks are not linear and may be done in any order;
   - possible improvements will present themselves at all times as well as in the context of use;
   - design will require recursive evaluations by users and experts;
   - the project will be characterised by false starts, rework on design and repeated revision.

2. Planning is organic, developmental and reflective as:
   - the start is a vague plan which will have the details filled in as the development progresses;
   - developments should be collaborative, – the design group (including many who will use the instruction) should work together to create a shared vision that will be developed during the entire project.

3. Objectives emerge from the design and development work in that:
   - it is only during the process of collaboration and development that the objectives emerge and become clear.

4. General ID experts don't exist – according to Willis:
   - instructional designers have to understand the subject material and the teaching methodology used before they can undertake a ID project;
   - and it is preferable to have developers who know and understand the content or context of practice and who pick up the ID skills needed rather than ID specialists who are not situated in the learning context or the knowledge domain.

5. Instruction should emphasise learning in meaningful contexts in that:
   - the instructional emphasis should be on developing understanding in context;
   - and approaches such as anchored instruction, situated cognition, cognitive apprenticeships, cognitive flexibility, hypertext, problem solving should be considered providing there is sufficient access to the knowledge required to solve the problems.

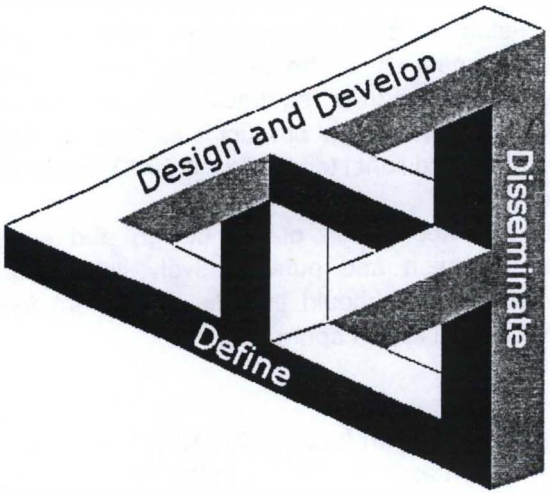
6. Formative evaluation is critical:
   - the most important assessment is the evaluation that allows the developer(s) time and information to change and improve the product.

7. Subjective data may be the most valuable:
   - Multiple choice questions give limited information - some things can be shown or observed but not quantified. Assessment should include authentic assessment such as portfolios, ethnographic studies, and professional opinions. Informal qualitative approaches such as interviews, observations, user logs, focus groups, expert critiques, and verbal student feedback can be useful to the instructional designer.

Adapted from Willis (1995: 12)

Willis (1995) states that the seven positions mentioned above do not collectively constitute an ID model, but an ID model based on constructivist-interpretivist principles should be compatible with most of them. In his article Willis (ibid) discusses the 'recursive, reflective, design and development' (R2D2) model as example of a constructivist-interpretivist ID model. It is non-linear and recursive as well as reflective in that the "ID team ... is expected to actively reflect on and analyse work to date and regularly revise and rework both the material being developed and the models that underlie its development" (ibid: 14). The model has four focal points, namely define, design, develop and disseminate, but as Figure 2.6 shows this is not a linear, procedural model, rather an interactive cycle of events.

Figure 2.6
Willis' R2D2 ID model



Redrawn from Willis (1995: 15)

The focal points of the R2D2 model are described by Willis (1995) as follows:

Define Focus

The definition focus is made up of several component parts that inform each other:

1. A 'front-end analysis' where the development team looks at the specification of needs and evaluates existing material.
2. An analysis of learners, which in Willis' view is an ongoing process. The team should include students to inform the team on the selection of topics, the selection of appropriate instructional strategies, as well as to give on-going feedback on the look and feel of the material being developed.
3. Task and concept analysis where "authentic instruction and assessment" strategies are identified (ibid: 16), and where the assessment focuses on the users' success in accomplishing the task. Willis emphasises that the discreet skills that are so important to the instructivists' educational systems should not be ignored, instead they should be framed in the context of how they relate to a particular task that is real for the user. Willis continues by saying that task and concept analysis is a continuous aspect of ID.
4. Willis states that the specification of instructional objectives is not required at the beginning of a project, and in his opinion "it may even be impossible to do that because the specific focus and direction of the ID project may not be well understood" (ibid: 17). In this model objectives evolve from the ID process and the authentic tasks determine the focus of instructional material.

Design and development focus

This area of the R2D2 model is made up of four components, but once again Willis emphasises that the boundaries between the components are extremely fuzzy.

1. Media and format selection that emerges from discussions with the educators and learners as well as literature reviews and the exploration of emerging multimedia instructional material.
2. Selection of a development environment. Willis states, "although there are many theories and models for selecting development environments, the fact of the matter is probably that development teams usually select authoring environments and support software they already know how to use". (ibid: 18). However, he goes on to say that it is useful to have a tool that is easy to learn so all of the development team can participate in the entire process, and that the tools chosen should allow for continual modification so as to support recursive design and development as the "R2D2 model encourages experimentation and exploration of alternatives" (ibid: 18). Willis claims that the advantages of combining the design and development tasks include the fact that the risk is reduced because fundamental problems are discovered early, that there is less chance of the team committing to a design that cannot be executed, it encourages experimentation, and revision and each person knows exactly what the others are doing.
3. Product design and development should be created by the development team trying out possible designs balanced with regular feedback from potential users and customers. Willis (ibid: 19) states that "an educational product is as much an artistic creation as it is a technical product", and that a traditional top-down, linear ID model is unlikely to produce a creative dynamic product.
4. Evaluation strategy "is an integral part of the design and development process. It emphasizes formative evaluation and puts relatively little emphasis on summative evaluation." (ibid: 19) Evaluations should include component feedback and package critique from student tryouts and expert appraisal.

Dissemination focus

According to Willis (1995) the dissemination focus of the R2D2 model is similar to behavioural ID models in all except the evaluation aspects. He states that "final packaging involves creating and producing any necessary print materials ..., creating a master of the instructional materials

..., and producing the package in quantity, as well as advertising, training sessions, workshops, creation of a user support system, and updates of successful packages" (ibid: 20).

The difference lies in the emphasis that the R2D2 model places on summative evaluation. Behavioural ID models require an objective assessment of the effectiveness of the instructional package, whilst in the R2D2 model "summative evaluation becomes a minor, and not always necessary, component" (ibid: 20), as far more emphasis is placed on the formative evaluation. In the example given by Willis (1995) the expert summations and final learning of authentic tasks were used as qualitative summative evaluation.

Richey takes a more pragmatic view than Willis and recommends an ISD systemic approach that avoids the use of "inflexible lock-step design procedures ... [that gives] increased attention to the dynamics of a given instructional context, ... [and] more consideration to the nature of the individual learner" (Richey, 1992: 10). She states that procedures need not be ignored, but they should be used more flexibly.

Chaos theory and instructional design

Chaos theorists look at non-linear systems that cannot be explained by Newtonian physics and its associate linear problem solving determinism. According to Jonasson et al (1997: 31. original italics) "chaos in a system occurs when small changes in the system's initial conditions result in large changes later ... This *sensitive dependence on initial conditions* principle has become one of the key components of chaos". In non-linear systems the output is not proportional to the input as described by Newton's laws, however, Jonasson (ibid: 32) argues, "irregular behaviors, once dismissed as unpredictable system anomalies, are actually predictable in chaotic terms".

You (1993) explains chaos theory by describing three key elements:

The first is the notion that chaotic systems are sensitive to initial conditions, a slight variation in one of these conditions can result in vastly different patterns and outcomes, thus making the predictability of outcomes uncertain at best. The system is described as non-linear. Chieuw (cited by You, 1993: 19) states "sensitive dependence on initial conditions ensure no two outcomes are alike".

The second element You (1993) addresses is fractals. He describes the word 'fractal' as meaning 'self-similarity' which is reproduced across scale. It "implies recursion, pattern inside pattern" (Glieck cited by You, 1993: 19) and "a repetition of detail present from the smallest to the largest scale, producing thereby a hidden pattern of order that has structure and regularity" (Chieuw, cited by You, 1993: 19). Thus, You concludes that fractals "are irregular throughout [and] have the same degree of irregularity on all scales" (ibid: 19).

The third key element of chaos outlined by You, is called "strange attractors", where "an attractor is the behavior that the system is attracted to or eventually settles down to". (ibid: 19). According to You (ibid) there are three different attractors that control or limit the range of movement of a system:

1. point attractors that act as constraints and settle the system's behaviour to a static equilibrium;
2. limit-cycle attractors that create the repetitive cyclic behaviour of the system; and
3. strange (or chaotic) attractors that stretch the system away from point and limit attractors toward different behaviours.

(You, 1993: 19)

Traditional ISD models follow a linear deterministic path. One step follows logically from another and any change in one step automatically makes a logical, calculable change in the next. According to You, (ibid: 20) "this type of ISD mechanism is not sufficiently flexible for working

with environmental turbulence or sophisticated educational systems" as the number of possible variables creates a system so complex that ISD methodology is unable to accommodate them. Jonassen et al (1997: 32) confirms this by stating "the instructional process is too unpredictable to be regulated to a linear sequence of operations that produce reliable outcomes". Both statements have direct implications for the evaluation of instructional systems and systems design.

You (1993: 20) suggests that non-linear systems "assume mutual causality and holism" where a small alteration in an initial condition can bring about a radical different result. For You (ibid: 20), the "multiplicity of interrelationships among the components in the ISD model results in disproportionate change: their feedback dynamics constitute the dynamic quality of a nonlinear system". Learning should be seen in the light of this dynamic process, in that it is in a continual state of 'becoming' rather than a linear process defined by a beginning, middle, and end.

Learning can also "be viewed as a self-organizing system" (ibid: 24) where new knowledge creates a disorder within existing knowledge "necessitating reorganization and restabilization" (ibid: 24). Thus new data requires an alteration to the entire knowledge system, similar to Piaget's theory of assimilation, accommodation and equilibrium. (Yelon and Weinstein, 1977). It also highlights the importance of Vygotsky's ZPD, where it is not so much what you can do, but what you are capable of doing that should be the focus of education and educational assessment.

Fractal scaling is important to ISD in that it suggests that an iteration of analysis, design and evaluation at every step becomes imperative. No ISD operation is more important than another nor does any operation come before another as "each operation plays it own unique role and together they form the distinctive character of the whole" (You, 1993: 25). The fractal structure invites an investigation into the whole system at both macro and micro levels as each are equally influential in the learning environment, echoing Richey's call for a systemic investigation in the ISD process (Richey, 1992).

Richey's procedural and conceptual models of instructional design.

Richey (1990) differentiates between conceptual models and procedural models. For her, a conceptual model is usually descriptive in the sense that a verbal description and definition is given of all the relevant components and links between variables are identified. She claims that conceptual models are usually based upon experience.

Procedural models, on the other hand, describe how to perform a task (ibid). These, she claims, are task orientated and outline the steps necessary to complete the task. They are based upon knowledge of what it takes to create a successful product, or they are derived from another theory. For Richey, most procedural models are product orientated.

Richey's procedural models

Procedural models are divided into their predominant theoretical influences. She looks at models based on 1) general systems theory, 2) learning and instructional theory and 3) communication theory.

1. General systems theory models will have the following core elements (ibid: 96)
    - Determine learner needs
    - Determine goals and objectives
    - Construct assessment procedures
    - Design/select delivery approaches
    - Try-out instructional system
    - Install and maintain system

2. Models based on learning and instructional theory are further categorised by Richey into general presentation models and task specific models. General presentation models are represented by models such as Gagné & Briggs' instructional events (discussed in this dissertation under the heading instructional strategies) and Merrill's component display theory (Brooks, 2001). Task specific presentation models are reflective of research on "narrower topics" (Richey, 1990: 121). She gives the Jassal-Tennyson's model as an example, summarised into five steps as follows:
   - A concept definition,
   - A best example (recalled as a prototype),
   - An expository set of instances (students will compare and contrast the instructional examples with the best example),
   - An interrogatory set of instances (students are directed to compare and contrast new examples with the best example and make a response), and
   - A classification test.

   (Jassal and Tennyson, cited by Richey, 1990: 121)

3. Communication theory models for Richey are generally related to textual structure and the "physical arrangement of information to facilitate learning" (Richey, 1990: 122). She categorises Marsh's nineteen step procedural model for designing messages as a "general communications model" (ibid) which she summarises into three stages:

   Stage 1:

   Basic planning phase.
   - Select strategy.
   - Profile receiver.
   - Determine central idea.
   - Establish performance objectives.

   Expansion of the basic planning phase.
   - Identify subordinate points and the overall structure of the content.
   - Select general tactics to be followed in the instruction.
   - Determine the level of obscurity this content has for the typical learner.

   Stage 2:

   Controlling the complexity of the messages.
   - Contextual atmosphere determined by selecting a level of diversity (auditory, visual, and structural variety) and level of density (the rate of change, the redundancy, and the structural complexity of the messages).
   - Selection of auditory or visual channels.

   Refinement of message complexity.
   - Sophistication level - degree of abstraction and precision.
   - Readiness of learners - facilitated through the amount of framing of the message, the emphasis on establishing the relevance of the content and the degree of reliance on mnemonics.
   - Arrangement and sequencing of major sections of the information, including, background information, amount of explanation provided and the amount of digression permitted.
   - Selection of graphics and language style.

   Stage 3:

   Type of response desired by the learner
   - Use of music, colour, as well as the visual composition of messages.

   Adapted from Richey (1990: 122 - 123)

Richey's second category of communication theory models is termed "a text organization model" (ibid: 124) Here she uses a model developed by Wright and Pyatte called "Organised Content Technique" as her example. The premise for this model is the assumption that the organisation of text on a page affects learning. It is intended to be a tool whereby the central idea of a message can be extracted and organised so that the learner can quickly identify its critical components. The key elements identified by the model are:

1. Configuration - the overall framework of the page;
2. Layout - placement of information within the configuration, including balance and spacing;
3. Display - techniques used to direct the learners' attention to critical aspects of the message;
4. Typography - style and appearance of the typed material;
5. Descriptors - headings, important commands, topic sentences, and
6. Style - writing style such as a condensed style with simple brief explanations.

Adapted from Richey (1990: 124 - 125)

Richey's conceptual models

The difference between a procedural model and a conceptual model, for Richey, is "a conceptual model does not provide specific guidelines to design projects as do procedural models. Rather, it facilitates an understanding of those factors which impinge on designs and their implementation" (ibid: 131). She claims a conceptual model is necessary as procedural models have such breadth and scope of experiential knowledge that a synthesis is necessary in order to be able to facilitate theory development. It is critical, in Richey's view, that "the model encompass current knowledge, and yet at the same time be flexible enough to permit the assimilation of new knowledge whenever possible" (ibid).

Richey presents a conceptual model that, in her view, is a synthesis of "the knowledge base provided by related theories and common practise. It is generic, but can be used to analyze specific situations. It is descriptive, not prescriptive." (ibid: 132)

She divides the model into four basic clusters:

1. The learner
2. The content
3. The environment
4. The delivery

She then offers taxonomies of each of the clusters (ibid: 131 - 165), which are summarised briefly below:

1. **The learner**

   Here she recommends that each of the following be fully explored

   - **Demographics** – including age, sex, cultural background, including ethnic culture and socio-economic.
   - **Capacity** – intelligence (including all levels of Gardner's multiple intelligences), cognitive development (as described by Gregorc and Kolb) and physiological capacity (including perceptual and motor development).
   - **Competence** – is made up of prerequisite skills of information processing, basic skills and content prerequisites. Experiential background such as family, leisure time, social and vocational and educational are also included here.
   - **Attitudes** – including aesthetic, moral and religious, school-related, subject-related and work related values. Academic, personal and professional self-concepts and finally motivational level as it refers to the individual's goals, interests and perseverance.

2. The content

Richey expresses her concern that the content of material to be learnt has many facets that can result in vastly different instructional situations, only some of which will be applicable to a specific instructional situation. In this section she highlights the following areas:

- **Type of learning tasks** – cognitive domain (including verbal information and intellectual skills), affective domain (with its associated values, beliefs, attitudes and emotions) and the psychomotor domain (including gross motor skills, fine motor skills, discrete motor skills and continuous motor tasks).
- **Mental operations required** – attention (focusing, expectations, reinforcement and guidance), retention (organisation, rehearsal for storage, retrieval for use) and transfer (lateral, vertical and creative problem solving thinking).
- **Subject matter domain** – basic skills (computing, critical thinking, reading, speaking, listening and writing), general cultural concerns (biological sciences, humanities, mathematics, physical sciences, social sciences) vocational and professional issues (interpersonal skills, leadership abilities, product knowledge, technical skills) and personal (avocational, interpersonal, self-help).

3. The environment

According to Richey (1990), the particular characteristics, constraints, and missions of our work places, as well as the particular needs of the student population, budgetary issues and time pressures, should be included in a comprehensive theory of ID. In this cluster she highlights the following areas:

- **Setting** – schools (pre-school, grades, higher education and vocational or trade orientated instruction), business and industry (manufacturing, services - both private and professional, trade and transport), health care (hospitals, clinics, private offices, health agencies), community (adult continuing education, social services, mass media organisations), government (military, local, provincial, national).
- **Climate** – external influences (such as economic, market potential, governmental influences, competition level, external image of the organisation), organisational climate (goals and values, size, reward system, support levels, leadership style, group code), physical materials and arrangements (resources, facilities, scheduling, instructional organisation), participants characteristics (teacher, student and interaction characteristics).

4. The delivery

ID "includes the development of specifications for delivery systems, which may be controlled by materials, or by an instructor. The actual process of implementing the delivery, however, is a facet of instruction, rather than instructional design" (ibid: 168). Richey summarises the delivery system into four key categories as follows:

- **Scope** – macrostructure and/or microstructure (programme, course, unit, workshop, lesson, single objective).
- **Strategy** – media (projected, non-projected, audio, video, computer or virtual reality three dimensional imagery) and process (mass, group, individualised or work embedded instruction).
- **Presentation** – tactics (secure attention and response, provide reinforcement, maintain interest, facilitate retention, assess performance).
- **Sequencing** – order (cyclical, hierarchical, external base) and schedule (as it refers to pacing, frequency and reinforcement patterns).

Adapted from Richey (1990: 131 – 165)

Richey's conceptual model is an example of both a systematic and systemic view of ID. Her model also highlights many of the areas that would need to be more fully identified and researched in the development of a theory of ID. Other models are not as thorough and could

be placed within sections of Richey's conceptual model. For instance Bloom's knowledge taxonomy could be analysed within the content section, whilst Gagné's instructional events fit in the delivery section, whilst some models are specifically orientated to the production of educational media, such as Cotton and Oliver's (Cotton and Oliver, 1993) flow chart model that will be discussed under the heading media production.

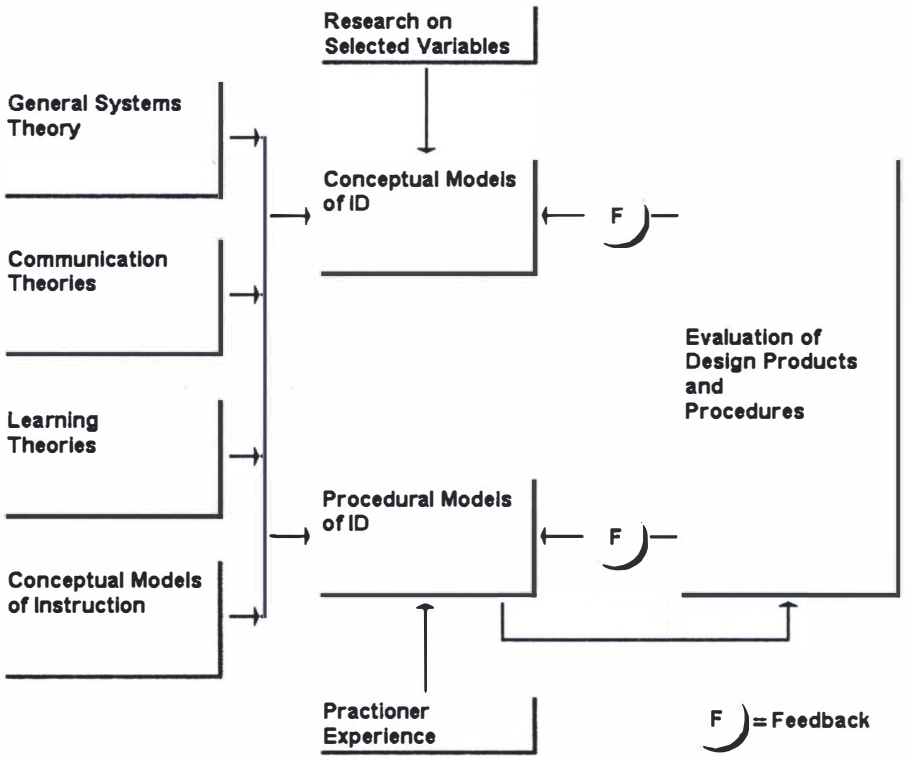
Towards a theory of instructional design

Wilson (1997: 23) highlights the differences between theorists and practitioners when he states "the theorist role is to reflect on problems, study and research questions, and share knowledge with the group. The practitioner role is to thoughtfully use knowledge toward the solution of problems. Both roles are essential to good practice and good theory".

The distinction between models and theories of ID appear blurred in the literature reviewed. There is an ongoing debate as to whether the models originate from, or contribute to, a theory of ID. For instance, Merrill, Drake, Lacy and Pratt (1996) claim there is a "scientific discipline" of ID that is being corrupted by "constructo-babble", whilst Dick argues that "the *instructional design process* ... is the theory" (Dick, 1997: 47, original italics).

Bannan-Ritland (1999) states that "focusing on shallow procedural processes rather than a thorough understanding of underlying theoretical constructs as vital to good design has been an apparent problem in many instructional design programs. ... often with the focus on media production as an end in and of itself". Similarly, Richey (1990) expresses concern about the 'status' of the theory of instructional design, which, in her analysis, is influenced by a number of separate theories such as general systems theories, communication theories, learning theories and by conceptual models of instruction. Figure 2.7 is a reproduction of Richey's diagram showing her interpretation of the status of the development of instructional design models and theories.

Figure 2.7
Richey's perception of the status of instructional design models and theories

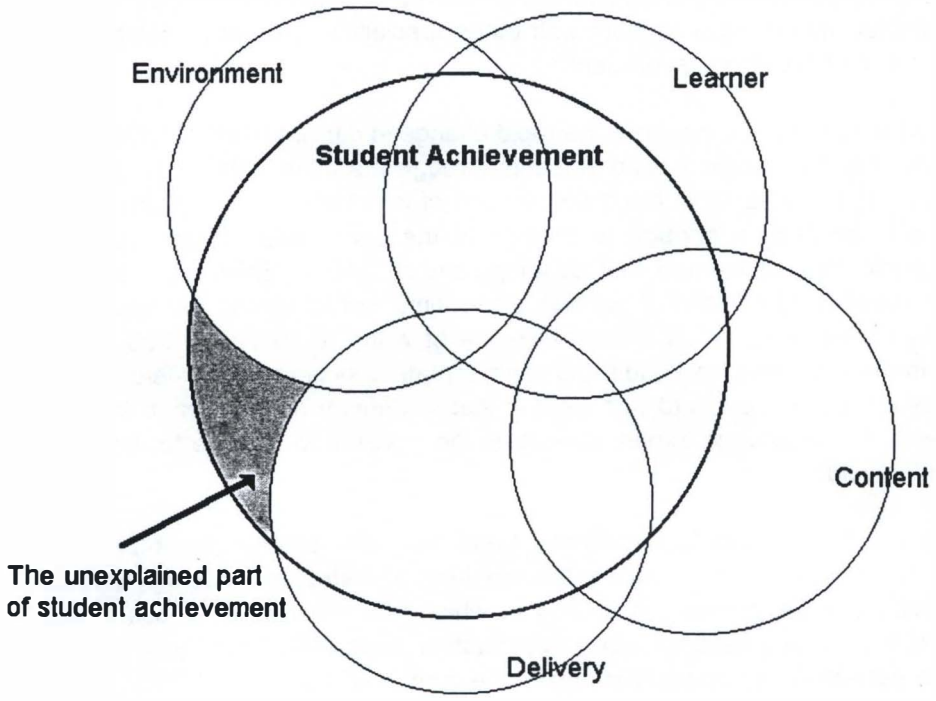


Richey (1990: 21)

In her analysis Richey (1990) highlights the difficulties in identifying a strict verifiable theoretical disciplined approach when she claims that there are a number of known variables such as learner, content, environment, and delivery, that make for successful instruction, but there is also an unknown element that is specifically involved with student achievement. This unexplained variable according to Richey could be the result of a number of factors such as measurement error, or the influence of an unknown, and possibly unrelated, variable. Laurillard (1993) also alludes to this issue when she states that although it important to base teaching strategies "on an understanding of learning, the relationship is fuzzy. The character of student learning is elusive, dependent on former experiences of the world and of education, and on the nature of the current teaching situation. What we learn from this will have an uncertain relation to what will happen in a new teaching situation." (ibid: 71).

Figure 2.8 summarises Richey's perception of the inter-relationship of the known and unknown variables that make for student achievement.

Figure 2.8
Richey's sample relationships among design variables and their relationship with student achievement.



Richey (1990: 134)

It appears that, for those who wish to redefine or eliminate the "art and craft" (Earl, 1987; Davies, 1991) in ID, more research is required to develop an understanding of the unexplained portions of instruction and learning, and where necessary employ the expertise of chaos theoreticians and critical analysis to develop a means of identifying the patterns of behaviour in a logical systemic manner.

Challenges of instructional design in university settings

All the models discussed above could inform the process of ID in an educational institution, whilst bearing in mind Reeves pragmatic paradigm in a real-world setting and lessons learnt from chaos theory. Unfortunately, according to Gros et al, "most multimedia and hypermedia systems are authored without the application of an ID model" (Gros et al, 1997: 48). One of the

major criticisms of the multi-million pound government funded 'teaching and learning technology programme' (TLT) in the United Kingdom was that "developers do not generally appreciate the necessity for instructional systems engineering (ISE) expertise" (Gilbert, 1999: 67). In Gilbert's view an even more damning indictment was that developers "*do not yet realise* that they do not have the necessary ISE expertise for TLT projects" (ibid: 78, original italics).

Wager (1993: 10) identifies four major pressures affecting ID that have direct implications for ID at tertiary educational institutions:

1. restructuring process in national public education;
2. pressure to make the design and development process faster and less expensive;
3. a switch to performance systems design; and
4. rapid changes in technologies.

The restructuring in education requires a systemic view of ID. Wager (ibid: 10) warns that "the educational system is a big bureaucracy, slow to change, with many vested interests. The technology for changing public education goes beyond the production of effective instructional materials. It must be shown that technology can not only do things better, but also do them cheaper, because the cost of the technology will have to be absorbed by the system".

Both Gilbert (1999) and Wager (1993) express concern that educators in universities and other educational institutions will have to work with other specialists in order to design instructional systems that are effective and cost efficient.

Another pressure not listed by Wager is the rapid change in current fields of knowledge and the need for humanistic fuzzy logic to lead students through the minefields of specific disciplines. Technology can certainly assist in the dissemination of information in an informed way but the systems need to be flexible enough to change at the same rate as the knowledge base. Laurillard is particularly concerned that development of CAE explicitly addresses academic learning as opposed to other types of learning. She claims that academic learning is "knowledge of descriptions of the world rather than knowledge of world" (Laurillard, 1993: 58) and as a result students need to learn to handle the representation system of the field as well as the ideas that they represent. Laurillard's concern is that students require a constructive dialectical relationship with the knowledge expert as well as the material to be able to develop a sound knowledge of the field.

In addition to this Dick states "a detrimental trend that may emerge among programs with limited numbers of faculty is to combine the teaching of instructional design and computer-based instruction. Typically, this is a course in which learners design a lesson that will be delivered via computer. A potential concern with such courses is that the design gets lost in the effort to simply get something up and running on the computer" (Dick, 1996: 59).

2.3.5 Instructional strategies

"How the information or skills will be taught is spelled out in an instructional strategy" (Dick, 1993: 12). Much of the literature reviewed for ID includes instructional strategies as part and parcel of the design process. Gustafson (1993) cautions his readers by stating "ID and ISD should not be confused with instructional strategies or models". ID should inform the process of instructional strategy selection only after a thorough needs analysis has identified the type of instruction best suited to the needs of the knowledge base, students and economic constraints, or following Willis's R2D2 model it should be developed in line with the design and development focus.

With this in mind, this section will look at some of the instructional strategies that are relevant to the teaching at the University of Natal's Medical School and are of particular importance to CAE developers at that institution. However, it is relevant at this stage to point out that "the transfer of

pedagogy from traditional to electronic or computer classrooms requires complex adjustments and substantial rethinking of the ways in which classroom time is spent" (Sullivan, 1994: 59). Traditionally computer delivered "educational software was developed to facilitate individual learning" (ibid: 65), and it "lock[s] in the assumptions, presuppositions, goals, biases, and limitations of those who program them" (Bruffee, 1993: 101). Bruffee (ibid) states that genuine interactions delivered by computers are deliberate and laborious and warns that changes to instructional computer programs take so much time that users' needs often outpace the development.

South African university educators use a number of instructional strategies to meet their teaching responsibilities. Some do this by default using methods that they experienced when learning their discipline, others are exploring new methods to meet the challenges of a changing environment (Laurillard, 1993). This section explores some of the new and old instructional strategies and looks at problem based learning in particular as it informs medical education world-wide and at the University of Natal's Medical School in particular.

Gagnè's instructional events

One of the most commonly discussed instructional strategies (often discussed as a model of ID) is that defined by Gagné as 'instructional events'. He highlights a number of issues that appear to be obvious when reviewed, but are often ignored by educators unversed in instructional issues, and states that the order in which these events are presented is variable and not all of them are invariably used (Gagné & Briggs, 1979). Instructional events are listed as:

- gaining attention;
- informing the learner of the objective;
- stimulating recall of prerequisite material;
- presenting the stimulus material;
- providing learning guidance;
- eliciting the performance;
- providing the feedback about performance correctness;
- assessing the performance; and
- enhancing retention and transfer.

(Gagné & Briggs, 1979: 170)

Gagné and Briggs take an instructivist approach to teaching and education, but a constructivist could still be guided by the procedures mentioned. For instance an instructivist is likely to inform the learning of predefined objectives, whilst a constructivist is likely to negotiate the learning objective with the participants. The manner in which specific events are used, devised, and implemented will reflect on the educational approach preferred by the educator. These instructional events can be used in the development of courseware using a number of different strategies.

Mastery learning

Mastery learning takes its early premise from work done by Carleton Washburne and his associates in 1922 and Henry C. Morrison in 1926 (Block, 1971). This work defined mastery in terms of particular educational objectives that each student was expected to achieve, and could include cognitive, affective, and psychomotor skills. Typically mastery courses were developed by breaking down complex tasks into subordinate prerequisite units that were perceived to be prior knowledge necessary for the successful mastery of the whole objective. Each unit consisted of a collection of learning materials systematically arranged to teach the desired objectives. Complete mastery of each unit was required before students were allowed to proceed to the next. Diagnostic-progress tests were administered at the completion of each unit to provide feedback on the adequacy of the students learning, mastery allowing the student to progress, lack of mastery pointing the students to remedial material. Mastery learning was seen

to be self-paced and students were usually permitted variable times for completion of the instructional objectives.

These earlier experiments were refined by John B. Carroll (Block, 1971; Joyce and Weil, 1980) who argued that a students aptitude predicted not only the level to which the student learnt a given task in a given time, but also the amount of time the student would require to learn to a given level. He thus defined aptitude as measuring the amount of time required to learn a task to a given criterion level under ideal instructional conditions. He argued that all people were capable of mastering subject material given sufficient time according to their aptitude. The model Carroll proposed consisted of a series of distinct learning tasks in which the student proceeded from ignorance to knowledge, from the inability to perform a task to the capability of performing it. (Block, 1971: 5).

Bloom modified this proposal into a "working model for mastery learning" (ibid: 6). Mastery was defined in terms of a specific set of major objectives (content and cognitive behaviours) that the student was expected to exhibit on completion of the subject. The subject was then broken into a number of smaller learning units and the unit objectives were defined whose mastery was essential for mastery of the major objectives. The instructor taught each unit using typical group-based methods, but supplemented this with simple feedback/correction procedures to ensure that each student's unit instruction was of optimal quality. Feedback usually took the form of brief, diagnostic (formative) tests administered at the units' completion. Each test covered all of a particular unit's objectives and thus indicated what each student had or had not learned from the unit's group-based instruction. Supplementary instructional correctives were then applied to help the student overcome any unit learning problems before the group instruction continued (ibid).

Joyce & Weil (1980) suggest that the development of self-administering multimedia units and the application of programmed learning procedures, has encouraged curriculum developers to invent comprehensive curricular systems and to reorganise schools to provide for a much greater degree of individualised instruction. Certainly early CAL programmes focused much attention on the delivery of mastery units in the form of drill and practice exercises.

Arnold (1996) states that criticism of this model includes the fact that some researchers say there is no evidence to prove that:

- a logical hierarchical structure of skills and behaviours exists;
- students gain a holistic understanding of the knowledge;
- there is any transference of skills gained;

and worse still, that:

- not only does transference not take place, but students develop a mechanistic view of the subject material

(Arnold, 1996)

Slavin argues that the basic premise of mastery learning – that all students can learn to the same level but will take different amounts of time to do so – is "tautological" (Slavin, 1987: 177), but he takes issue with the assumption that the remedial time required to bring all students to an equal understanding of the subject matter is immaterial. His argument is that if faster students cannot progress until their slower counterparts have caught up they are held back in their learning, and it is exceptionally costly for extra lessons to be conducted outside of normal class times. Arlin (cited by Slavin, 1987) points out that it is a fallacy to believe that once the basic misconceptions are addressed the need for corrective instruction diminishes.

Outcomes based education

"Outcomes-based education (OBE) specifies the 'outcomes' students should be able to demonstrate upon leaving the system. These outcomes are derived from a community vision of

the skills and knowledge students need to be effective adults" (McNeir, 1999), which are represented in South Africa as citizens who are able to:

- participate effectively in a rapidly changing world of work in an increasingly global economy;
- actively build and sustain a dynamic, creative and culturally diverse society based on principles of individual freedom, tolerance, caring and democratic participation.

(Juta, 2001)

"Outcomes are the end goals of learning, they are the things that learners can DO. They are not lists of subject matter or content that have to be memorised. For a learner to achieve an outcome they (sic) need to develop:

- relevant knowledge;
- skills to acquire and apply that knowledge to solve problems;
- the values and attitudes to perform effectively and responsibly".

(Juta, 2001: original emphasis)

The Spady model described by McNeir (1999) closely resembles the definition of mastery education described above. According to McNeir, Spady's model suggests schools "generate 'exit outcomes' based on the challenges and opportunities that students will face after graduation and then to 'design down' "(ibid). Central to this model is the concept that students should be awarded "expanded opportunity and instructional support. Students are given more time if needed to master material, and they are offered second chances or given a grade of Incomplete (*sic*) until they succeed. Teachers use 'coaching' as well as grouping and team teaching to provide additional assistance" (ibid).

Criticisms of OBE generally focus on concerns of the definition of 'outcomes' which typically concern values, attitudes, opinions and relationships rather than objective information, and that OBE's goals are affective rather than academic (Schlafly cited by McNeir, 1999). McKennan (cited by McNeir, 1999) argues that "predicted outcomes are antithetical to the very nature of education", which he considers to be explorative, unpredictable, and valuable for its own sake.

Lack of comprehensive research into OBE (McNeir, 1999 and Slavin, 1994) makes it difficult to verify or contradict arguments for or against the system, with Slavin pointing out his critique of mastery learning is not to be interpreted as a critique of OBE. However, Harber (2001) cites Jonathen Jansen of the Macro-Education Policy Unit as saying that if OBE is to succeed "even in moderate terms, a number of independent education innovations are needed simultaneously" amongst which he lists:

- trained and retrained teachers;
- radically new forms of assessment;
- classroom organisation which facilitates monitoring and assessment;
- additional time for managing this complex process;
- constant monitoring and evaluation of the implementation process;
- retrained education managers or principals to secure the implementation as required;
- new forms of learning resources (textbooks and other aides) consonant with an OBE orientation;
- opportunities for teacher dialogue an[d] exchange as they co-learn the process of implementation.

(Jansen cited by Harber, 2001)

The challenge of OBE focused educational practice is to ensure that students master those outcomes, and to evaluate both the students' and the system's success.

Collaborative learning

Collaborative learning takes its premises from the Vygotskian theory of the social constructs of knowledge, that "learning is a naturally social act in which the participants talk among themselves" (Gerlach, 1994: 8), and that group activities draw on Vygotsky's ZPD theory to enhance learning to the benefit of all group participants (Bruffee, 1993). According to Smith and MacGregor (cited by Gerlach, 1994) collaborative learning is:

5. "an active, constructive process in which students integrate new material with prior knowledge to create new ideas and new meaning";
6. "learning depends on rich contexts that ask students to collaborate with peers to identify and solve problems by engaging in higher-order reasoning and problem-solving skills";
7. "learners are diverse and have different backgrounds and experiences. The various perspectives that emerge during collaborative work clarify and illuminate learning for all involved – the student, the members of the collaborative group, and the teacher";
8. "learning is a social act in which students talk to learn. This social interaction often improves the participants' understanding of the topic under consideration";
9. "learning has affective and subjective dimensions. Collaborative activities are both socially and emotionally demanding and most often require students not only to articulate their own points of view but also to listen to the views of others. Students realize that they can work with others to create knowledge and meaning. They no longer have to rely solely on the teacher and the textbook".

(Gerlach, 1994: 8-9)

Most authors take collaborative learning to be indicative of a constructivist approach to education, but this can be misleading. Hamilton (1994) cites Trimbur as categorising collaborative approaches into three broad models; the "post industrialist model", the "social constructionist model", and the "popular democratic model". Hamilton describes these models as follows:

The post industrialist model
Collaboration takes "the form of group efforts to solve common problems formulated by an instructor whose curricular agenda determines group structure, time on tasks, goals, and anticipated answers" (ibid: 94). Hamilton goes on to say that groups are often set up in competition with one another and the pedagogical approach is based upon "cognitive based concept of teaching such as mastery learning and effective instruction, in which the individual mastery of curricular content is the ultimate goal of classroom activity" (ibid: 94).

The social constructionist model
Hamilton (ibid: 95) states that in this model of collaborative learning "students in a particular discipline work together to solve common problems through the collective understanding of all, including the instructor". Instructors and students share many of the decisions relating to content and learning procedures. They "work [together] at discipline specific problems, issues, and application of concepts, exploring the course and constructing meaning about the discipline" (ibid: 95).

The popular democratic model
Hamilton (ibid: 95) distinguishes between the social constructionist model and the popular democratic model by stating that where the former emphasises similarities within a group, the latter highlights and draws upon differences. For Hamilton (ibid) it "presents in essence a pedagogical imperative for the multi-cultural, multilingual, polyglot classrooms of the urban university of the twenty first century. ... The challenge is for instructors not to obliterate essential differences in the search for commonalities but rather to envision these essential differences — age, race, color, economic status, background, motivation, or prior knowledge — as catalysts for the making of meaning within the specific concepts of the particular course" (ibid: 95-96)

Although many authors have reported successes with the use of collaborative learning (for instance Emerson, Phillips, Hunt and Alexander (1994); Bruffee (1993)), there are general concerns that are reflected across the literature. The most commonly reported being resistance from the students, whereby "too many students resist this non-traditional approach. These students do not know how to talk collectively, offer no suggestions, are not honest with each other, and are afraid of hurting each other's feelings" (Emerson et al, 1994: 88). In some cases this method is met with suspicion whereby "most college and university students are confirmed in the habit of identifying the authority of knowledge in a classroom exclusively with the teacher's authority. As a result, they often do not believe that a request to collaborate is genuine, and they do not always know what might be in it for them if they did collaborate" (Bruffee, 1993: 27). The question of 'authority of knowledge' expressed by Bruffee (ibid) challenges both teachers and educational administrators alike, "changing college and university teaching depends on changing teachers' understanding of what knowledge is" (ibid: 3). In his view "collaborative learning brings to the surface the relationship between the authority of knowledge and the authority of teachers" (ibid: 7). "Traditionally, after all, collaboration skates dangerously close to the supreme academic sin, plagiarism" (ibid: 27).

Traditional early CAE programmes were developed for highly instructivists modes of education, including self-paced, mastery-levelled instruction. Bruffee (ibid: 101) states that "television and computer programs lock in the assumptions, presuppositions, goals, biases, and limitations of those who programme them, genuine interaction with both is deliberate and laborious" and continues by warning that changes to instructional computer programmes take so much time that users needs have often outpaced the development.

Bruffee maintains that computer programs can be used to enhance collaborative learning if:

1. "learning tasks [are designed] to be undertaken collaboratively and directed toward achieving consensus";
2. "programs [are designed in such a way] that [they] help students learn the social conventions of working successfully in small, semiautonomous groups"; and
3. "[the] programs ... supply the information, assumptions, tasks, and evaluative criteria that guide collaborative work constructively and help people learn from each other".

(Bruffee, 1993: 106)

With the increasingly common use of networked technology in education, it becomes far more feasible to address both the issues of programming time and collaboration. Bulletin boards and learner authored web pages offer an ideal opportunity to explore asynchronous collaborative learning.

Bruffee (ibid) sees the following as the major advantages of CAE delivered collaborative learning tasks:

1. "each person's existing skill and knowledge, brought out and guided by focused conversation";
2. "the willingness of group members to submit their presuppositions and biases ... to the examination and influence of peers";
3. "the experience of guiding, teaching, and influencing peers";
4. "the confidence gained as each member of the community, with the support of other members, experiences and survives the risk-taking transitions involved in learning"; and
5. "the stress each group member experiences under the pressure of having to evaluate the work of other members of the group".

(Bruffee, 1993: 108)

Situated learning

The concept of situated learning is credited to Suchman, Lave, and Shoenfeld who argued that "knowledge is situated and is partly a product of the activity, context, and culture in which it is

used." (McLellan, 1993a: 5). "Knowledge is co-produced by the learner and the situation; [thus] engagement of the learner in the situation is critical" (Damarin, 1993: 27).

According to Winn, (1993) situated learning takes place "when students work on 'authentic tasks' whose execution takes place in a 'real world' setting" (ibid: 16). Situated learning typically takes place in apprenticeship learning situations, although this definition can be extended to include immersion strategies and action learning (Bannan-Ritland, 1999).

> "in the real world, people do not solve problems by the logical application of decontextualized knowledge ... Rather, they reason with what a situation affords them in order to solve the problems that occur there.. And they reason in ways that often appear intuitive, alogical, or 'plausible'."
>
> *(Winn, 1993: 16)*

For Winn there are two routes to situated knowledge; the first is the teaching of general skills at a level that allows for generality and application to multiple settings, and secondly to teach knowledge and skills in the situation where the knowledge is to be used.

Hey (1993) warns of the dangers inherent in situated learning, typically in apprenticeship learning, whereby

> "apprenticeships, as well as communities of practice, can be sectarian, dictatorial, controlling, divisive, exploitative, cliquish etc. The community can sometimes leave students with a binary choice of in or out; and, once in the community the divisive community can leave students with little opportunity to escape. We need not think of only the divisive communities whose practice encompass hatred, such as the KKK, youth gangs or the skinheads; but any community of practice where students do not have the ability to break out and redescribe themselves and their community".
>
> *(Hey, 1993: 34)*

He goes on to say that:

> "Students have no 'space' to create knowledge within the community of practice until they reach a certain station in relationship to the center of the community — by which time, most newcomers are transformed into old-timers. Then they are so vested into and implicated by the community of practice that to think certain thoughts would undermine their position in the community, as well as the community itself".
>
> *(Hey, 1993: 35)*

Damarin (1993) points out that various people, especially marginalized people, have different experiences of the world and situations. The learning that takes place in the same situations by these people can have vastly different outcomes and interpretations. The challenge for the proponent of situated learning is to give equal credence to the learning and knowledge of these people, and recognise that they 'travel' between different worlds;

> "we must recognize in practice the adeptness with which all students shift among knowledge communities of home, school, and other social settings, among social subgroups within each of these, and among school situations as different as standardized test-taking and playground recess. For students of color, and any students whose life situations entail 'travel' from and to situations which are linguistically, psychologically, racially, culturally, or otherwise distant from the situations of schooling, we should explicitly make visible and attach

> such positive value to ability to shift among situations which are more numerous, more diverse, and more complex than those available to or required of students whose lives are most similar to the situations inherent or described in schooling"
>
> *(Damarin, 1993: 30)*

Winn argues that "instructional design and implementation, traditionally separate, need be reunited so that the technologies of instructional design — analysis, strategy selection, and evaluation of strategy effectiveness — can be applied in real time" (Winn, 1993: 17).

To avoid the pitfalls of situated learning genuine collaborative learning methods can be employed to "help students go beyond their experience, to use it and reflect on it, and thereby change their perspective on it, and therefore change the way they experience the world" (Laurillard, 1993: 26). There need not be a division between theory and practice but students should articulate and critique the underlying theory that leads to the action (Maddux, 1989).

This gives rise to the question of how situated learning should be assessed? "Evaluation in a situated learning context is based on a dynamic, continuous, over-emerging assessment of the learning process, the learner's progress, the instructional strategies deployed, and the learning environment" (McLellan, 1993b: 39). Collins (cited by McLellan, 1993b) suggests that assessment should be based on "*accomplishments* rather than *aptitude*" (original emphasis). McLellan suggests that assessments could be amongst others based on:

- portfolios — where learner created products reflect the process of learning and development over time;
- summary statistics — showing patterns and trends in the learner's development;
- diagnosis — analysis of learners progress based on portfolios, summary statistics and teacher's continuous assessment of learner's progress and capabilities;
- reflection and self-assessment — including debriefings, video or audio replays, abstract replays, dramatisations, interviews, portfolio critiques, group discussions, knowledge telling, co-investigation, and post-mortems of problem solving episodes;
- learners as designers of instruction — such as videos and computer programs, the success of the product with other learners can be assessed as well as the product itself and the process of creation.

(McLellan, 1993b)

Problem based learning

Problem based learning is a system designed to develop problem solving strategies, disciplinary knowledge bases and relative skills in learners. Students are confronted with an ill-structured problem similar to a real-life problem. The tasks that they encounter in solving the problem include:

- "determining whether a problem exists;
- creating an exact statement of the problem;
- identifying information needed to understand the problem;
- generating possible solutions;
- analysing the solutions; and
- presenting the solution, orally and/or in writing".

(Classroom of the future, 2001)

In the 1960s McMaster Medical School introduced a learning environment that combined "small group, cooperative, self-directed, interdependent, self-assessed PBL", and it was found to be highly successful (McMaster, 2000). Shanley and Kelly (1999) argue that PBL is relevant for medical and dental teaching as the traditional curricula:

- frequently lacks a coherent educational philosophy;

- is directed towards the memorising of facts and gaining of technical skills without sufficient concern for understanding clinical reasoning;
- evaluation procedures promote encourage rote learning and discourage independent thought and innovation;
- requires students to learn excessive irrelevant details;
- encourages the dominance of the teachers' philosophies over those of the students;
- usually has molecular biological principles taught and learned in isolation and older disciples such as anatomy, physiology and biochemistry are emphasized over other disciplines;
- has insufficient emphasis on non-cognitive attributes such as patient/practitioner interactions, communications, personal characteristics and management skills;
- lacks integration between departments and encourages fragmentation of the whole education process;
- excessive emphasis on secondary and tertiary care and lack of emphasis on interventions and promotion of health issues;
- lack of awareness generated in students of priorities in health care, the economic issues and how to control the major causes of mortality and morbidity in different communities;
- on graduation students are not versed and experienced enough to carry out independent practice.

Programmes that use PBL typically have procedures that include:

- small group learning;
- a trained faculty tutor/facilitator who may or may not be a subject expert in the field;
- carefully designed problems that will require the students to develop new knowledge to solve the problem;
- fact gathering interview sessions with either patients (or actor stand-ins) or communities that are trying to deal with the problem;
- a number of different resources for the study of issues raised in the problem solving exercise;
- self and group evaluation of each member on curriculum goals with input by peers and the tutor.

The Illinois University School of Medicine (1999) outlines a number of advantages in the use of PBL over traditional methods, these include:

- development of an effective and efficient reasoning process in the students;
- increased retention of data;
- integration of knowledge across disciplines;
- ability to continue investigative work after formal training is completed, leading to life-long learning habits in their graduates;
- increased and early clinical experience;
- increased student faculty interaction; and
- it is highly motivating for the students.

However, no new innovation is problem free and the disadvantages of PBL can be difficult to overcome. Shanley & Kelly (1999) and the San Diego State University (1996) outline the disadvantages as:

- students may not score as high on standardized tests, although generally PBL favours long term retention;
- extensive time demands on faculty for assessment and preparation of material;
- students coming from an instructivist background have difficulties with self-directed learning, and are unclear about their role as students;
- faculty need to move away from the traditional lecture/tutorial, 'dispenser of knowledge' role usually associated with traditional teaching and develop facilitatory skills and they have little experience in this activity;

- generating the appropriate problems and questions to ensure that all the important subject matter is studied is difficult, time-consuming and needs to work across traditional disciplinary divisions;
- The scientific evidence in support of PBL is not strong and may be viewed as insufficient to justify the inconvenience of changing to different system;
- PBL requires different and probably more physical teaching resources because it is based on small groups and because of its logical assessment methods.

Assessment of PBL learners at the Illionis University Medical School (1999) takes the form of:

- informal tutor group assessments — where students conduct self-assessments of their performance, the group and tutor assess the individual student's performance with a view to identification of individual strengths and weaknesses;
- Performance based assessment — where the students are evaluated in terms of their progress toward curricular goals, in order to give the student feedback regarding his/her progress; and
- End of unit assessment — which may take the form of written or oral examinations, standardized patient interactions including case write-up scenarios as well as clinical reasoning.

According to Albion (1998) PBL usually involves students working in small groups whilst interactive multimedia tends to be used by individuals. Matching the two is difficult, but he argues that interactive multimedia can play an important role in PBL in that it has a great potential for pictorial richness and accurate portrayal, it offers access to a large collection of resources which can be carefully indexed for easy retrieval, and it should include context relevant help files and easy forward and back navigation (ibid). These are of particular importance when developing resources for material with a great deal of factual content.

Computer mediated communication

The advent of the Internet and relatively cheap accessibility has opened the door to a myriad of new opportunities in CAE. Using the computer networks as a means of communication has changed the focus of much research from intelligent tutoring systems to interactive and/or collaborative learning support systems (Reeves, 1998). Paulsen (2000) defines computer mediated communication (CMC) as "Transmission and reception of messages using computers as input, storage, output, and routing devices. CMC includes information retrieval, electronic mail, bulletin boards, and computer conferencing".

According to Paulsen (ibid) CMC can be grouped according to a framework outlined by the following:

- one-alone techniques — that use resources such as information retrieval from on-line databases and journals, online software libraries, access to subject experts for interviews which all require "minimal interactive participation by the teacher" (ibid);
- one to one techniques — include learning contracts, apprenticeships, internships, and correspondence studies as well as peer collaboration when they are facilitated by e-mail communications;
- one to many techniques — including presentations to students by one or more individual experts or by interacting experts where students have read only access to their communications, as well as techniques that include lectures, symposiums and skits; and
- many to many techniques — where all participants take part in the interactions in open or closed computer conferences, e.g. debates, simulations, role-play scenarios, case studies, discussion groups, transcript based assignments, brainstorming, questionnaires with opinion feedback, group work, forum and project groups.

Boyd (1991) sees CMC as a potentially liberating technology that can, with careful moderation, free discussion from the bonds of face-to-face communication. He suggests that face-to-face communication is disadvantaged by:

- the difficulty in giving each participant a "full and equal chance to contribute, and to digest the contribution of others" (ibid: 85), and
- "unfair dominative speech acts cannot be ruled out of order until they have taken place" (ibid: 85) and the damage is done.

Hiltz & Wellman echo this when they state that "because CMC has less social presence than face-to-face communication, online communications are often more uninhibited, creative and blunt" (Hiltz & Wellman, 1997: 49). They warn that "beyond a certain size, the amount of material generated in the class leads to information overload, and the number of people involved gets too high to foster a sense of community" (ibid: 48). They go on to predict that "Loyalties to a few local communities of, say residence and work, are likely to weaken, whole ties to geographically dispersed 'communities of interest' will strengthen. The end results are part of the continuing social transformation toward a global connectivity" (ibid, 1997: 49).

2.4 Media production

This section deals with the development of computer delivered media, although some of the design procedures and principles may be relevant to the production of other types of media. Media production only begins if the needs analysis discussed under the heading instructional design suggests a need for CAE media production. In other words the instructional designer must be clear that the use of computer delivered or mediated material can enhance the learning process, and that there is no existing package that will already cater for this need.

2.4.1 Delivery technology

The first step of media production is to choose or specify the delivery platform. Whatever the decision made at this level will affect the choice of authoring system, and some aspects of the human computer interface (HCI).

The decisions surrounding the delivery system include a choice of:

- the hardware platform – Macintosh or PCs; and
- the operating system e.g. DOS or Windows, Unix etc.

In the introduction to his book Vaughan (1994: xxv), states "in a few years, multimedia computers will be an anachronism". This has certainly come to pass. Apple's Macintosh computers were developed from inception to be a multimedia computer (ibid) and many developers for CAE material have used them. However, Apple adhered to the call for sanctions against South Africa in the 1980s and as a result it was illegal to sell Macintosh computers in this country. Those that were brought in were extremely expensive, and as a result educational institutions that invested in computer equipment and infrastructure during the 1980s invested in the PC platform. It is still unusual to see a modern Macintosh computer in educational institutions in South Africa.

The other common platform, the PC, is now usually sold as a fully operational multimedia system, which means that it is no longer necessary to check compatibility and graphic capabilities. However, the systems should have adequate RAM and processing power to ensure the smooth and efficient running of the memory hungry multimedia compression systems particularly of sound and video, especially when compounded by the use of operating systems such as Windows NT™. Not all institutionally owned machines are purchased with CD ROM drives and this may limit the choice of delivery mechanisms. If the product is to be delivered to a variety of platforms there are some authoring systems that allow for cross platform compatibility or dual development.

The other issue that needs to be addressed is if the program should be delivered on a stand alone PC or in a networked environment, and if so will the delivery take place over a local area network, wide area network, or the Internet. The compression modes for large media files such as video and sound are of particular interest to developers of programs that are to be delivered over the Internet. Technology for all these platforms changes at such a rapid rate that valid recommendations are likely to be out of date within a couple of years, and the process of decision making should be revised with each development and sometimes even in revisions of current developments.

2.4.2 Development systems

Programs developed for multimedia interactive resources are usually developed using computer programming languages or tools specifically designed for this purpose. According to Strauss the choice of a development tool will have a major impact on the timely development, feature selection, and maintenance of the program (Strauss, 1995). These he claims fall into two camps: authoring systems or programming languages.

Programming languages are used by computer programmers to custom develop applications. To create a multimedia title using a programming language involves the writing of code, which is then subsequently compiled into executable files (ibid). Compiled programs generally run much faster than authoring systems, and the power of the language allows the developer a significantly larger flexibility than is available to users of authoring systems. Although there are many competent programmers available the skills required are different to those of 'authors', and this will have direct impact on the multimedia development team (ibid). Programming languages typically have dependable bug free languages, so bugs that do evident themselves in the final product can be fixed by an adequate programmer (ibid), however, prototyping can be time consuming and formative evaluation expensive.

Authoring systems allow a developer to assemble multimedia elements into "a playback sequence and provide a structured method or language for responding to user input" (Vaughan, 1994: 148). According to Siglar, "authoring systems vary widely in orientation, capabilities, and learning curve" (Siglar, 1999). He states that although users of authoring systems do not need to know the intricacies of a programming language they do need to understand how programs work. The strength of authoring tools is in the accelerated prototyping facilities that can reduce the development time considerably (ibid). Strauss maintains "in general applications that have unique features, especially consumer titles, tend to be developed with programming languages. In-house training and educational applications, prototypes, museum displays, kiosks, and presentations tend to be developed with authoring systems" (Strauss, 1995).

Authoring systems are usually categorised by their metaphor. There are a variety of paradigms some of which are described below.

Scripting	the closest to traditional forms of programming, but the language is interpreted, not compiled, so the runtime gains over other authoring methods are minimal (Siglar, 1999). Javascript is the most commonly used scripting method for web pages, but the TenCORE[1] Language Authoring system was often used by universities porting PLATO™ systems to PCs in the late 1980s and early 1990s (Price and Murrell, 1990).
Iconic/flow chart	multimedia elements and interaction cues are organised as objects in a structural framework or process. These system typically display flow

[1] TenCORE - Computer teaching corporation

	diagrams of activities along branching paths (Vaughan, 1994). Authorware[2] is a typical example of this paradigm.
Frame	is similar to the iconic/flow chart authoring style, but the links between icons are conceptual and do not always represent the actual flow of the program (Siglar, 1999) Quest[3] and TenCORE Producer are typical examples.
Card or page based	where the multimedia elements are organised as pages of a book or a stack of cards. These are useful for hypertext applications, and an example of this type of program is Toolbook[4].
Time based	elements and events are organised along a time line, and are most useful when the system will have sequentially organised messages with a beginning, middle, and end. The more powerful time-based systems allow program triggers to jump to any location in the sequence thereby adding navigational controls into the program. Some of these systems use 'tracks' similar to a video or music score and 'cast' members as their metaphor, which allows each member of the cast their own script. Macromedia's Director uses both aspects of this metaphor.
Hypermedia linkage	is similar to the frame paradigm in that it shows conceptual links between elements but it lacks the visual linkage metaphor (ibid). A program such as Guide[5] would fall into this paradigm.
Tagging	typically uses tags in text files to link pages, provide interactivity and integrate multimedia elements in a system. This method is typical in HTML type documents.

Authoring systems have some distinct advantages especially as they tend to be quicker and easier to learn, with easy interfaces and built-in features that offer quick and easy prototyping of applications which allows for greater flexibility in formative evaluations (Strauss, 1995). However, they tend to have slower execution than compiled programs requiring runtime versions of the authoring system to be loaded on the delivery machine. This can increase the cost of delivery and creates a dependency on the company that produces the authoring system. However, as authoring systems are themselves programs they are not immune to bugs, and upgrades that fix these bugs can be expensive, or the developer needs to work around the bugs that can compromise the final product. Upgrades to authoring systems tend to lag behind developments in computer technology, which may mean that new developments and additions have to wait for the systems upgrade.

The choice of authoring system should be advised by the delivery platform, the built-in instructional tools and features, tools available to the students, administrator tools, delivery rights, software costs, hardware costs, technical support available from both the suppliers and in-house technical staff, and ease of use. A decision matrix such as that offered by Marshall University's Center for Instructional Technology (2000) for the evaluation of on-line authoring tools can assist in the decision making task. Figure 2.9 is an adaptation from this matrix to accommodate the needs of LAN delivered educational software, but many of the features now commonly available in web based authoring systems are included as they can lead to significant enhancement of the educational quality of the material developed.

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[2] Macromedia product - also known as Authorware Attain
[3] Quest is a product of Allen Communications
[4] Asymetrix
[5] OWL International

Figure 2.9
Authoring system decision matrix

Features	Authoring system		
	1	2	3
Developmental features			
System allows for cross platform delivery			
System allows for Internet delivery if required			
Platform uses open data standards so existing database resources can be used.			
Content can be authored on PCs running Windows 95/98/NT			
Courses can be delivered on PCs running Windows 95/98/NT			
Multiple choice, true/false, and matching questions can be created and scored by the system			
Short answer questions can be created and scored by the system			
Essay questions can be created and stored for later marking by the system			
System allows for customised feedback to questions			
System supports question databases for management of test questions			
System allows for the generation of random questions from a databank of questions			
Platform supports student and staff communication and threaded discussions			
Vendor provides development services			
Management component will create reports for tracking student use of the system and progress reflected by responses to online tests			
Instructional features			
Allows for consistent interface development			
Training is provided for development staff and instructors			
Allows for student access to external data sources and library databases			
Supports various media formats and allows user interaction with these media.			
Students have immediate feedback on interactions and can track their progress throughout the course. Allows comparison of marks			
Online help is available to students			
Allows students to manage bookmarks as well as to take and print notes			
Permits student to submit files for collaborative learning and marking			
Student manipulated glossary and indexing features			
Search tool			
An area for student presentations			
Development and delivery costs			
Hardware costs			
Software costs			
Runtime costs			
Need for specialist programmers			

Adapted from Strauss (1995)

In the event of two authoring systems showing similar results, the various variables can be weighted to help in the decision making process. However, Strauss recommends "it is worthwhile to consider tools that exceed the initial program design. Software applications have a way of accumulating new features and functions as they develop" (ibid).

Another cautionary note sounded in the literature is that many authoring systems impose a format or predefined metaphor on the design, for example earlier versions of Toolbook™ imposed a book metaphor on the design of the finished product. Developers should ensure that this is suitable for their end product or choose a more versatile authoring system.

2.4.3 Media production

The development procedures required for CAE closely resemble the instructional design procedures discussed earlier. The authoring systems available have greatly enhanced the viability of prototyping and thus allow a more cost effective formative evaluation and revision process. Vaughan (1994) divides the production process into four stages:

1. Planning, which starts with the idea and a need, as outlined in this dissertation under the heading of instructional design. However, at this point the developers need to identify the text, graphics, music, video and other expertise that will be required to create the finished product. Vaughan maintains that interface design activities should take place during this process, as it is necessary to "develop a creative graphic look and feel, as well as a structure and navigation system that will let the viewer visit the messages and content" (ibid: 24).

2. Designing, which is summarised by Vaughan into the one line: "perform each of the planned tasks to create a finished product" (ibid: 24).

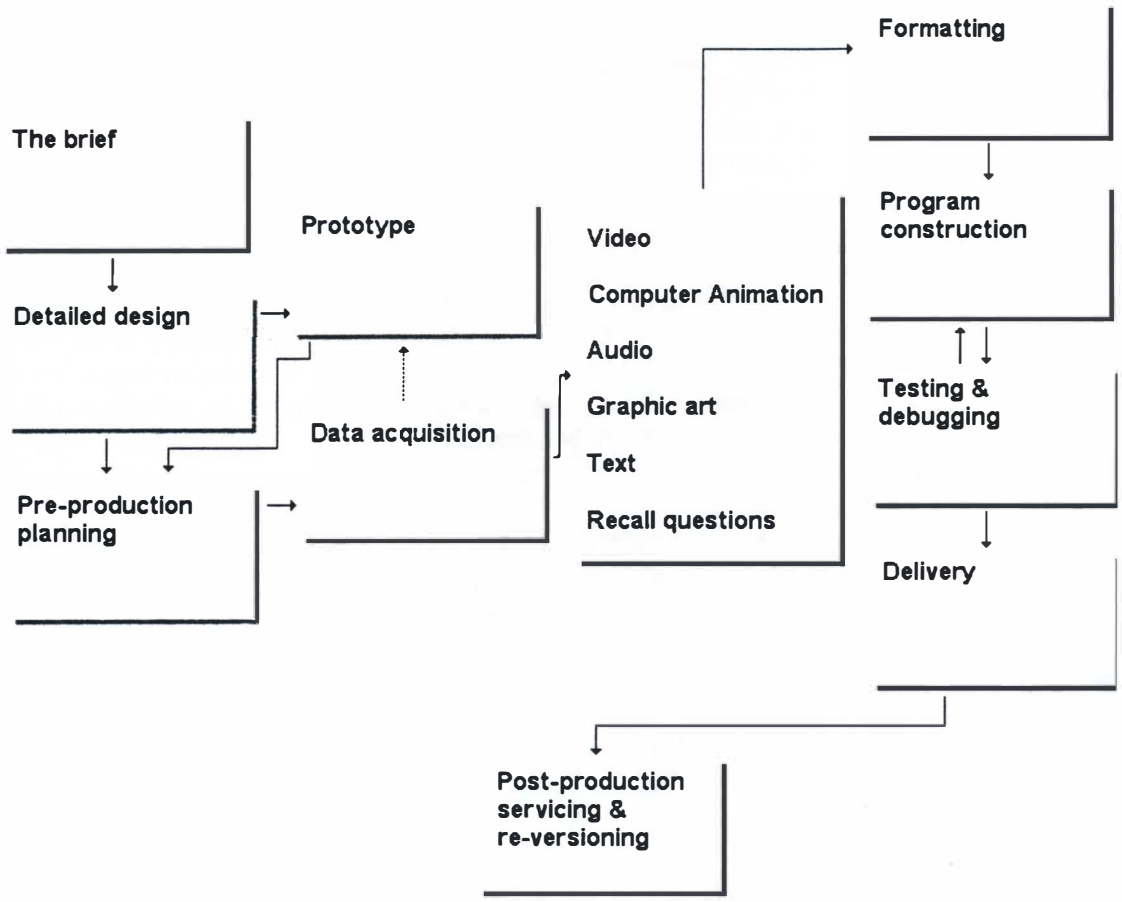
3. Testing, which Vaughan warns is an essential part of the project, particularly in ensuring that the program meets the objectives, that they work properly on the intended platforms and they meet the needs of the client or end user.

4. Delivery, which involves the packaging and delivery of the product to the end user.

Cotton & Oliver (1993), on the other hand, use a more traditional flow chart to display the process of development (see Figure 2.10). They include some iterative design protocols where changes can be made from initial prototypes as a result of feedback from formative evaluation procedures, but their system is similar in many ways to the instructional design procedures recommended by the Dick and Carey models.

It appears that the more friendly the authoring system or programming language is to prototyping, the more likely the use of extensive formative evaluation and revision at early stages of production. However, a common warning that is repeated in the literature about commercial production is that the developers should allow a limited number of iterations of the original design, otherwise the production process will continually be revised and run over time and over budget (Vaughan, 1994). Using higher language development tools should permit all developers of educational material to include a mechanism that allows easy alteration in order to allow for flexibility in selecting the material to be presented and the easy updating of the subject matter.

Figure 2.10
Media production flow chart



Adapted from Cotton & Oliver (1993: 80-81)

2.4.4 Interface design

The Human-computer interface (HCI) is the way in which the user experiences the computer. It includes all aspects of computer usage from screen design to the positioning of the computer in the student's work area. The screen design and navigational feature would usually be produced in the detailed design portion of Cotton & Oliver's flow chart, but would also be continually revised during the production process. The ergonomic aspects of design and delivery are often outside the control of the multimedia development team, but should inform an institution's strategic planning process should they decide to make a commitment to this form of instructional intervention.

The importance of interface design is often underestimated, but Baeker and Buxton (1987) make an emphatic statement on this issue when they state that no matter the system being designed or the computational effectiveness of the coding, the human-computer interface is "the single most important aspect determining the success or failure of the system" (ibid: 1). Shneiderman echoes this concept when he states that when considering educational and office applications "ease of learning, low error rates, and subjective satisfaction are paramount because use is frequently discretionary and competition is fierce" (Shneiderman, 1986: 17) and Sullivan (1994: 65) adds that "if students are required to learn programs that they do not think they will ever use again and if the programs are difficult to learn, students are likely to resist using them". A good interface will fade into the background and the user will focus on the task at hand (Vaughan, 1994).

In order to ensure that the interface is suitable Hansen (cited in Shneiderman, 1986) advises the developer to "know the user". Shneiderman states "all designs should begin with an understanding of the intended users, including profiles of their age, sex, physical abilities, education, cultural or ethnic background, training, motivation, goals, and personality" (ibid: 53). The effects of these variables may be difficult to predict, thus it is commonly accepted (Andrews, 1994: Amory and Mars, 1994), but not often practical, that the design team and the testing sample be made up of as culturally diverse groups as are likely to use the program. Some of the variables that are said to have direct implications on the acceptability of the user interface of CAE applications are discussed below.

Prior experience

The "beliefs and expectations with which she (the computer user) sits down at her terminal or personal computer are a direct result of her concept of what the computer is like and what the computer has become" (Baeker & Buxton, 1987: 40). This includes preconceived expectations of design elements as well as emotional responses to using the computer. One example is that of students whose interaction with PCs has only taken place in the Windows environment and they are likely to be confused if faced with DOS commands.

However the other aspect of concern that is raised by Baeker & Buxton is users' insecurities about 'hidden agendas' and unexplained recording keeping which may influence the acceptability of the system. Andrews (1994) describes an experience whereby a teacher deliberately sabotaged the use of a CAE system fearing the system would replace the teacher's function. Unexplained questions such as "For whom and for what purpose is the computer being used? Who has the power? Who is in control? How are decisions being made?" (Baeker & Buxton, 1987: 40) may jeopardise the effectiveness of a system, and seriously compromise the ethics of any research that may result.

Another factor that is of particular importance to South Africans contemplating the introduction of CAE into the curricula is that these systems could further disenfranchise already disadvantaged students (Murrell, 1998). However, in cases of perceived racism such as in the allocation of marks for assignments, impersonal computer systems can be used. However, there are other aspects whereby the technology itself is perceived as prejudicial, for example, in the case of visually impaired or deaf students being excluded from poorly designed systems.

Learning time

The comment that "any system which cannot be well taught to a layman in *ten minutes*, by a tutor in the presence of a responding set-up, is too complicated" is attributed to Ted Nelson (cited in Baeker & Buxton, 1987: 47, original italics). This 'ten-minute' rule is particularly important in the development of interactive course material. Ten minutes could be considered generous as the focus of learning must be on the subject material and not on the computer interface. The system should be as intuitive and natural as possible (Murrell, 1998), as "an interactive system [that] is well designed ... almost disappears, enabling the users to concentrate on their work" (Shneiderman, 1986: 8).

Various factors lend themselves to the shortening of the learning time, the most important being familiarity, consistency and the use of metaphor. The user is able to look for instructions and messages in a consistent place, becomes familiar with the navigational system and is able to use the metaphor to predict the outcome of certain interactions. Bandura suggests that the ability to predict the outcome of interactions will lead to confidence and quicker interactions with lower error rates (Bandura cited by Nevid et al, 1997).

Use of metaphor in the interface design

A recurring theme in the literature on interface design is the use of metaphor. For Waterworth (1992) "a key aspect of developing usable multimedia is the notion of conceptual models designed into interfaces by their creators, and the actual mental models that develop in users' minds as they interact with the system. One way of breaching the gulf that tends to form between the two is through the use of analogy. Interface metaphors are one way of providing consistent models for both designers and users (though not necessarily the same one), by tapping real-world knowledge: (ibid: 23).

Wager reiterates this when he writes, "most of our behaviours are motivated by perception of consequences (or lack of them)" (Wager, 1998). People instinctively make use of analogy to make sense of the real world, and predict the outcome of new and novel actions. The constructivists' learning theory hypothesises that learners "construct new ideas and concepts based upon their current/past knowledge" (Kearsley, 1988), which creates a predictability and order in behaviour and expectations. By imposing a familiar metaphor on a 'virtual world', the user is better able to predict outcomes of new interactions and can identify patterns of behaviour within the system. It also has the added advantage of giving the designer a model by which to guide the development of consistent interactions and representations. However, care must be taken that the analogy is familiar to the users' experiences in the real world, and similar enough to be incorporated without excessive explanation.

Cultural issues

In his writings Vygotsky highlighted the role that culture plays in the development of language and the tools of communication (oral, gesture and writing) and how the use of such tools impacts on learning (Vygotsky, 1978). Research by Australian academics such as Henderson (1994) shows the importance of ensuring that cultural issues are taken into consideration when developing online learning, and if properly done it can enhance the accessibility of higher education for communities that have traditionally been excluded.

In South Africa, Andrews (1994) states that it is vital for CAE developers to consider these issues. It was found when developing a program called *Funda* to teach Zulu literacy to illiterate Zulu speaking people that when "working in a multi-cultural environment such as that in South Africa it is important NOT to make any assumptions at all... The lessons Funda taught us are important ... Learning them and applying them could make the difference between success and failure for the implementation of any technology in South Africa or any multi-cultural society" (ibid: 9). She cites some examples where ignorance of culture can make a difference to acceptability of a product such as in one game based on 'snakes and ladders'; "the colour of the snake had to be green as this made it an ancestral snake therefore acceptable ... a brown snake swallowing a man would not be amusing at all." (ibid: 11)

Many South African people adhere to fundamental religious beliefs. Inadvertently offending someone's religious sensibilities can lead to alienation of that person, for instance the popping of a champagne bottle would offend Muslim users (Murrell, 1998), whilst Shneiderman (1986) points out that some people find common computer language such 'abort' or 'illegal command' offensive.

Amory & Mars (1994: 2) suggest "the encapsulation of complex ideas into simple pictures often makes it easier to transmit information to user (*sic*). However, the interpretations and understanding of such icons and other elements, such as colour, are often culturally based".

Navigation

Hypertext and hypermedia systems are usually perceived as combinations of links and nodes. Nodes contain the text, graphics, sounds, or related information in the knowledge base, whilst links are the "connections between the conceptual elements, that is, the *nodes*" (Vaughan, 1994: 234 original italics). Links are thus the navigation paths to accessible topics, documents and messages.

There are three common ways of navigating CAE programs and hypertext or hypermedia documents: menus, point and click buttons, and search indexes. Most current interfaces make use of a 'direct manipulation interface' that Mayhew defines as one "in which users *perform actions directly on visible objects*" (Mayhew, 1992: 289, original italics). These are sometimes referred to as 'point and click' interactions.

Vaughan (1994) recommends that a navigation map be plotted at the early stages of a multimedia development. He claims the advantages of this are that it outlines the connections or links between the various areas of content, helps organise the content and messages, provides the developer with a table of contents and charts the logical flow of the interactive interface. He outlines four fundamental organising structures as:

- Linear - where users navigate sequentially from one frame to another
- Hierarchical - where users navigate along branches of a tree structure that is shaped by the contents natural logical content.
- Non-linear - where users navigate freely through the content unbound by predetermined routes
- Composite - where users may navigate freely, but are occasionally constrained to linear presentations.

Adapted from Vaughan (1994: 390)

The navigational methods provided to the user constitute an important aspect of the interface. "Poor navigation aids can make viewers feel lost and unconnected to the content; or worse, they may sail right off the edge and just give up and quit the program" (ibid: 401). New or naive users want to know where they are, where they have been, and how far they still have to go. They should also have a way of exiting, and returning to the same place at a later stage, without being locked into a system until a section is completed. However, advanced users will wish to move directly to portions of the program with as few interactions as possible using a quick, reliable and intuitive navigation system. Vaughan (ibid) recommends that the interface include navigational options for both naive and sophisticated users.

Menu navigation:
In the early days of text based interfaces much research was done in the field of menus versus command language structures as well as more detailed research into menu structures. Command language structures are not considered feasible interaction models for CAE programs as they take time to learn and intermittent users are likely to forget the command syntax. However menu options (embedded or otherwise) are still predominant in the development of new applications as they are considered "especially effective when users have little training, are intermittent in using the system, are unfamiliar with the terminology, and ... need help in structuring their decision-making process" (Shneiderman, 1986: 86).

Use of mnemonics in menu options is helpful in assisting intermittent users remember menu options and short cuts, with Shneiderman (ibid) pointing out that the user is likely to feel confident in making selections. In Windows applications mnemonics are used as an alternative to mouse selection methods, which also benefits blind and partially sighted users.

Direct manipulations:
More recent developments in Graphic User Interfaces encourage designers to use clickable iconic representation, selectable text embedded within the document, or regions of an image map, to navigate hypermedia. Whilst these options are often very pleasing to the eye and have the added advantage of being placed in context, care must be taken that the visual attributes are clear to all users. Andrews (1994) and Amory, Mars and Meyerowitz (1999) suggest that graphic literacy is influenced by culture, social, and educational background.

Many authors, such as Shneiderman (1996), Mayhew (1992), and Vaughan (1994), recommend that developers should adhere to guidelines similar to the following when designing menu, iconic or embedded selections:

- All graphic representation should have textual descriptions to avoid misinterpretation of the picture by users.
- Familiar terminology is usually preferred over jargon, as it improves understanding and accessibility. For instance the term 'print' is preferable to the term 'hardcopy'.
- Developers are encouraged to use concise phrasing and avoid excessive instructions e.g. 'print' is usually considered sufficient and 'Click here to print this page', too lengthy.
- Consistent use of terminology throughout the system allows the user to quickly scan the terms and search with ease.
- Users are likely to make faster selections if keywords are the first to be scanned. In South Africa where reading takes place from left to right this would mean that keywords would be positioned on the left.
- When a menu map is required, the items relating to similar functions should be grouped together as far as possible as this enables the user to scan options for a function in one screen, and allows them to make logical decisions when choosing a navigation path through menu options. If this type of ordering is not possible developers could look at another logical, instinctive alternative such as alphabetic listing for an index or glossary, or displaying value items in ascending or descending order.
- If users are unable to access the screen they require with the use of a couple of keystrokes or mouse clicks, they find the system tedious and unusable. Developers are encouraged to avoid multiple screen transversals or displays for selection purposes.
- When using tree menus users find it helpful if the level of the option is highlighted within the tree structure. For example if there are a number of options within a print instruction, the second level of the menu structure should clearly indicate that print has been selected. Furthermore, Shneiderman, (1986: 111-112) suggests that "the exact words used in the high-level menu items should be used as the titles for the next lower-level menu" which will remind the users how they moved down the menu options and the path they should take should they wish to use the option again. This also enhances the users' ability to make decisions related to backtracking through the menu options.
- Placing the most frequently used items and more important items first or more prominently than less frequently used items enables the users to make quicker and more efficient selections, as they do not need to scan numerous unwanted options.
- Perceived user control over a system is often considered a high priority. To enhance this error messages related to inappropriate selections should give the user the relevant information for correcting the selection and should be placed in a consistent position so they are easily identified and read. Furthermore, users should be able to correct or undo all interactions.

Designing menu options for internet delivery may require different considerations to locally delivered applications as the speed of multiple screen transversals differ considerably between the two delivery options. Vaughan, (1994) suggests that "in designing your navigation system, bring the user to a particular destination with as few actions and as short a wait as possible" (ibid: 200), whilst, in a similar vein, Shneiderman (1986) states that:

> "Deep menu trees or complex traversals become annoying to the user if the systems response time is slow, resulting in long and multiple delays. With slow display rates, lengthy menus become annoying because of the volume of text that must be displayed. In positive terms, if the response time is long, then create menus with more items on each menu to reduce the number of menus necessary. If the response rate is slow, create menus with fewer items to reduce the display time. If the response time is long and the display rate is slow", menu selection is very unappealing".
>
> *(Shneiderman, 1986: 106)*

Transaction options that enhance ease of movement through many CAE programs include:

Help — if a user needs further instruction or assistance, it is counter productive to make them transverse many menu levels to obtain relevant assistance. Links to help screens and files should be immediately available, and contextually relevant;

Forward — the user should be able to move on to the next screen or information display with ease and without having complete difficult menu manoeuvres;

Backward — similarly, the user should be able to "page back" to logical previous screens with ease;

Backtrack — in a hypertext or hypermedia display the user should be able to review previously displayed screens, which could be different to the "logical previous" screen;

Quit — the option to exit the program should always be available and the user should be permitted to exit at any time;

Index — a link to an index or table of contents to assist advanced users; and

In the development of web pages it is important to remember that a user may enter the site on any of the pages. Obvious forward and backward movement through the whole document or groups of documents should be made available if the documents are linear in design. Links on a page often indicate 'previous page' or 'next page', which should not be confused with the back and forward buttons supplied by the browser, which refer to movement through cached documents.

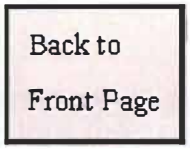
There is a "need for consistent navigation metaphors in hypertext" (Neilson, 1990: 137), and Amory (1994) suggest the use of a video or tape deck analogy, as the following buttons are equally familiar to all cultural groups in South Africa:

Figure 2.11
Video buttons as a navigation metaphor

Adapted from Amory, (1994)

All buttons and navigational instructions should have a consistent placement on screen, clarity of iconic representation and text alternatives. Care must also be taken to avoid any ambiguity (Waterworth, 1992), such as the button reproduced in Figure 2.12.

Figure 2.12
Ambiguity



(de Lisle, 1998)

Colour

Most computers currently sold have the capability of displaying millions of colours, however, it is still important to consider variations in the hardware settings when selecting and setting colour options.

Although a full range of the colour spectrum is necessary for the display of realistic images and photographs, careful consideration must be given to the range of colours used in alphanumeric displays. The following are generally listed as guidelines for the use of colour in alphanumeric displays (Fowler and Stanwick, 1995; Schneiderman, 1986; Travis, 1991):

- In order to enhance readability across different display capabilities designers are encouraged to design for monochrome and add colour for emphasis.
- The use of complementary colours is recommended at they are said to be perceived as harmonious and harmony is said to create a sense of order.
- Colours that are too bright or combinations that have too much contrast make it difficult for the user to focus e.g. pure red and pure blue are on opposite ends of the spectrum, and the eye uses different muscular combinations to focus. At any one time either the red or the blue text would fade into the background.
- Most theoreticians suggest no more than four colours be used as too many colours on the screen are said to be overwhelming and detract from the information that the user is meant to absorb. In order to avoid this type of sensory overload developers are advised to avoid highlighting too many groups at once, restricting highlights to one or two key items.
- The use of bright foreground colours on a dark or dim background, or dark foreground colours on a light background, is said to enhance legibility. Thus the literature advises developers to highlight regions by using colours that contrast with the background in hue, saturation and luminance. It is suggested that separate areas on screen can be linked by a common background or text colour and where important colour judgements are to be made, objects be viewed against an achromatic (neutral/colourless) background to add emphasis.
- As it is difficult to see saturated blue without the eye blurring the edges of the image, it is recommended that it not be used for fine detail.
- Colour coding can give an easily recognisable order to the system so many researchers suggest that due recognition be given to the power of colour coding, however, they warn that when doing so the developer should ensure consistency throughout and that the norms of representation should be followed, for example a green stop sign would send ambiguous messages to the user. They state that colours chosen for colour coding purposes should be discriminable, detectable, perceptually equal, meaningful, consistent, and aesthetically pleasing.
- Colour can also be a useful indication of a change of status; for instance, web browsers do this successfully by altering the colour of a visited link. The same principles could easily be adapted to encompass multimedia CAE interactions.

- Information groups are clearly visible if surrounded by a neutral background colour, termed 'white space'. White space consistently used can separate the screen into logical groups of information and make it more legible, whilst creating "symmetry and balance" (Mayhew, 1992: 467).

Another concern often overlooked in the development of multimedia presentations is the issue of 'colour blindness'. Fowler & Stanwick (1995) point out that the term 'colour blind' is in fact a misnomer, as a complete lack of colour vision is extremely rare. A more accurate label would be 'colour vision deficiency' or 'colour discrimination deficiency'. Table 2.2 is an adaptation from that used by Travis (1991) to highlight the incidences and confusions of people with colour vision deficiency.

Table 2.2
Colour confusions commonly perceived by people with colour vision deficiencies.

Type of deficiency	Incidence in (%)	Typical confusions	White matches:-
Achromatopsia	0.003	All colours look like shades of grey	Many colours
Protanopia	1	Bluish-green & brown green, olive, tan & red-orange blue & red-purple violet & purple	Blue-green
Deuteranopia	1	Dull green & pink Olive & brown yellow-green & red-orange greenish-blue, dull blue & purple	Blue-green
Tritanopia	0.004	Green & greenish-blue oranges & red-purples	Yellow-orange
Protanomaly	1	Mild anomalous may appear normal. Severe anomalous tend towards protanopia	Not applicable
Deuteranomaly	5-6	Mild anomalous may appear normal. Severe anomalous tend towards deuteranopia	Not applicable

Adapted from Travis, 1991: 59

Graphic files with millions of colours can take up extraordinary amounts of disk space, and care should be taken that they do not unnecessarily slow down the display of information particularly when developing Internet deliverable information. An option for many graphic images is to reduce the number of colours in the graphic file to 256 as this allows quicker display times and compatibility with most computer colour monitors. However, to avoid annoying screen flicker and unnecessary degradation of image quality, graphics should be mapped to the same palette (Vaughan, 1994).

Sound

Sound can be both appealing and intrusive, "the use of sound should be carefully considered, and users should have the option of turning it off" (Mayhew, 1992: 482). In CAE developments sound can be used to enhance meaning, and should not distract the learner's attention from the

point of instruction. There are a number of instructionally valid areas where music and voice recordings can be used in a multimedia project, including sound used:

- to highlight transition as the user moves from one topic to another, drawing attention to the change in information;
- as a warning when potentially fatal instructions are detected, to enhance and draw attention to the warning messages;
- to highlight meaning or enhance understanding such as the pronunciation of foreign or unfamiliar terms.

Sound can be also be used as an important cue for blind or partially sighted users. However it is recognised that voice recordings and music have intense cultural significance, and it is sometimes important to ensure that the intended audience does not react negatively to the recordings, for instance Andrews (1994) found that her audience were disconcerted by headless voices. Research by Amory & Mars (1994: 2) indicates that students preferred a "clear female voice" when speech was recorded, but generally it was felt that any gender is acceptable with preference being given to an 'unaccented' voice. At the same time, when considering including voice instruction in a CAE application the developer must bear in mind that "greater effort is required to pay attention to spoken words than to browse text" (Vaughan, 1994: 200).

Messages, instructional prompts, and status reports

It is often necessary to give users instructions, information, or messages on screen. However, these should be easily understood by a naive user, quickly read and identified so as to be as unobtrusive as possible and not distract the user from the ultimate use of the program.

Mayhew (1992) offers the following guidelines:

- Messages that are brief and concise can be read quickly. They inform the user of the necessary actions to be taken without taking too much of the user's time with irrelevant information. Similarly prompts should be displayed when and where they will be needed.
- If messages are designed according to the users' level of understanding and knowledge, they will not be encumbered with trying to understand messages that are irrelevant to their particular goals. This enables them to carry out the necessary instructions easily and efficiently.
- Messages that are constructive and avoid critical expressions assist in the maintenance of a positive user attitude.
- Should the user be required to do something specific, the message displayed should be phrased with words that are consistent with the action.
- Prompts that are ordered chronologically assist the user in following the necessary steps.

Feedback

Laurillard (1993) highlights the need for continuous and constructive feedback for learning tasks. This is equally important for users of computer systems. Feedback on user interactions should be immediate, positive and instructional. One of the main advantages of using computerised instructional systems is the ability to give instantaneous feedback to learners, but care should be taken that the feedback is always phrased in a positive light, and that it gives enough information for the learners to readjust their reasoning if necessary.

The tone used throughout any interactive computer system that is to be delivered to people of various cultural and linguistics groups should be one of respect for the user and the subject material. When dealing with people on a one-to-one basis, the advantage of body language, gesture and tonal variation, allow occasional trespass into culturally inappropriate behaviour. Sensitive facilitators will quickly pick up that the audience is not responding as expected and alter their manner of delivery. However, this immediate, instinctive interaction is not available on

a recorded system, and the system can continually repeat an infringement that is perceived by the user as a form of battery and abuse.

In order to avoid any inadvertent breach of etiquette it is advisable to treat the subject material and user as formally as possible; for instance slang and gestures that are acceptable in one area of the English speaking globe may be extremely offensive in others.

Screen layout and design

"The primary goal of graphic design for the computer screen is to establish a consistent visual structure, in which the important information is immediately obvious, and where everything else is subordinate and undistracting" (Lynch, 1994). The layout of a screen is always a controversial issue; what is aesthetically pleasing to one person may be considered dull and boring or, conversely, garish to another. A quick browse through various web pages will highlight this problem and web pages such as "*Web pages that suck*" (Flanders, 1999) show that certain people can use some features creatively whilst others simply misuse them. Perhaps the best advice to novice designers is to aim for elegant simplicity, and consistency.

It helps to divide the screen into a grid where similar types of information are consistently placed. This helps the designer form a visual sense of balance across screens, and the consistency will aid the user to quickly locate the important information.

Issues such as cognitive overload from too much information and too many diverse media used simultaneously will detract from the learning task. Each screen should include just enough text, graphic and animation to make one point, and its supporting ideas, clear.

Font

"Experiments have shown that reading text on a computer screen is slower and more difficult than reading the same text in hard copy or book form" (Vaughan, 1994: 205). He warns "too little text requires annoying page turns and unnecessary user activity; too much text makes the screen overcrowded and unpleasant" (ibid: 200). The choice of font size and number of headlines placed on screen relates to the complexity of the message to be conveyed (ibid).

Vaughan (ibid: 201-202) makes the following recommendations:

- too much variation in font styles makes it difficult to read the text, Vaughan recommends that developers use as few different faces as possible in the same work, but vary the weight and size of the typeface for emphasis;
- If the size of the font is varied in proportion to the importance of the message a user can quickly browse of the text to get a overview of the salient points;
- Vaughan maintains that lines that are too tightly packed are difficult to read and can lead to a sense of information overload; he recommends that the font leading be adjusted for the most pleasing line spacing;
- Decorative and script fonts are considered difficult to read, thus it is suggested that the most legible font available should be used for small text.

Font sizes are hugely debated topics, and may be dependent on the information being conveyed. Most web sites are essentially text based information sources with the multimedia aspects being added to highlight or draw attention to certain aspects. Individual users are likely to set their own font sizes to suit their specific preferences and screens. Multimedia interactive courseware has a different look and feel, and is often used because some interactions and graphics are not easily deliverable in HTML. Legible font and uncluttered screens tend to be more aesthetically pleasing, whilst a mixture of upper and lower case, as normally viewed in a printed document, is said to make the text more legible than all upper case text. Sans serif fonts such as Verdana have recently been developed specifically for screen delivered material as

they are considered more readable than serif fonts like Times Roman developed for the print media.

Titles give the user a sense of 'place' within the system, if each screen is titled and each title matches the interaction that brings the user to the screen a sense of orderliness and predictability is enhanced. Different levels of titling can be used to show how far into an interaction the user has moved.

A final warning from Vaughan (ibid) is that not all systems have the same font tables as the development machine. He advises the developer to ensure that the font tables travel with the application when software is delivered.

Scrolling

In multimedia programs users expect to see the "whole" screen at once. If excessive scrolling is required to make associations with various ideas, the user's attention could be drawn away from the main topic. However, users of Web pages have slightly different expectations; they find vertical scrolling acceptable, but horizontal scrolling disconcerting. Similarly users' expectations regarding the acceptable amount of information displayed on screen differs between web page instructional material and locally delivered interactive multimedia developments. Web pages should have enough information to develop a concept from beginning to end to avoid repetitive download delays, whilst in interactive multimedia courseware each screen should constitute one idea or concept that can be developed over a number of screens. If necessary users should be able to move backwards and forwards through these screens simply and instantaneously.

Disabled students

In the designers' haste to meet the needs of the majority of the student population they often ignore or overlook the needs of the disabled students. It is important to consider these needs when developing material for users that may have physical challenges. Advances in technology have enabled disabled people greater access to resources than ever before; "optical character recognition technologies, coupled with speech synthesis, provide reading machines for the visually impaired. Voice input technologies permit those with motor disabilities to interact with their environment in a way never before possible. And portable terminals with modems enable those with restricted hearing to make use of the telephone" (Baeker & Buxton, 1987: 675).

The Employment Equity Act (Unwembi Communications, 1998) places a legal imperative on institutions to adopt a policy of "non-discrimination"; they will be morally and legally obliged to admit a growing number of students with physical disabilities. As visually impaired or blind students are unable to participate in laboratory experiments they tend to be attracted to studies that are predominantly delivered via print media such as the humanities and law. Such disciplines are experiencing a growth in the number of such students admitted into their programmes and there is a strong possibility that hearing impaired students will also begin to request access to a number of disciplines including the sciences. The needs of wheelchair bound and paraplegic students should also be accommodated whilst not forgetting those of students who are temporarily injured and unable to use their hands or legs because of plaster casts and other medical treatments. It is thus incumbent on educational institutions to ensure that disabled students have equal access to information resources, and provide adaptive technology wherever possible. This has direct implications on interface design of CAE programs.

The W3C's Web Accessibility Initiative (WAI) (W3C WAI, 1999) states:

> "Common accessibility problems on Web sites include: images without alternative text; lack of alternative text for image map hot-spots; misleading use of structural elements on pages; uncaptioned audio or undescribed video; lack of alternative information for users who cannot access frames or scripts; tables that are difficult to decipher when linearized; or sites with poor color contrast."

In essence this will mean that if a course is to include people with various ranges of physical abilities, the following issues should be addressed:

- Blind students are unable to use a mouse but are usually keyboard literate, so developers should offer keyboard alternatives to mouse interaction.
- If sound is recorded a text alternative could be made available for deaf students.
- Textual explanations or alternatives for graphics allow blind students equal access to the information.
- Blind readers make use of screen reading software which usually reads information displayed on each line of the screen from left to right. In tables the word wrapping in each cell makes the text nonsensical thus making it necessary to create alternative text for tables if the material is to be accessible to blind users.
- When designing communal facilities institutions are encouraged to ensure that they can accommodate all students regardless of differences. Thus students who may be larger than most, students using wheelchairs, crutches or callipers, or those that can not see to use card-access systems should be able to gain entry to the facilities on an equal basis.

Unfortunately screen reading software designed for use by blind students (such as Windows Bridge™ and Jaws™) tends to be set up for standardised software applications. When coding a program from scratch or using an authoring tool such as Authorware™, the screen settings are not necessarily standardised and 'set' files have to be created for each of the programs. This process is tedious and tends to be ignored if the number of students requiring such adaptation is limited. "A major challenge to the industry is to get to the point where *transparent access* is the norm for the bulk of disabled users" (Baeker & Buxton, 1987: 675 original italics).

Availability, reliability and access

Availability of suitable equipment is an important consideration when developing CAE applications, particularly when the distribution of technological infrastructure is likely to be skewed in favour of one group of students over another. It is imperative that universities ensure suitable and equal access to facilities for all students.

Similarly, if partially sighted or blind students are required to use computers to access print material, submit written assignments and exams, then the institution should ensure that there are sufficient adaptive computers in a suitable, safe environment for them to use.

The reliability of existing computing facilities and connectivity is of equal importance. Students who need to repeatedly try and access web pages only to find the connections are faulty are likely to become disenchanted with the process.

Security

There are two aspects of security involved in CAE applications, the first the computer related one where the user should be confident that any information stored is secure from unauthorised access, and will not be used for anything other than the stated purpose.

The other aspect is a social problem in a crime-ridden society. Users who need access to equipment outside of their normal home environment or work hours may find travelling late at

night alone compromises their safety and thus they may limit their access time to safer times (Clarke, 1999). Designers of systems that may require this type of access, for example, designers of CAE for distance adult learners, will need to bear this in mind when they design their interactions and systems allowing the user to work off-line and use the system for uploads only.

Consideration could also be given to the idea of allowing residential, full time students, remote access to systems where possible, thus allowing them to work from home if they have suitable equipment.

Integrity

If a system is being used to score and calculate marks towards degree certification, the users have to be assured that such systems are accurate and the data integrity will not be compromised.

Ergonomics

The sound use of ergonomic studies and research should play an important role in the way equipment is made available to learners. It has direct effects on the way in which people make use of the equipment, the length of time they are prepared to sit at a work station, their concentration level, eye strain and fatigue. Although a full literature review of this phenomenon is outside the scope of this dissertation, an institution should make cost effective decisions related to the best acoustics, seating, lighting, and air quality for their particular requirements (Baeker & Buxton, 1987).

2.5 Implementation issues

The implementation of any new system requires forethought and planning. Baeker & Buxton pose two questions that should be considered when introducing new technology;

> "How does the structure of an organisation affect the use and effectiveness of computers, and how does the introduction of new technology affect the functioning of an existing organisation?"
>
> *(Baeker & Buxton, 1987: 40)*

These can translate into issues related to accessibility; including both the delivery options and development skills required, organisational culture, the effectiveness in the defined work place, and the sustainability of the system.

2.5.1 Accessibility

Accessibility has been dealt with briefly in section 2.4, but includes the issue of accessibility of the delivered program to all sectors of the target student group. When referring to CAE the question 'how easily can the students access the computer facilities, and will this access be reliable?' should be thoroughly researched. Should computers become an integral part of the learning process, across the spectrum of faculties, strategic plans should be made to accommodate the potential load on current, and future, computing workstations and Internet bandwidth. Furthermore the increased workload of support and development staff should be anticipated and accommodated with the concomitant financial implications for the institution.

2.5.2 Organisational culture

Other issues that often relate to the implementation of new technology in an institution, such as the university, include the expectations and fears of the facilitators. Andrews (1994: 12)

describes a facilitator "who saw the computer as a rival he had to discredit or he would lose his job. This in spite of a week of careful training about his role and that of the computer." However, with the enormous pressures on academic staff at present, many academics are either already introducing CAE into their curriculum or are interested in investigating it (Greaves, 1997).

The major issue for the university administrators is the cost efficiency of introducing CAE. According to Harper (1987) the continued introduction of technology into the workplace will increase the net costs for educators, because software development has become increasingly expensive and the development of computer technology is so rapid that software quickly becomes outmoded and requires continual upgrades.

2.5.3 Maintenance and sustainability

Development of CAE systems is time consuming and expensive. If systems are to be developed the institution funding such development needs reassurance that the system will be useable in its current form for enough time to ensure that they can recoup development costs. Price & Murrell (1990) suggest that the effectiveness and use of CAE programs is dependent on a "champion" to ensure both the effective development and implementation of a system. However, there is little written in the literature reviewed that shows how systems are used once this 'champion' leaves the project or institution.

Part of the process of sustainability is the ability to modify a system (Koppi, Chaloupka, Llewellyn, Cheney, Clark, and Fenton-Kerr, 1998) when the content is found to be outdated, or irrelevant. Traditional CAE programs were not easily modified and often the source code was unavailable to second tier users. However, with the development of third and fourth generation languages as well as integrated database technologies modifications become technically more feasible. Once the initiator of a project has left, new faculty can adapt the system to their needs provided they have the motivation and time in which to do so.

2.6 Evaluating computer assisted education

Scholars have learnt from, and contributed to, a large body of knowledge for many centuries, without the assistance of computers. Thus one assumes that this technology is not essential to the learning process. However a fascination persists to the extent that vast sums of money are invested in the development and distribution of education and training programs, despite "the generally poor success of CBE in most educational contexts" (Reeves, 1997), and the "paucity of empirical evidence that interactive learning technologies are any more effective than other instructional approaches" (Reeves, 1999).

2.6.1 Research questions

Generally CAE programs are developed in an attempt to enhance learning, and it is thus important that researchers be particularly careful when formulating their research questions to ensure that they ask how the program improves the learning process. Learning will take place with or without the media, but if learning can be significantly enhanced and take place in different settings then the interventions are useful. Exactly what constitutes improved learning is clearly a hotly debated topic, and varies according to the type of information or skills being taught, so these premises should be outlined at the beginning of the research project.

According to Thomas, research should "comprehend the entire complex of important variables that interact to determine learning effectiveness" (Thomas and Kobayashi, 1987: 21). These, according to Thomas, include:

- Characteristics of the technology
- Characteristics of the learner
- Specific skills or subject matter being taught

- Attitudes and skills of instructional personnel
- Physical conditions of the learning setting.

He also says that information about effectiveness needs to be combined with other data such as feasibility and efficiency, including:

- Political conditions;
- Cultural suitability; and
- Extent of change required by the technology

Acceptance

Thomas also measures popularity because "technology is successful to the degree that it is widely accepted in the educational community" (ibid: 19). This popularity is measured in terms of its availability and/or use. The distinction between availability and use is important, as some media could be available to educators but not used, whilst others would be used if they were it possible; for example when there is no electricity the possibility of using many media is severely limited.

Cost effectiveness

On a different note, Thomas (ibid: 1987) points out the importance of differentiating between the effectiveness of a technological intervention and its efficiency. He states that effectiveness refers to how well a technology does a specific job, whilst efficiency refers not only to whether the desired goal is achieved but also at what cost in terms of money, time, energy and personnel displacement. If two media can achieve the same goal, Thomas state the cheaper is the most efficient. In simplistic terms this makes sense, but not all aspects of educational interventions can be measured and equated with a financial value; enjoyment, motivation and participation are some of these aspects.

Many of these variables are difficult to quantify and qualitative and critical analysis would need to play an important role in making valid conclusions about their role in an educational intervention.

2.6.2 Methodology

As with other areas of research into instructional technology and educational interventions, different theoreticians choose categories that reflect their particular ideological frame of reference, be it a scientific paradigm of experimentation and validation; a sociological qualitative paradigm taking into account the chaotic influences of unidentified variables, or a critical analysis in the form of expert views, opinions and experience.

Evaluation paradigms

Hlynka and Belland (1991) argue that there are two predominant evaluation paradigms, quantitative and qualitative, but, in their view, there should be a third, which takes the form of critical analysis as it is used in literary or art criticism.

Quantitative paradigm

Quantitative statistical analysis is the analysis paradigm more commonly used in scientific research. Reeves (2000) states that this paradigm consists of "experimental, quasi-experimental, correlational, and other methods that primarily involve the collection of quantitative data and its analysis using statistics, e.g., the analysis of variance in exam results among students in traditional courses and web-based courses". Essentially researchers adhering to a quantitative paradigm take numerically based values to prove or disprove a

hypothesis under circumstances that can be replicated. As Hlynak and Belland (1991) state "quantitative methods are 'nomothetic' requiring generalizations as an end result".

Qualitative paradigm

Qualitative research consists of "observations, case-studies, interviews, and other methods that involve the collection of qualitative data and its analysis using ethnographic approaches, e.g., participant observation in web-based course" (Reeves, 2000). According to Hlynak and Belland (1991) in this paradigm truth statements are 'idiographic'; generalizations are neither possible nor expected.

Critical analysis as a paradigm

Their third evaluation paradigm does not use any traditional statistical or experimental methodology, but is based on models of art and literary criticism in which evaluators:

- "put their trust in a thinking person, rather than a procedure;
- tend to focus on 'the work' and how it relates to the entire contextual system;
- are empirical to the extent that they refer to 'the work' which can be examined by other critics and by the public;
- are public in that the body of critical work is disseminated and cross-referenced so that other critics and the public can examine the range of critical thought for themselves; and
- treat a work not as a closed text, from which readers are expected to extract a single true meaning, but rather as an open text, subject to a multiplicity of meanings, sometimes even contradictory ones, with those meanings residing in the text, in the author, and in the reader".

(Hlynka & Belland, 1991: 8)

Aoki (1991) states that critical evaluators are concerned with:

1. the "underlying root interests, root assumptions, and root approaches" (ibid: 75) of a particular curriculum;
2. the implied view the teacher or curriculum developer has of the student;
3. the ownership of interests served by the curriculum;
4. the root metaphors that guide the developer, implementer and evaluator;
5. the basic bias of developers and publishers of recommended resource material; and
6. the world view supported by the curriculum.

Adapted from Aoki (1991: 75)

This type of evaluation can take various forms, for instance Belland (1991) argues for the recognition of "connoisseurship" within the evaluation of educational technology. He states that

> "becoming a connoisseur requires the development of: fine discrimination, a hierarchical system of concepts, organizing principles to structure the relationships among the concepts, and strategies so that one can focus on the salient aspects and ignore the myriad array of other aspects present in any complex phenomenon".
>
> *(Belland, 1991: 27)*

In order to develop connoisseurs in instructional technology Belland (ibid) suggests that instructional technologists need to:

- "experience the 'classic' works in the field — especially instructional film";
- "review and critique instructional systems in all media forms";
- "interact with a heterogeneous array of individuals who are in various stages of developing connoisseurship for the field";
- "read critical literature in the curriculum field as well as general artistic criticism published in the popular press";
- "develop courage to hold and express unique observations and analyses and be able to interact with others based on them";

and that

- "Professors of educational technology will need to study the extent to which connoisseurship can be developed in general. In this way, the profession can decide whether it can continue to prepare scholars capable of observing educational technological phenomena in general or whether sharp specialty divisions will be required"; whilst
- "Researchers will need to examine the extent to which connoisseurship will improve the gathering of data even under traditional experimental paradigms".

(Belland, 1991: 33 - 34)

Recognition of connoisseurship would allow experts to make necessary adjustments to a program and alleviate the negative connotations associated with the 'artistic' aspects of instructional design.

All methodologies have strengths and weaknesses and whilst Reeves states that "any approach quantitative, qualitative, critical, and/or mixed methods, is legitimate as long as the goal is to enhance education" (Reeves, 1999), it could be argued that a mixed method approach would ensure that the researcher is able to utilize the strengths of each and cross correlate the results to ensure validity.

Evaluation stages

Draper (1997), for example, categorises evaluation according to stages and the different aims of each evaluation. He divides these into formative, summative, illuminative, and integrative. He argues, as does Willis (1995), that formative evaluation is most important as it allows time for modification whilst resources are still available. He suggests the most helpful form of formative evaluation is to use "real students in their normal learning situation", but this is likely to increase production time considerably. Early usage of a beta product is often more feasible, but raises ethical questions of making users do the testing that should have been done before the delivery of the product. The result of formative evaluation is usually the modification of the existing design.

Summative evaluation, for Draper, is similar to "consumer reports on goods", the testing often being done by a second party, and the results thereof used by potential purchasers of the product. The problem with including this type of evaluation in the design process is, as Willis (ibid) points out, it often comes too late to rectify any potentially fatal flaws. Thiagarajam (1993) is more scathing stating "unless you are working on your doctoral dissertation, there is no special advantage in collecting data and writing reports if nobody reads them and no useful improvements result".

Illuminative evaluation is open-ended 'ethnographic' research whereby the researcher or investigator participates and interacts with the students and educators to find out what they think and feel about the whole educational situation. "Illuminative evaluation is in effect a systematic focus on discovering the unexpected, using approaches inspired by anthropology rather than psychology" (Draper, 1997).

Finally, Draper suggests the use of an integrative approach to evaluation, which involves the study of "the *real use* of CAL as part of university courses, but with evaluators who can gather more and fuller information than a teacher alone can do" (ibid: emphasis added). This approach encourages a holistic evaluation of the integration of computers within the context of a particular course. Draper says that the effect has been that teachers no longer ask whether to use CAE, or which package to use, but how to make best use of the CAE material available to them. This type of evaluation is important for the assessment of localised use of educational programs and educational interventions.

However, with rapid developments in the technology, and frequent enhancements to course curriculae, very few CAE programs have a long shelf life in their initial format. It is thus suggested that all CAE programs should be considered as 'work in progress' requiring continuous formative evaluation.

2.6.3 Research tools

There are numerous tools available to researchers within the field of CAE. These include software tools such as spreadsheet applications, statistical packages and graphic applications to analyse and present data as well as tools specifically designed for the gathering of data. For instance, The Multimedia Information in Mobile Environments (MiMe) web pages have a number of development and evaluation tools freely available on the Internet, including an:

evaluation matrix which prompts the researcher to consider each evaluation question and to decide which of the many data collection options have the greatest potential for providing the desired information. This tool requires the researcher to list questions on the vertical axis of the matrix and list all the feasible collection methods on the horizontal axis. Each question is then considered and the most appropriate collection method marked;

anecdotal record form is a manner in which observed incidents, or over-heard comments can be recorded. Each anecdote should be limited to a single incident, it should contain a factual, non-inferential description of the observed or reported incident, it should include a description of the situation in which the incident occurred and written as soon as possible after the incident and it should include a separate section detailing the researchers interpretation and feelings about the incident;

expert review checklist which is a simple check list of items that interest the research to checked by an expert in the field. It is expected that the expert would pick up on other issues not addressed by the review, which should assist the researcher in defining the issues to be addressed;

focus group protocol that allows for the formalization of a group discussion and interview process related to the assessment of an IMM program, usually conducted in a localised setting, but could be run online using discussion forums;

formative review log in essence a detailed review of the program including each screen and interaction. It should include a recording of the reviewer's reactions, question and errors for each item and a recording of the corrective measurers taken by the developers for each of the feedback items supplied;

implementation log that records the plans and actual happenings at the time of implementation and a reason for the difference between the two should they occur. Additional space can be allocated for issues that arise in the context;

interview protocol which is a survey activity that should be done systematically to assist in organizing the survey team, determine the survey goals, select a representative sample, generate the questions, construct the instrument, test the instrument, analyse the data and make effective use of the results;

questionnaire which can take the form of checklists, rating scales, multiple choice questions, open-ended questions etc. The person filling in the responses should not need to spend too much time completing the form;

(Heidler, Reeves and Brackett, 2000)

Although it is not necessary to use all these tools, and any tool chosen would need modification for a particular project; the web site offers a comprehensive overview of the types of research tools available to the field.

Thomas (Thomas & Kobayashi, 1987) recommends several approaches he finds useful to estimate effectiveness of educational media:

1. The opinion survey in which the users are asked to describe the strengths and weaknesses of the technology. This has the advantage of providing information from diverse groups, but the disadvantage is that it lacks precision in depicting the factors that have influenced the user's perceptions.
2. Action-research which takes place in the field. This has no control over experimental variables although every attempt is made to assess the variables as accurately as possible. The major disadvantage of this method is that there are too many uncontrolled or unmeasured variables so that it is impossible to estimate how each one has effectively contributed to the results.
3. Controlled experimentation, in which the researcher seeks to limit the number of variables affecting the outcome. Here the disadvantage is that the experimental conditions are usually so different from the field that it is impossible to correlate the outcomes with actual practice.

Draper warns that the practice of using student feedback questionnaires is not nearly as informative as gathering information on the spot, "methods such as exam-type tests and questionnaires with fixed response categories will never warn you that something you did not anticipate is in fact important in the situation you are studying. Hence it is always vital to have some open-ended question and preferably personal observation by the evaluator" (Draper, 1997).

Analysis of data obtained from the use of such tools can be done with spreadsheets, and statistical packages such as SPSS™ for quantitative data and Nvivo™ for qualitative data.

2.6.4 Research ethics

"Respect for persons, their dignity and their rights, holds a central place among the fundamentals that have defined moral thought and shaped the development of society" (Becker, 1998). Evaluation of educational material is fraught with ethical considerations. At the most basic level researchers should take care to 'do no harm' and ensure that participants are no worse off after the research is completed than they would have been had they not participated.

It is not always desirable to use a scientific experimental model of subjects and control subjects. To highlight this point one could consider the following scenario:

An experiment is to be set up that involves three different groups of students, one using the educational intervention only, one participating in the traditional instruction as well as using the intervention material, and the last participating in only the traditional instruction. The most immediate question is how the groups are to be constituted: if by volunteers then the motivation between groups is questionable which could invalidate the results obtained; if the groups are assigned by the researcher or educator then the criteria of selection creates a natural bias; another choice is to assign students to a course in accordance with their marks, but this would mean that prior learning would favour one group over the other and, again, the results of such research would be compromised. Should the researcher opt for random selection then the question of informed consent comes to the fore as some students may justifiably feel discriminated against if they do not have access to all the media available, particularly if the experiment either fails or is eminently successful.

Trandis (1983) places great importance on the issue of 'informed consent' and insist that the subjects should understand what is going to be done and that they should agree, without duress, to participate in the study. This is confirmed by Schrum who states, "researchers should describe in detail the goals of the research, purpose to which the results will be put, plans of the researcher to protect participants, and recourse open to those who feel mistreated" (Schrum, 1995). Confidentiality should be maintained at all times (Melville and Goddard, 1996; Schrum, 1995). Trandis is particularly concerned that the research experience should also "bring some tangible benefit to the participants" (Trandis, 1983: 90).

Reeves (1995) takes the ethical question one step further, making a call for socially responsible research. He reiterates the need for researchers to assure the validity and social relevance of investigation in the instructional technology field even if this requires the redefinition of relevant methodologies.

2.7 Changing face of university education

> "The institution which continues to live on its past successes and practices without regard to the changing social situation of which it is a part will probably find itself without a relevant purpose, without validity, and without usefulness to any but its most devoted members. On the other hand, to force change in an institution without regard to past experiences — both its successes and its failures — without recognition of the subtleties of past adjustments, without sensitivity to tradition, is to ignore the need for internal coherence and orderly creative growth".
>
> *(Ross, 1976: 3)*

As discussed in educational theory, education and educational institutions are influenced by society and in turn influence the society in which they operate. This section reviews the literature that discusses universities at this juncture in their history and the influences that these bring to bear on the development of CAE. It then looks more specifically at a historical perspective of education, and CAE in South Africa and the organisational issues at the University of Natal that have bearing on the introduction of CAE.

2.7.1 Global issues.

Higher education systems in developed countries are being transformed by the same pressures and in similar ways (Scott, 1995); the 20th century, in particular, has witnessed radical changes in university education. There has been a rapid movement from the concept of an elitist ivory tower bent on maintaining the status quo to a mass delivery of educational certification (Katz and associates, 1999).

Scott (1995, 123) points out that during the period 1930 to 1960 universities came to be seen as "intellectual institutions, in an active engaged sense, rather than cultural institutions, in a passive and conserving sense" and that "their claim be the leading scientific institutions ... was uncritically accepted". However, since the 1960s universities have also witnessed:

- the massification of tertiary educational institutions whereby between 15 and 40 percent (Trow cited by Scott, 1995: 2) of the traditional intake age group seek access to these institutions;
- the movement from a binary tertiary educational system to a unitary system whereby the differences between technikons or polytechs and universities becomes increasingly blurred;
- the shift from a conception of innovation as predominantly produced by scientists and other experts to a more pluralist interpretation emphasizing the creative role of users and other stakeholders, thus taking away the perceived exclusive rights of the university as technological and scientific innovators;

- the growth of post-Fordist economic and management trends characterised by flexible organisations, flat hierarchies, and a 'just-in-time' delivery philosophy;
- declining availability of public resources and funding with an increasing enthusiasm for market, rather than social, solutions placing economic accountability at the forefront of university management procedures;
- changes in the nature and demand for particular subject material;
- rapid globalisation and the concomitant pressures of competition brought about by the dissolution of physical boundaries, as well as, the complexities of catering for a multi-cultural student population; and
- the dawning of the information age.

All these forces combine to influence not only the subject matter to be taught, but also the manner in which it is conveyed, to whom it is directed, and the time period over which such discourse takes place. Whilst cognisance is taken that each of these influences has a dialectal relationship with the others, contributing to a radical shift in education they are discussed under separate headings below.

Massification of tertiary education

Traditionally universities have drawn the majority of their students from the 18 to 24 year old population group. Statistically, in developed countries, this group is growing. The intake in Britain being approximately a third of all school leavers (Dearing, 1997) as well as more mature students seeking admission. South Africa's initial foray into an open system (as apposed to the limited access regulated by the apartheid quota systems) followed this trend. The National Commission on Higher Education (NCHE) proposed a strategy that would enable South Africa to increase higher education participation to approximately 30% of the 20-24 year-old group over the next decade, increasing the student population from approximately 800 000 students to approximately 1 500 000 in the year 2000 (Sehoole, 1999). Accordingly adjustments to the teaching methodologies were made to accommodate the increase in student numbers, but further modifications were also to necessary to enhance the learning of students from a variety of cultural, social, and economic backgrounds.

However, the predicted growth in this area is now being questioned in a society that is facing an HIV/AIDS pandemic. UNAIDS (2000: 124) estimates that in 1999, 19.94% of all South Africans were living with HIV/AIDS, whilst in 2000 the Department of Health (2000) estimated that of the total South African population 24.5% were infected with HIV, and in KwaZulu Natal, this estimate was as high as 36.2%.

The UNAIDS (2000) report points out student numbers and productivity are directly influenced by the spread of the disease, as the traditional intake age group is the most susceptible. HIV positive students could fail to re-enrol for courses or become progressively more ill and less productive during the course of their study. However, as the disease spreads and takes a hold on other family members less direct influences could include the loss of financial support to HIV negative students whose financial guardians face increasing burdens on their limited resources.

Institutions facing this pandemic also have to consider the potential loss of productive academic staff and their teaching expertise as faculty becomes more susceptible to the disease and less able to fulfil their teaching and research commitments. Educational Institutions throughout Africa are under pressure to find innovative ways to ensure they harness current intellectual skills for future teaching and research needs. One possible method could be the development of sustainable CAE systems, allowing less experienced staff to take over the role of facilitators and freeing the role of experienced staff to develop the learning material.

The development of a unitary system of tertiary education

As more people demand access to tertiary education, the institutions that support it are modified to suit the growing needs. Scott (1995) identifies four types of higher education systems:

- dual systems, in which universities stand apart from the rest of post-secondary education;
- binary systems, where alternative higher education institutions are established to complement or rival the universities
- unified systems, in which all higher education institutions are treated equally
- stratified systems, characterized by a division of institutional labour.

Adapted from Scott, (1995: 169)

He suggests that there is a flow whereby there is a "tendency for dual systems to develop into binary systems, for binary systems to become unified systems, and for unified systems to become stratified, whether formally or informally" (ibid: 169).

For Scott (ibid), elite higher education systems have clearly demarcated frontiers, but the boundaries of mass systems are more difficult to define. He states that the extensions of higher education have incorporated more of other post-secondary education through partnerships with other organisations, including corporate training, mass communications, research and development partnerships with industry and other stakeholders, as well as technology transfer and consultancies. He goes on to say that the boundaries are further eroded internally between departments.

This is clearly reflected in certain aspects of tertiary educational development in South Africa where the differentiation between technikons and universities has become progressively less defined, where both types of institutions vie for corporate partnerships, and where many of the new courses being developed are looking for students employed in the corporate and government sectors.

Universities will have to appeal very carefully to the sensibilities of industry in a) attracting traditional age group students who are concerned with the marketability of their degrees, and b) selling their courses to corporations for the reskilling of their employees.

Post-Fordism

The industrial revolution and Fordist mass production methods required a 'just-in-case' development in industry and education. Traditional university teaching required students to learn vast bodies of fairly stable information with the idea that it would generally prove to be useful at a latter date. However, the mass-production of Fordism has now changed to a 'just-in-time' philosophy whereby goods are manufactured when they are needed, and manufacturing plants are able to customize mass produced goods on request. The same is being reflected in education, whereby courses are customized for individual needs, societal concerns within specific time frames, and on a 'need to know' basis. Duderstadt (1999: 4) argues that we are witnessing a change from a 'just-in-case' educational system to a 'just-in-time' system including programmes that are 'just-for-you'. Students are required to find out the information required to solve particular issues and critically apply previous solutions in ever changing situations. Thiagarajan (1993) suggests that there is a need for 'just-in-time' instructional design strategies to allow for the rapid adaptability and necessary customisation of teaching modules.

Educational literature is permeated by the catch phrases of industry, for instance, Lloyd (2000) writes of "educational establishments address[ing] new markets with new products" and "a different product portfolio and cost structure could replace some traditional providers". He sees "university business systems" providing a barrier "against loss of market share ... providing income streams". Smyth, Dow, Hattam, Reid and Shacklock et al (2000: 1) argue that

educational institutions "are being required to act as if they were private businesses driven by the quest for efficiency, pursuing concrete specified outcomes, and operating in a supposed atmosphere of marketization and competition with each other for resources, students, reputation and public support for their continued existence".

Sehoole (1999) states that South African institutions have "responded positively to the challenges of the market" and gives as examples "diversification of programme offerings and [the] introduction of new programmes to attract new students, ... [as wells as the] introduction of distance education programmes and technology-enhanced learning in traditionally face-to-face higher education institutions". In South Africa there is certainly a proliferation of private sector companies showing an interest in registering as private higher education institutions; as at the 8 May 2000 there were 21 conditionally registered institutions, a further 20 offered conditional registration, and 101 offered extensions for registration (Ministry of Education, 2000). Blustain, Goldstein and Lozier, (1999: 54-55) warn "colleges and universities cannot continue to draw boundaries around themselves and say, 'we are the only legitimate players in the higher education business'".

Existing, traditional universities have to create a market for themselves in competition with these new private enterprises, particularly as the private higher educational institutions are eroding the student intake in the low-cost high-return courses such as commerce and leaving the high-cost low-return courses such as the sciences to government funded institutions (Gourley, 1999).

Along with these changes we see the change in management styles within institutions with flatter hierarchies, amalgamation of departments and cross-discipline courses proliferating. Initial explorations in CAE and CMC suggest that technology can play an important co-ordinating role and facilitate changes in these areas, as well as attracting students to well resourced facilities.

Declining availability of public resources and funding

Other "evidence indicative of fundamental changes in education include[s] decreasing financial support from state governments; increasing requirements for accountability, such as post-tenure review and national education standards; increasing demands to justify funding and funding increases, e.g., caps on tuition increases; and calls to improve the cost-effectiveness of education using technology" (Tissue, 1997). In South Africa, there is enormous competition for limited public resources from: elementary and secondary educational requirements; infrastructure development; welfare needs of the unemployed, disabled and pensioners; health; housing; job creation; and land reform.

University funding is low down on the list of public spending priorities. In an attempt to meet growing demand for higher education whilst costs are increasing and public revenue and support is declining, many institutions have increased tuition fees (Duderstadt, 1999; Johnstone, 1997). Simultaneously, in order to survive, universities are paying more than just lip service to the needs of the private sector and are actively encouraging partnership agreements that move them from the field of pure research to applied research and teaching. Johnstone, (1997) suggests that "the solutions to the new austerity of higher education will be some combination of:

- less spending per student in the traditional universities, mainly meaning fewer regular, fully qualified faculty per student
- more students shunted off to lower-cost, short-cycle forms of tertiary education;
- more rigorous standards, including more stages or levels, even with the first degree, at which point students deemed to be insufficiently performing can be turned out of the university system, thereby lowering overall enrolments (and costs); ...
- governments encouraging the formation of private universities and colleges ..., and

- governments rushing to embrace new technology-based forms of tertiary education, less for the added access or the added learning that these forms make possible, but for the lower costs that they are thought to promise".

Lloyd (2000) states that investments in computing and communication technologies "can improve the efficiency with which existing educational services are provided and with careful thought, the effectiveness with which education as whole can be delivered". The technology would enable the institutions to reach more people with a decreasing cost per head, and a decrease in the overheads of maintaining buildings and other infrastructure requirements for face-to-face lectures. Blustain argues that corporate customers see "technological sophistication as an important differentiator among education providers". (Blustain et al, 1999: 57).

However, the development of such computer courses poses new dilemmas for the institutions and participating developers; the question of intellectual copyright of course material is a hotly debated subject and has lead to union action in Canada, with a final decision that university professors will not be forced to use technology (ibid: 70). Faculty also express the fear that once materials are developed less experienced tutors will be employed to facilitate the course and the more experienced, and thus more expensive, staff will either be retrenched or not replaced when they leave. There is also the added question of faculty, in their private capacity, developing course material for other institutions, which then act in competition with the faculty employer.

Changes in technological and scientific innovation

As mentioned the funding crisis also has implications for the type of research undertaken at universities. Duderstadt (1999: 4) states "the relationship between the federal government and the research university is shifting from a partnership, in which the government is primarily a patron of discovery-orientated research, to a process of procurement of research aimed at addressing specific national priorities". However, further to this, industry is increasingly taking a leading role in technological and scientific innovations, as can be seen by recent developments in pharmaceuticals and computer technology. On occasions this commercial innovation is done in collaboration with university researchers, but the relationship between commercial interests and "pure" research is not unproblematic especially when the questions of ownership of patents and intellectual property rights have strong fiscal imperatives.

This increased competition between organisations to register products for their own financial gain can be detrimental to pure scientific endeavour and research. Scientific innovations are very seldom developed by a single person, and many diverse teams of people working towards the same goal leads to a collaborative and healthy development cycle; when enormous amounts of money are involved the participates are less likely to collaborate, more likely to guard their work jealously; and this may hamper true scientific endeavour. Educational institutions need to clearly identify policies, procedures, and ethical concerns before implementing systems for purely short-term financial gain. The same considerations should be given to the implementation of CAE systems, and systemic analysis should be paramount when considering the overall implications.

Changes in the nature of, and demand for particular subject matter

The changing relationship between universities and industry is compounded by the rapid development of knowledge and innovation in many disciplines, this in turn brings about changes in the content of disciplines being taught. These changes come about from:

- within a discipline, especially in the basic and applied sciences where there is rapid development in the knowledge base;

- perceived obsolescence and/or irrelevance of many academic programmes and faculty, including the study of 'a dead languages' such as Latin, and the study of ancient Greek and Latin classics;
- the rapid growth in demand for some courses such as commerce and computer sciences, where potential graduates perceive a ready market for their newly acquired skills;
- the need for integration of knowledge across traditional disciplines, such as education, psychology, sociology, and computer science in the development of CAE programs; and
- obsolescence of the physical locality of teaching with the advent of the Internet and proliferation of distance learning.

Adapted from Johnstone (1997)

CAE systems need to be easily modified if they are going to have a long-term impact in a dynamic changing learning environment.

Globalisation

Globalisation is a buzzword touted by industry, education, and the media, however very few of these industries offer a definition. Waters (cited by Smyth et al, 2000: 1) defines globalisation as "a social process in which the constraints of geography on social and cultural arrangements recede and in which people become increasingly aware that they are receding".

Blustain (Blustain et al, 1999: 54) argues "in a world of twenty-four-hour financial markets, real-time global video games, telecommuting, and instant images from Mars, there is no reason why pedagogy must depend on rounding up students into one room for fifty minutes, three times a week".

Dawning of the 'information age'

Literature about the educational needs in the 'information age' refer repeatedly to the concept of life-long learning. Scott cites Christopher Duke as having written of the learning university aligned with the learning organisation and learning society. He claims that Duke argues that the university has ceased to be "a finishing school for school-leavers and instead is predominantly engaged in providing continuing education for adults" (Scott, 1995: 4). Lloyd echoes this sentiment stating, "the role of Higher Education has become increasingly important for an increasing proportion of the community".

There is certainly a notable growth in the number of mature students applying to universities particularly for courses specifically designed to meet the needs of continuing professional development. However, Scott (ibid) points out that with a growth in population numbers from the traditional intake age group, the universities have not yet abandoned their role as 'finishing-schools'.

Blustain et al (1999) point out that traditional students contemplating registration at a tertiary educational institution would make their decision based on a combination of the reputation of the institution, the curriculum and educational standards offered, the cost of the course, the physical location, and the student activities offered. However adult learners and corporations wishing to enrol their staff are concerned with: access in terms of proximity to home and work; convenient schedules accommodating both work and family commitments; partnerships in terms of the ease of doing business and adaptability of courses, and the customisation of curriculum to their specific needs. Flexibility of course content, design, and delivery included with accessible modularised delivery are crucial to capturing these markets.

2.7.2 Historical context of education in South Africa

South Africa is prey to the same forces changing tertiary education as other universities in developed countries. Sehoole (1999) begins his paper by stating "As I was listening to a range of speakers outlining challenges facing higher education in their respective countries, it was as if I was listening to a report on challenges facing higher education in South Africa". However, there are certain elements that are uniquely South African at this time in history. The most obvious being the rapid integration of a multi-racial, multi-cultural, and multi-lingual student population in what was, until recently, predominantly mono- cultural, single-lingual institutions.

South Africa has also witnessed attempts to change the curriculum and teaching methodology of schools from which tertiary educational institutions traditionally draw their student population. This, however, has not been entirely successful and students entering university are often from vastly different educational backgrounds, with varied levels of educational preparedness. The reported demise of Outcome Based Education in South African schools is premature, but there are still attempts to modify the system to cater for our specific needs and create a workable model across differently resources schools.

Government interventions that attempt to ensure quality control and standardization are currently underway under the auspices of the National Qualifications Framework and the Skills Act. This concept is not uniquely South African, but it is new to many of our faculty who are reformatting their courses to cater for the legislation, whilst expressing concern about academic freedom. It also raises the question of unlicensed copying of courses as the modules and specifications of each course will be published in detail and private enterprise can emulate the entire system.

In the light of the pressures that have evolved over the last six years it is important to consider the history of an institution in order to place a perspective on who, what, and by whom, students are being taught.

Historical background

As the 20th Century draws to a close, it is perhaps pertinent to highlight some of the historical events that lead the University of Natal to its current position, particularly as in the near future many of the students entering the institution will have no conscience memory of these events. (Please note that terms referring to race are used in their historical context only and are thus enclosed in quotation marks.)

In 1936 the Natal University College (later to become known as the University of Natal) offered part-time segregated courses for 'non-white' students in the humanities, with some limited courses in the law faculty. The faculty of medicine was established in 1951, and admission was restricted to 'non-whites'. The Extension of University Education Act (No 45 of 1959) became law on 19 June 1959. It created state-controlled universities alongside state-aided universities; it removed the right of universities to accept or reject students for admission; it prohibited 'whites' from attending the universities for 'non-whites'; and it barred 'non-white' persons from registering with or attending as students of 'white' universities. However, there was one notable exception; a 'non-white' person could be admitted, "subject to the approval of the Minister, to a course of studies at an open university if such a course of study was not offered at the particular university college to which he was entitled to go" (Behr, 1978: 137).

In 1978 the University of Natal's Medical School accepted 'whites' into postgraduate courses for the first time. In 1979 the Universities for Blacks Amendment Act (No 52 of 1979) made provision for 'black' universities to admit students other than 'blacks' as long as the permission of the Minister of Education and Training was obtained in writing.

The early 1980s saw some lifting of the policing of these Acts and The Universities Amendment Act No 83 of 1983 introduced a 'quota systems' allowing universities to take responsibility in admitting individual students subject to the quotas determined by the minister in consultation with the university authorities (Cooper, Motala, Shindler, McCaul and Ratsomo, 1984). Finally the lifting of the embargo against the ANC and other liberation movements saw radical changes in the demographics of university students.

However, little change has taken place in terms of the staffing and teaching that continues at most of these open universities. Some concern is expressed about 'previously' disadvantaged students, language issues and lack of preparedness - but there is little visible effort made by the university to change its culture of learning and teaching to accommodate these changes.

Robert Brand, in an article in "The Mecury" (Wednesday September 8, 1999), quotes Education Minister Kadar Asmal as saying "the standard and way we do things at our universities is appalling ... Our whole method of teaching, of education and training, is still redolent of the teaching of 100 years ago".

The lifting of the Apartheid prohibitions on access to tertiary educational institutions led to a belief that the number of students attending universities in South Africa would grow exponentially and that these students would be of differing racial, cultural and religious groups. More recent trends suggest that the growth curve has levelled and may even begin to decline, although students are from diverse backgrounds. The unexpected change is that the students average age is also changing, where in the past most students were representative of the ages between 18 and 24, now the universities are increasingly servicing the needs of the "life long learner" (Gourley, 1999).

Specific needs of the University and its medical school

It is important to place the teaching at the University of Natal's Medical School in a historical context. Unlike the other two campuses at the University (Howard College and Pietermaritzburg), the students at Medical School have always been drawn from the groups most disadvantaged by the Apartheid structures. Thus the majority of the students were under-prepared by under-resourced schools, learning in a language that was not their mother tongue and learning a subject that is intrinsically of a foreign or secondary culture. More recently the demographics of the student population have begun to change and there is more variety in the cultural and educational backgrounds of the students attending Medical School, but by far the majority still fit the initial categorization and any educational developments taking place must consider the difficulties that these students face.

The University is obliged to meet the requirements of the National Qualifications Framework (NQF); use outcomes based education; and make the best provision it can for a student base from a multi-lingual, multi-cultural background. These incentives or constraints place a responsibility on all staff to explore as many instructional strategies as possible to ensure they can meet both their moral and legal obligations.

Medical school curriculum is characterised by vast amounts of factual information across a number of different scientific disciplines. Traditional teaching of this information has taken the form of instructivist lectures and tutorials that are "overly biased in favour of tertiary care medicine" (Ross and Ross, 1989: 173). This has had the effect of encouraging students to develop a mastery learning strategy, with the result being a marked decrease in the retention of factual information over time, whilst other methods can greatly enhance long term recall, problem solving skills and transference of knowledge (Blunt and Blizzard, 1975; Reeves, 1995).

Concern is expressed repeatedly in the literature that the curriculum lacks relevance to the needs of the community, trains for curative medicine at the expense of primary and preventative

health care, and produces doctors who are unfamiliar with problem solving techniques and the continuing education required for modern holistic medical care (Ross & Ross, 1989). The University of Natal's medical school faces not only this dilemma but also the added pressure that their undergraduate students will soon be situated in remote rural hospitals whilst undertaking their studies. As a result the University curriculum developers have investigated problem based learning, as initiated by McMasters' Medical School and emulated by medical schools around the world, and the Medical School's entire curriculum will move into this mode beginning in 2001. There is thus a pressing need to be able to distribute learning resources to remote areas whilst remaining in contact with students who will have different scheduling commitments. Distributive processing, telematics, collaborative and situated learning, and CMC facilities become vital for the educational process.

2.7.3 Historical background to the use of computer assisted education in South Africa.

Although faculty who wish to introduce CAE into their courses at the University must look at, and learn from, international issues, it is as important that they take cognisance of local experiences. Previous internal investigations at the University as well as a review of conference papers delivered locally shows the historical development of CAE in South Africa.

It is clearly evident that most early developments in the late 1980s and early 1990s in South Africa made use of the PLATO™ systems. However, due to the high cost of maintenance of the Cyber Mainframe and dedicated terminals, institutions such as the University of the Western Cape and Rhodes University began to port the software to PC based networks using TENCORE™ as the authoring program (Price & Murrell, 1990).

During this period, institutions interested in developing their own software were using the Quest authoring language. Nearly all of the work was done in the DOS environment except where PLATO™ used its own Cyber system.

Generally delivery took place via Local Area Networks (LANs) or on stand-alone PCs except once again the PLATO™ systems that facilitated long distance delivery such as the University of Transkei and Fort Hare University acting as satellites of Rhodes University's system. The major advantage of the PLATO™ system was its vast library of software; one of the major disadvantages was that these were developed for an American audience, based on the United States' educational curricula. Terminology for English courses were American (e.g. 'sidewalk' instead of 'pavement'), which was particularly confusing for second language users of the system, and in at least one mathematics module, the BODMAS system used by South African schools was ignored (Personal observation, 1990). Later versions of PLATO™ tried to address these issues, but these were not always addressed adequately.

Three of the universities that invested in the PLATO™ system used it for 'outreach' programs as well as for their own educational purposes. Rhodes University, as mentioned previously had remote stations, the University of the Western Cape had a schools outreach programme, and the University of Zululand bussed students from outlying schools to use the system.

During the period 1989 to 1998, the rapid development of technology and software for the World Wide Web (WWW) made it more viable for delivery of multimedia educational systems. It was also during this time that the South African legal restrictions on Internet accessibility and web server activities were lifted and Internet Service Providers proliferated.

By 1998 a clear trend is indicated in which universities have modified their developments to run under the Windows operating systems, or to be delivered via the Internet. Most of the developments discussed in papers presented at the 1998 SAARDHE Educational Media

conference were about Internet/intranet delivered material and a great deal of interest was expressed in the use of email for computer mediated communication in teaching and learning. However, it is also interesting to note that Stellenbosch University, one of the more prolific developers and users of CAE programs in the early 1990s, was 8 years later changing their *modus operandi.* In his paper at the Educational Media Conference in 1998, Hugo outlined "an alternative model for media support in Higher Education". He pointed out that Stellenbosch intended moving away from the concept of a media centre for development to a combination of outsourcing high level programming requirements and staff development for the easier developments such as Powerpoint™ (Hugo, 1998).

2.8 Conclusion

This dissertation is a typical example of a cross-discipline research project where a number of different disciplines come together in developing effective educational material for a changing society. The literature reviewed reflects most of the current issues being debated in this area and highlights numerous researchers' concerns that across the broad spectrum of disciplines there is a need to refocus education to cater for:

- increasingly diverse student populations;
- different learning styles;
- a change in the composition of tertiary educational institutions;
- change in the management of such institutions;
- change in the composition of knowledge and exploration of various disciplines;
- increasing competition across geographical boundaries;
- technological advances which may or may not be the result of research within these institutions;
- the shift of focus from preparatory education to life-long learning.

This literature suggests that educators are looking to technological innovations to assist in the delivery of quality education whilst addressing these changing dynamics. South African institutions that would like to compete within this borderless global community, must ensure that they at least maintain, or preferably improve, on both the quality and accessibility of their courses, at the same time maintaining relevance for this country's specific socio and economic demographics.

In developing new material it is important to consider both the historical failures and future potential of CAE. But it is equally as important to bear in mind the changing dynamics of the society in which we live, including the changing dynamics of the educational process in the 'information age', and the developments in technology allowing for improvements in the development and delivery of such material.

CHAPTER THREE
CASE STUDY – INSTRUCTIONAL DESIGN

3.1 Introduction

This chapter discusses the instructional design process of the case study following the key steps of the ID process; analysis, design, development, implementation and evaluation. However, the design process closely followed Willis' R2D2 model as discussed in the literature review. Each phase resulted in several iterations of previous stages, the most radical of these being during the design and development phases.

These topics are separated into the following headings:

- Choice of study project
- The needs analysis
- Design and development
- Implementation
- Evaluation

3.2 Choice of study project

When embarking on a course of study one tends to be influenced by the department and current research within a department and this dissertation is no exception. For some time there has been a reciprocal relationship between the Department of Computer Science and the Medical School whereby the Computer Science honours students studying Computer Assisted Education work on projects to be used by the medical faculty. There are a number benefits to all parties in this relationship.

- Most importantly the students work on 'real' projects, having to consult with an external client, work to a deadline and in some cases work in teams to complete a project. They generally expressed appreciation that their work would be used, and that it was not some arbitrary project dreamt up by the course facilitator.
- The medical school has managed to compile a 'library' of software, some usable and immediately useful, others requiring modification before implementation.
- Faculty at the medical school were able to make comparisons between expensive commercial programs and locally created software.

This project was initiated within the parameters of this scenario, working with Department of Human Anatomy. Initial interest in CAE was expressed as the department was having a number of difficulties in teaching their particular course using traditional methods and it was hoped that a locally developed CAE program might alleviate a number of problems.

1. The course normally consists of lectures, tutorials using skeletons and dissections of cadavers. At the time of initial negotiations the department was experiencing difficulty in sourcing sufficient cadavers for their purposes as normal sources had dried up.
2. The department expressed a need to have supplementary material available for the students to explore outside of scheduled tutorial and laboratory times.
3. Software available commercially is expensive and does not use the methodology adopted by South African medical teaching institutions.
4. If the project and final program was seen to be valuable, other institutions could share the development of further sections and a final version be made available to all participating institutions.

The area of study was limited to the leg[6], the smallest area of study within the anatomy syllabus. Subject experts suggested that it would be manageable as a research project with limited graphics, but it would be sufficient to assess the value of the development. However, there were unforeseen disadvantages in limiting the area of study, the most significant being the limited scope of revision exercises and the resultant lack of exam questions in this anatomical area in final conventional examinations. This severally limited the types of summative statistical analysis available to assess the overall significance of the project.

3.3 The needs analysis

Usually, the first task of instructional design is described as a 'needs analysis'. This was conducted within the boundaries of the project spelt out above and included;

- an assessment of the facilities available to the department and needs of faculty,
- a broad assessment of student profiles and educational needs,
- a review of current material available, and
- a outline of the methodological approach to the subject material and course outcomes.

The design process was similar to that described by Willis (1995) in that the project was identified by a body separate from the developer, and to a lesser extent separate from the staff for whom the product was being developed. Some of the requirements were only pinpointed as the development took place, and during extensive formative evaluation.

An initial needs analysis was conducted through informal interviews with departmental staff and a review of research projects conducted by University of Natal staff members. Whilst some of the needs identified were common amongst most medical teaching institutions there were others that specific to either South Africa or this specific institution. The key elements identified in this process are discussed below

3.3.1 Course outcomes

Students are required to know the names, anatomical position, functions and clinical aspects of the bones, muscles, nerves and blood vessels of the leg. At the end of the course the students should have a clear understanding of the functions of each component and how to diagnose injuries to the leg. They should also be able to make assessments of the clinical value of various anatomical structures and know which are the most likely to be used for grafting and transplanting purposes.

3.3.2 Student Profile

Two hundred students are admitted as first year students and, as pointed out in the literature review, they are drawn from a broad spectrum of the South African population. The students attending the course during the study period were multi-cultural, and the racial composition was a mixture of mostly 'Black/African' and 'Indian'. 'Coloured' and 'White' students were notably in the minority making up less than 10% of the total intake. Many of these students came from disadvantaged schools and were thus largely under-prepared for a scientific and medical curriculum.

Language

The medium of instruction is English, which for many of the students is at best a second language, sometimes a third or fourth language. Furthermore not all the faculty are South African, and staff members with broad east European accents teach the students. This is further

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6 Anatomically the leg is the portion of the lower limb that starts below the knee and ends above the ankle.

complicated by the necessity to learn the Greek and Latin terminology used in medicine. There was also a need to make a transition between the jargonised English used in the textbook and the limited command of the language used by the students. By introducing the terms to the students using a variety of media the students should be able to access the medical terminology and writing style in medical literature. However, not all students would require these interventions, so the development had to involve the careful construction of the text in order that people didn't feel they were being patronized and options were given to users for additional information.

Graphic literacy

Research by Amory and Mars (1994) showed that students display different abilities in the interpretation of graphics. Not all students are able to make necessary associations between the different types of images used in medical literature. These typically include sketched images, graphically realistic images, photographs, which must also be cognitively associated with the grey matter viewed in the dissecting room, and the bloodied realistic mass on the operating table.

Textbooks are particularly difficult for the students as graphics are often placed a number of pages earlier than the text being reviewed. It was envisaged that a system that presented various forms of imagery on the same page as the relevant text would be extremely useful to the students.

3.3.3 Educational theory and instructional strategies

Historically the medical school has used an instructivist method of teaching in lectures, tutorials, and laboratory work. Students were based on campus with all interactions between students and faculty conducted on the University's campuses. Changes in educational methodology are being introduced in the year 2001. The Medical School is moving to a problem based curriculum, where the six year course is being reduced to five years, and students will be based in remote off-campus hospitals in the near future.

It was necessary for the CAE program developed for this case study to take into account the language, culture, and learning styles of the students. Furthermore, whilst recognising that the curriculum would change shortly, the current students would need to use material suited for the current didactic styles.

The high level of factual information in the curriculum of Human Anatomy lends itself to instructivist teaching and rote learning, including mastery instructional strategy, which has been practiced in face-to-face lectures. However, the introduction of a self-paced interactive module was seen as lending itself to a more student centred approach as the students were given greater control over the time and pace of their learning. Whilst this was by no means constructivist in approach some of the problems associated with lecture-based instruction were alleviated.

3.3.4 Assessment of learning

True to an instructivist mode of education, most examinations of Human Anatomy take the form of multiple-choice questions. Some of the students claim that they are disadvantaged by this mode of testing as the questions are phrased in such a way that they need a clear understanding of the nuances of language to correctly interpret the question. They feel they are being tested on their understanding of English, not the subject matter at hand. The students expressed a need to have a self-testing and revision section similar to the examinations conducted by the department.

3.3.5 Physical conditions of the learning setting

At the beginning of the project students were required to work in a 30 workstation PC laboratory with a Novell Network running under Windows 3.1. The machines were a combination of 386 and 486 systems with a maximum of 256 colours and screen settings of 640x480 pixels. All machines had a CD reader and sound cards.

Prior to implementation, this equipment was upgraded to a 100 workstation PC laboratory, running with a Novell Network but using Windows NT. The screen settings were adjusted to 800x600 high colour resolutions.

The speed of the Network and Internet accessibility at the time of development was slow thus a decision was made that the software developed should, if possible, run from the local file server but also be deliverable via individual compact disks.

3.4 Design and development

The design and development was informed by the information obtained in the literature review and many of the elements of design took place simultaneously with the development of the program in line with the R2D2 model of instructional design. These are discussed below under the headings of the literature review where they informed the development of this program.

3.4.1 Choice of authoring system

As is the case in most developments the choice of authoring system was made by external parties. The University of Natal's Multimedia Research Group had done extensive research into the systems available at the time, and made a recommendation that the University standardise on Macromedia's Authorware™. Initially this software was purchased under an educational license agreement that specifically states that any developments cannot be sold for profit. However, a more recent version of the program was compiled under a professional license, which would allow the program to be sold should it prove beneficial[7].

There are two major advantages in using Authoware™ for this development, the first being that it lends itself to a prototype methodology and allows for easy modification following formative evaluation. The second is that it has no runtime costs as it creates a self running .exe file when packaged.

3.4.2 Development methodology

It was decided from the outset to use a prototype system of development, with initial designs being reviewed firstly by the experts within the Multimedia Research Group, by postgraduate students in the department of Computer Science and by subject specialists.

3.4.3 Interface Design

The literature reviewed highlighted the importance of the interface suggesting it could be one of the critical factors leading to the success or failure of a system (Baeker & Buxton, 1987; Shneiderman, 1986; Sullivan, 1994; and Vaughan, 1994). The development process took cognisance of this and careful consideration and formative testing were used to develop an appropriate interface. The most important aspects of interface design identified by the literature review that influenced the design of the program are listed below.

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[7] This does not negate the issues of copyright related to the intellectual material and images used in the program and discussed under the heading "Data acquisition and the issue of copyright".

Prior learning

At the beginning of the project the students at medical school had no formal training in Computer Literacy as part of their course. Some would enter the course having used computers at school or at home but the majority of students were viewed as novice computer users. They would become familiar with Windows 3.1 and any system developed should adhere to these conventions.

Learning time

The time spent learning to use the system should be minimal. The design was made as intuitive as possible, but instructions for the use were given for those that needed some assistance in understanding the conventions.

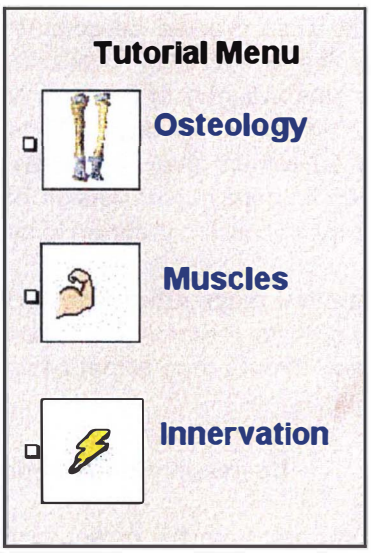
Major conventions followed

The design adhered to major conventions such as textual hot spots being displayed in blue, and mouse icons changing to a hand when passed over selectable items.

Cultural issues

Cognisance was taken of the multi-cultural constituency of the student body and care was taken to insure that language was non-sexist; images portraying people were multi-racial and where anatomically appropriate of different genders. The language used for messages and feedback was non-patronising and no insulting graphics were incorporated. Following the findings of Andrews, (1994) as well as Amory and Mars, (1994) all iconic symbols were clearly labelled so that students with different cultural interpretations of images would understand their meaning in context.

Figure 3.1
Iconic labelling



Colour

It was important that all images display true photographic quality, but care was also taken to adhere to medical conventions in the display of nerves and blood vessels. Particular note was taken that in the display and animation of realistic images of nerves the colour yellow did not contrast sufficiently with the background, but the negative aspects of breaking a medical norm would be more detrimental for the learning process. Background colours were used as subliminal cues to the students that they had entered a different area of the program and to provide a visual contrast with the images. Where images were not clear against the background, as in the case of the cross section images, a secondary black background surrounded the images.

Figure 3.2
Backgrounds

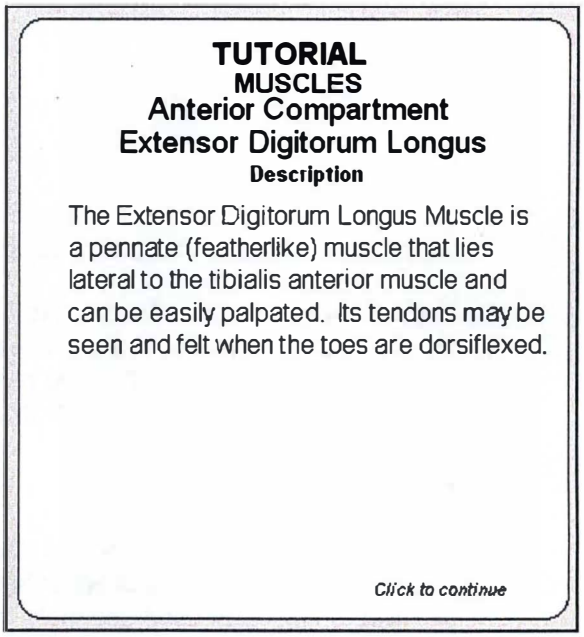
	Used for the entry screens and major navigational options.
	Used for the instructions screens.
	Used for the tutorial modules
	Used for revision modules.

Textual information placed on top of the textured backgrounds was not easily readable and thus a boxed white area was created to enclose the factual information to be read on screen.

Text chunking

Text was chunked into readable sections, allowing one point to be made per screen viewed. Where more text was necessary to cover a topic a 'more' button was placed immediately below the information as a cue for the students to read further. One of the major problems of medical textbooks is that the images are often positioned on pages far removed from the actual text so it was important that the images were placed along side the relevant text on screen. Generous use was made of white space and Arial fonts were selected to enhance readability on screen.

Figure 3.3
Textual layout



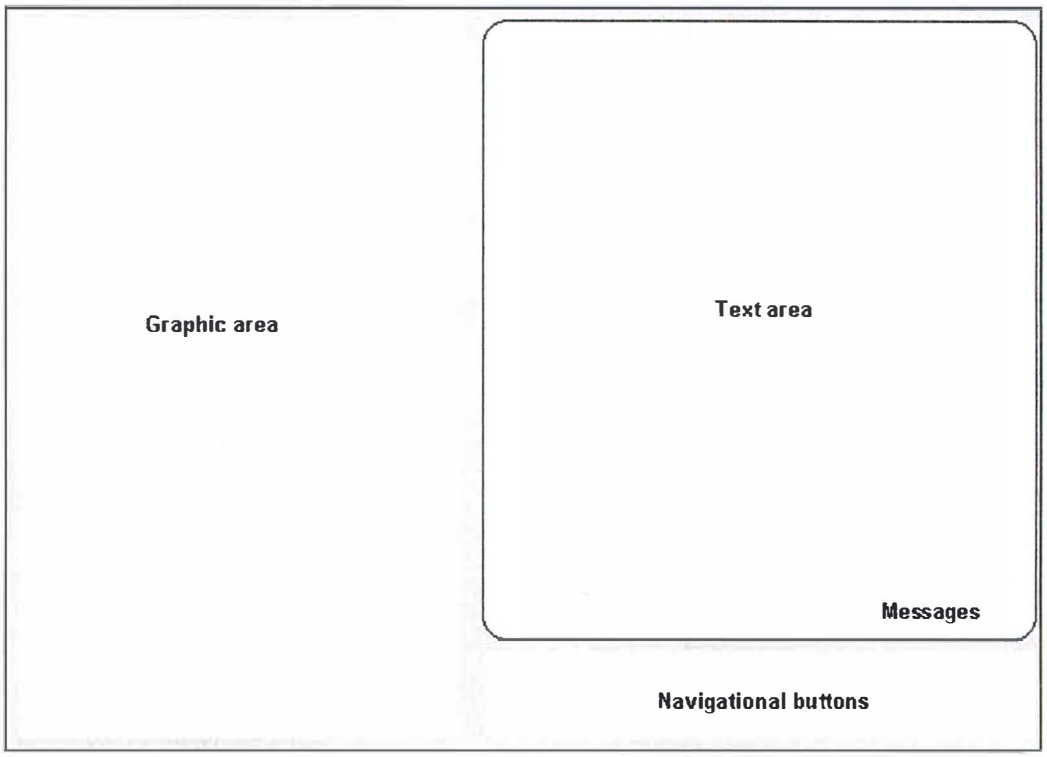
Messages and feedback

Care was taken to ensure that navigation messages would be viewed immediately below the area being viewed and were usually placed at the bottom of the text box. Feedback on revision exercises incorporated feedback for both correct and incorrect answers and was always phrased in a constructive, positive tone.

Screen layout

The subject experts expressed a preference for the visual material to be presented in as anatomically correct position as possible which, given the subject material, lent itself to a vertical rectangular shape for diagrams. Thus the screen was divided into three main sections, the graphics on the left, the text to the right and the navigation buttons permanently present in the bottom right hand corner.

Figure 3.4
Screen grid



The initial development was designed to fill the entire screen, but at the time of implementation the screen resolutions were in the process of being changed and varied between 400 x 600 pixels with 256 colours and 800 x 600 pixels and true colour. It was thus decided to make the program fill a specific number of pixels that would accommodate both settings.

Sound

Depending on how it is used, sound can be either appealing or irritating. Working on the principle that if an element does not enhance readability or understanding of the topic it should not be used, sound was used sparingly in the overall design, and the whole system could be used in machines without sound cards. Music was used as a cue that students were moving from one section to another. Sound bites were added for the pronunciation of unfamiliar terms, but these were added as an iconic selection so only those students who specifically wished to hear the words would have them sounded.

Animation

Animations were used to draw attention to certain elements. Arrows were animated to draw the student's eye from the text to the specific portion of an image, whilst the magnifying glass indicated that a certain portion of an image would be enlarged for greater detail. Nerves and blood vessels were animated to highlight the path they follow in the area of anatomy. Screen transitions were simple but text displayed downwards in order to draw the eye to the natural reading order.

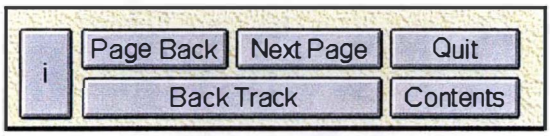
Use of metaphor in navigation

The initial prototype included a menu driven system that was rejected at the outset by the experts within the Multimedia Research Committee as being too far removed from the experience of the students. It was decided that a book metaphor would best suit all their needs.

Thus navigation was described as 'Page Forward' and 'Page Back' and the index as Table of Contents.

It was presumed that students would choose to take either a holist or serialist path through the material as described by Pask (Claxton & Murrell, 1987). Thus the navigation was designed so that students could page through the entire program using the Next Page and Page Back options in a serialist manner or they would be able to use short cuts in the table of contents and hot spots in the text for a holists approach to the subject material. The information button was used to give the students a contextual overview of the length of the topic being reviewed, whilst the Back Track button was available for students to move to previously viewed screens if they had made use of the short cuts. The buttons were placed on the bottom right hand corner of the screen and were permanently accessible.

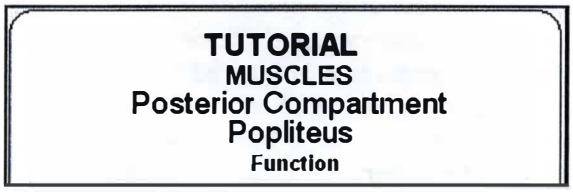
Figure 3.5
Navigational buttons



Labelling of screens

The criticism of "getting lost in cyberspace" is also relevant to locally delivered application programs. Thus to give the students a sense of where they were in the program, each screen is clearly labelled with the topic and sub topics being discussed, figure 3.6 shows the headings that would be displayed when the student was viewing the information on the functions of the popliteus muscle in the posterior compartment of the leg.

Figure 3.6
Headings as a cue to position within the program.



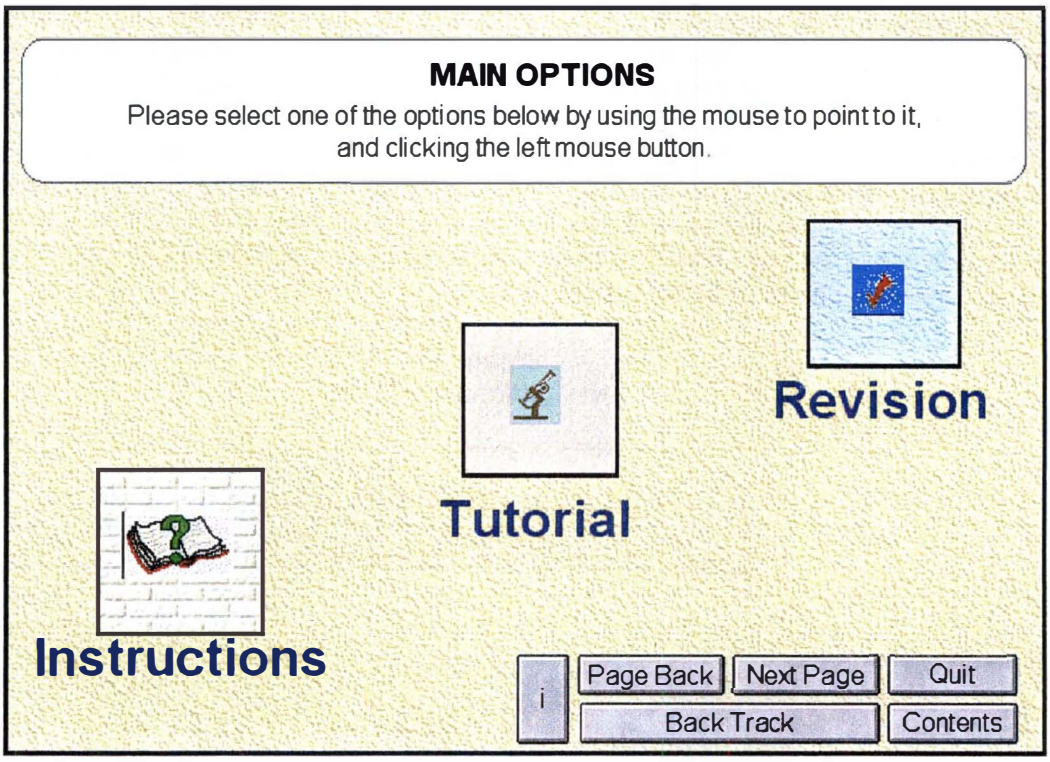
3.4.4 Navigational flow

The program was divided into four major sections: the title page and main options; instructions for use; tutorials; and revision. These were reflected in the Main Options screen where links to the major sections were presented to the users.

The user could choose which of the major sections to visit on entry into the program. It was envisaged that some students would require the instructions on first visitation whilst others would prefer to experiment, thus instructions on the use of the program were a selectable option and users were not compelled to use them.

The major part of the program is the tutorial section so this was placed in the centre of the screen. Revision was considered important, but most students would need to make use of this after going through the tutorials and just before examinations. The selection for revision was thus placed on the right but given prominence by being placed slightly higher on the screen.

Figure 3.7
Main options



Flow chart of user instruction section of the program
Topics in the instructions module were presented linearly, with the only exit options being the navigational buttons. This module was designed to introduce the user to the main conventions used in this program in an entirely introductory and linear fashion as outlined in Figure 3.8a.

'Next Page' navigation through the tutorial section of the program
The tutorial section contains most of the information for the students. The faculty expressed a need for the information to be grouped and presented using a complementary system to the manner the information was presented in the traditional teaching mode. Thus the information was divided into three major sections; osteology, muscles and innervation. In turn each of these sections had their sub-sections; osteology being divided into the two major skeletal features, muscles into the three crural compartments; and innervation into the two major nerves servicing the leg. Further to these each of the muscle compartments had information on general features and functions of each group and then divided into the specific muscles. Each muscle (boxed with a red line in Figure 3.8b) had links to an anatomical description, function, origin, insertion and finally a link to the cross sections.

Students are able to access the information by selecting 'Next Page' to move to the main pages and selecting the appropriate hot spots on the various pages, or by selecting the 'Table of Contents' at any stage and selecting the major section or sub-section they wish to review. Figure 3.8b depicts the structure of this section and 'Next Page' navigation through the information.

"Next Page' navigation through the revision section of the program
It was envisaged that students may wish to conduct self evaluation tests as they move through each section as well as check their knowledge of the whole anatomical section. Thus the revision module was divided into the major subsections but students were given two paths through the module; the first has its entry point at the end of each major subsection where the user can select a hotspot link to the revision module for that specific section, the second had its

entry from either the "Main Options Screen" or the "Table of Contents" and navigation through the questions presented would take them through a selection of all the revision questions. 'Next Page' navigation through the program linked the students to the revision module at the end as represented by Figure 3.8c. For each question presented to the student there were at least two random options so that the student could not memorise a pattern of answers and would have to treat the questions as unique, however as the leg is a minor part of the anatomy curriculum there were insufficient questions to make an analysis of responses meaningful.

Figure 3.8a
Flow chart of user instruction section of the program

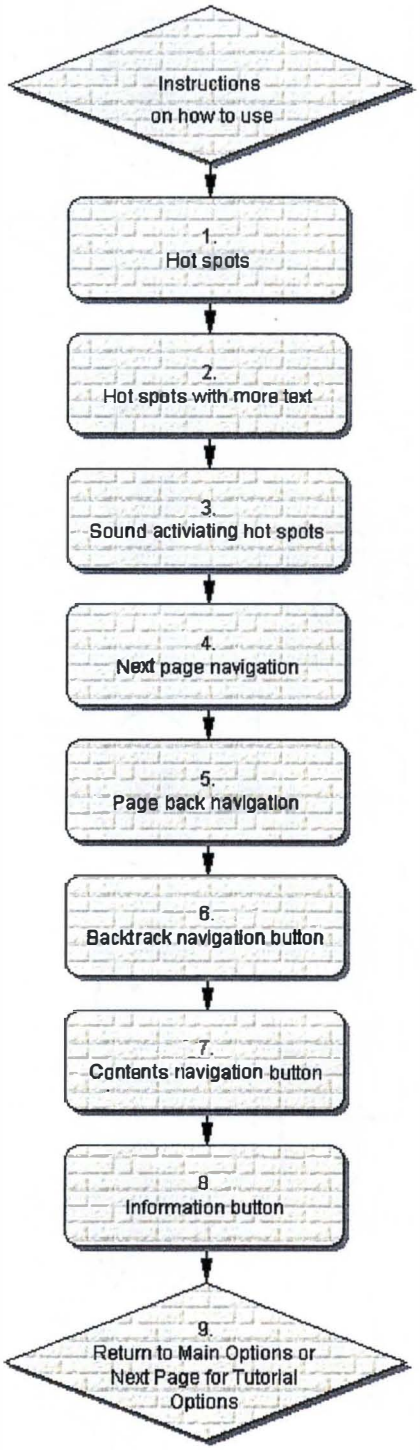


Figure 3.8b
Flow chart depicting 'Next Page' navigation through the tutorial section of the program

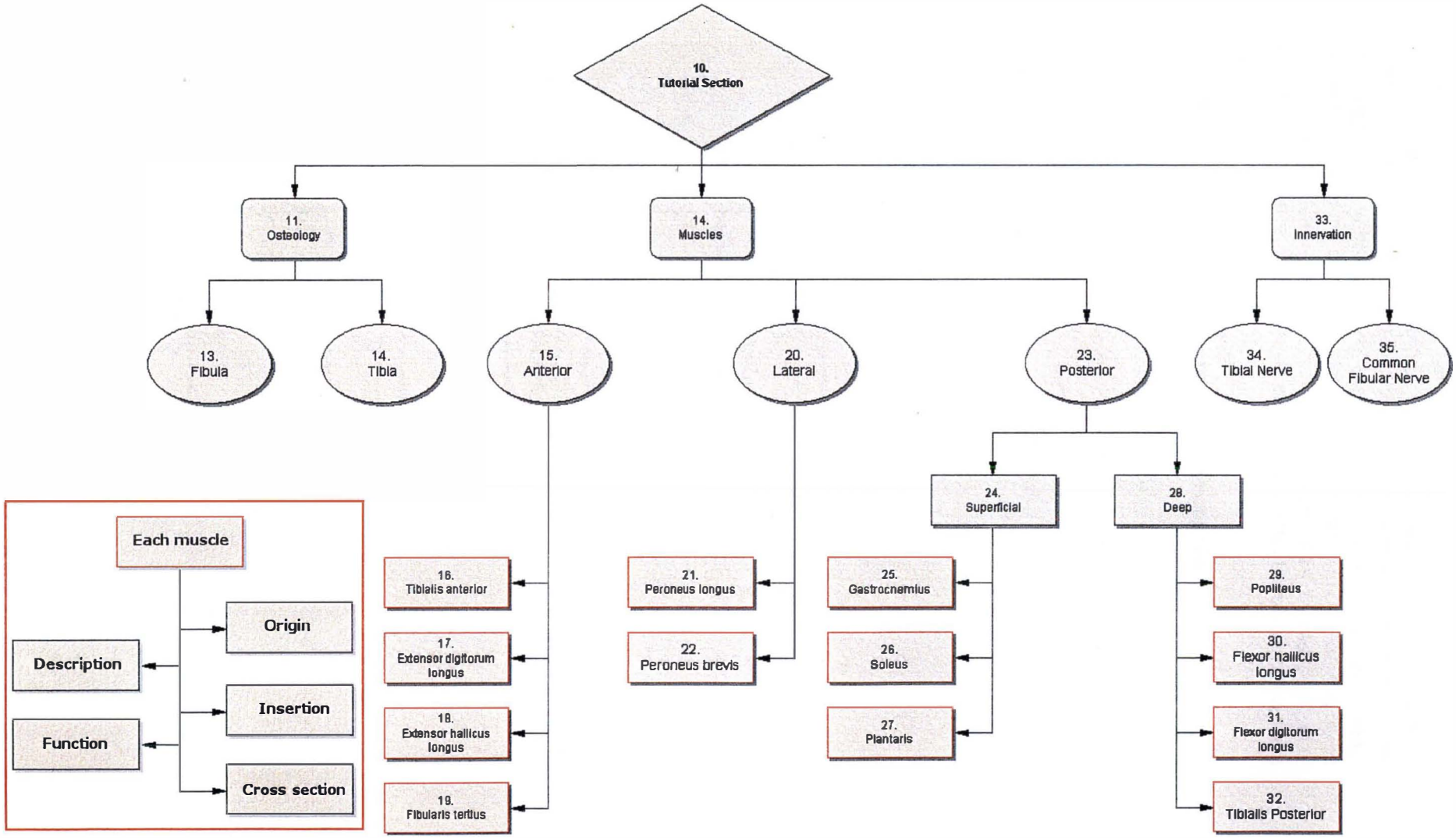
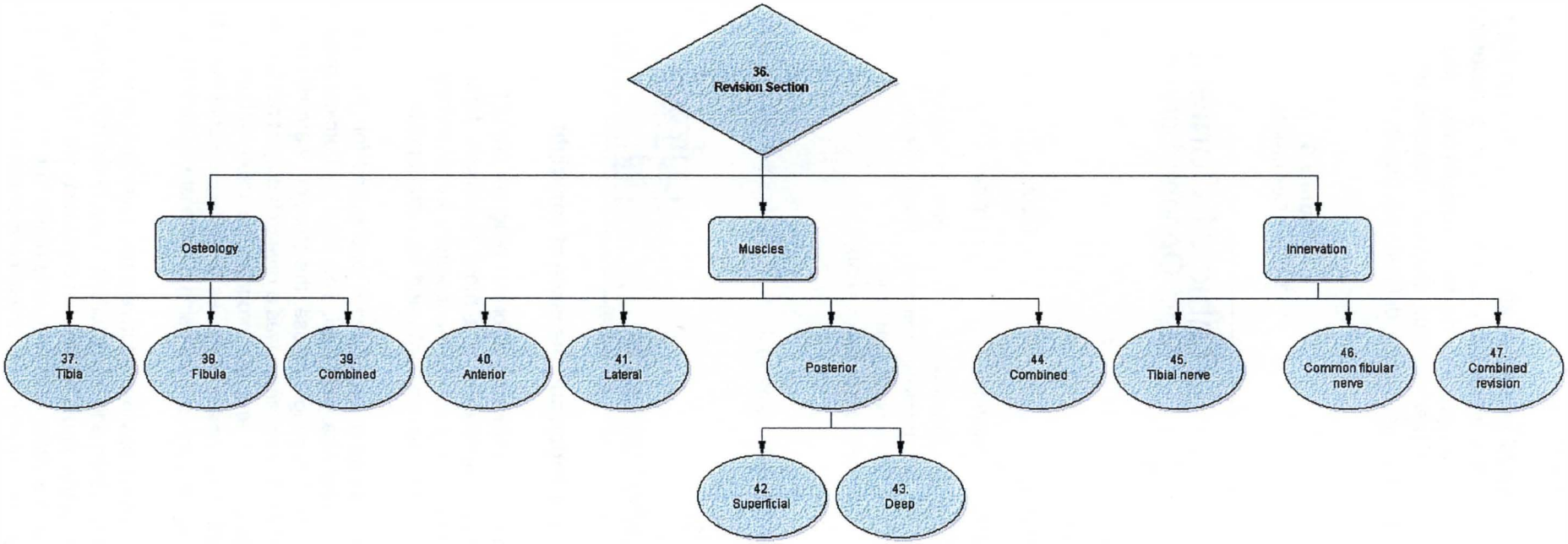


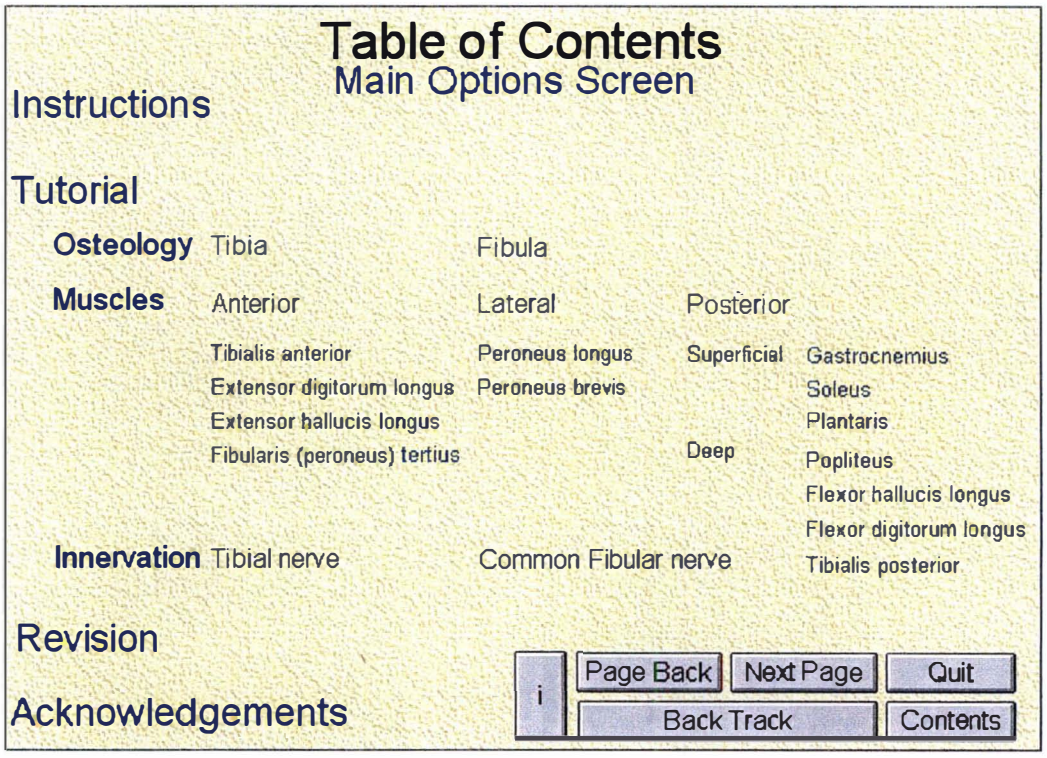
Figure 3.8c
Flow chart depicting 'Next Page' navigation through the revision section of the program



The 'Table of Contents'

The 'Table of Contents' offered an alternative path through the material. This was specifically designed to group the information to be learnt in a hierarchical fashion that echoed the methodology used by subject experts. Initial designs colour coded the information, but formative evaluation from Computer Science students indicated that this broke the blue hyper-link convention and made navigation difficult. All blue text on the screen indicates a possible selection.

Figure 3.9
Table of contents



3.4.5 Data acquisition and the issue of copyright

The major source of information for the program came from the prescribed text book, but the information was re-arranged in a more accessible format and language for the students, following the structure given by the lecturers. Other sources included library reference material and multiple choice question books and past exam papers.

Images were scanned in as bit maps and edited for readability so that only the information pertinent to the text was displayed. The legal and ethical question of copyright was dealt with under the 'fair use' copyright clause, the students were still required to purchase the source of most of the original work, and it was a research project not for gain (Alpern, 1999). Should these circumstances change and the program be used without the text book, or the system be developed further for resale purposes the images would have to be recreated with original art work and the system recompiled using a professional version of Authorware™.

Attempts were made to video cadavers but these images were not clear, the muscles were grey and indistinct on video and the resultant imagery did not add sufficient content to be considered useful. Two links that could have been considered useful that were not included because of time constraints, were a video of movements of the foot in relation to certain muscular activity in the leg, as well as video material of clinical syndromes such as foot drop.

3.4.6 Formative evaluation methodology and issues raised

Extensive use was made of formative evaluation techniques and prototyping. Initial designs were presented to the University's Multimedia Research Group members for comment. An interface standard was agreed upon at this level.

Second level formative evaluation had the development of minimal data acquisition and layout, which was presented to the subject experts for verification. The system required extensive remodelling to follow their approach to teaching the subject material.

Third level formative evaluation had the prototype reviewed by computer science honours students who identified navigational bugs and interface design inconsistencies. One of the main changes was highlighted earlier when it was explained that initial designs had the table of contents coloured coded for easier reading, but the honours students suggested that it broke the interface norm of blue being a selectable link, and was thus too confusing to use effectively. The second major flaw identified by the honours students was that the 'backtrack' button did not always function as expected. This was identified as a bug within Authorware™ when more than three levels of frames were used. The system had to be recoded to flatten the hierarchical frames in order to avoid the bug.

The final formative evaluation took place when subject experts checked all content for factual accuracy, and senior medical school students tested the system as a secondary backup ensuring the factual accuracy of the content and quiz responses.

3.5 Implementation

Before installation on the student LAN the system was demonstrated to the target audience during one of Dissecting Hall laboratory tutorials. This was timed to coincide with the week that they dealt with the leg in formal classes. During the demonstration, the students were told how to access it on the student LAN, given full details of the research project whereby they were also assured of confidentiality of record keeping and that the use, or lack thereof, would not be reflected in their marks for the course. The students had unlimited LAN access to the program for the semester, but as the LAN is situated in the library their computer time was limited to library hours and totally voluntary.

The installation on student LANs was done via a system known as the *'Novell Application Launcher'* which is familiar to all students. However, changes to the networking system required changes to the student rights allocation of sub-directories for record keeping purposes. Theoretically this meant that a student could hack into the system and alter their records if they so wished. Extensive backups were made to ensure that this did not happen, but it posed a potential threat to the security of the system.

It should be noted that a few weeks after the installation, the xtras subdirectory was deleted which fatally disrupted the execution of the program. It is presumed that this was an administrative error on the part of the LAN technicians and not an attempt to hack into the system, as it did not happen again. However, it is also interesting to note that no complaints were received from either the anatomy department staff or the students despite them being informed that they could contact the developer via the academic staff, their student representative or directly if they had any problems relating to the program.

3.6 Record keeping and data collection methodology.

The main thrust of the research was to find out if students liked the system, would recommend further similar developments, how they navigated through the system and if there were any

differences in the way students from different educational or cultural backgrounds related to the use of such software.

In order to keep a record of the navigational path used by students a record keeping system was an added to the design as a separate component that could be removed after completion of the research project. This system stores a text file (see Appendix B for an example) recording the navigational path taken by the students as well as the marks that they obtained during revision times.

One of the major stumbling blocks of the program became apparent in the development of this section in that anatomically the leg is a very minor part of the structure of the body and there were few questions relating solely to the leg in the literature and previous exam papers. This severally limited the usual summative evaluation method of looking for significant differences in student marks.

The questionnaire (see Appendix C) was designed to give students an opportunity to explain their perceptions of the program. It was deliberately kept open-ended so as to limit bias in the responses, and some questions such as the first one asking students to describe their home culture were deliberately vague, as these students were likely to be amongst the first group who experienced education outside of the Apartheid 'Christian National Education' system and were likely to perceive themselves differently to the racial stereotypes imposed by the Nationalist government.

3.7 Summation

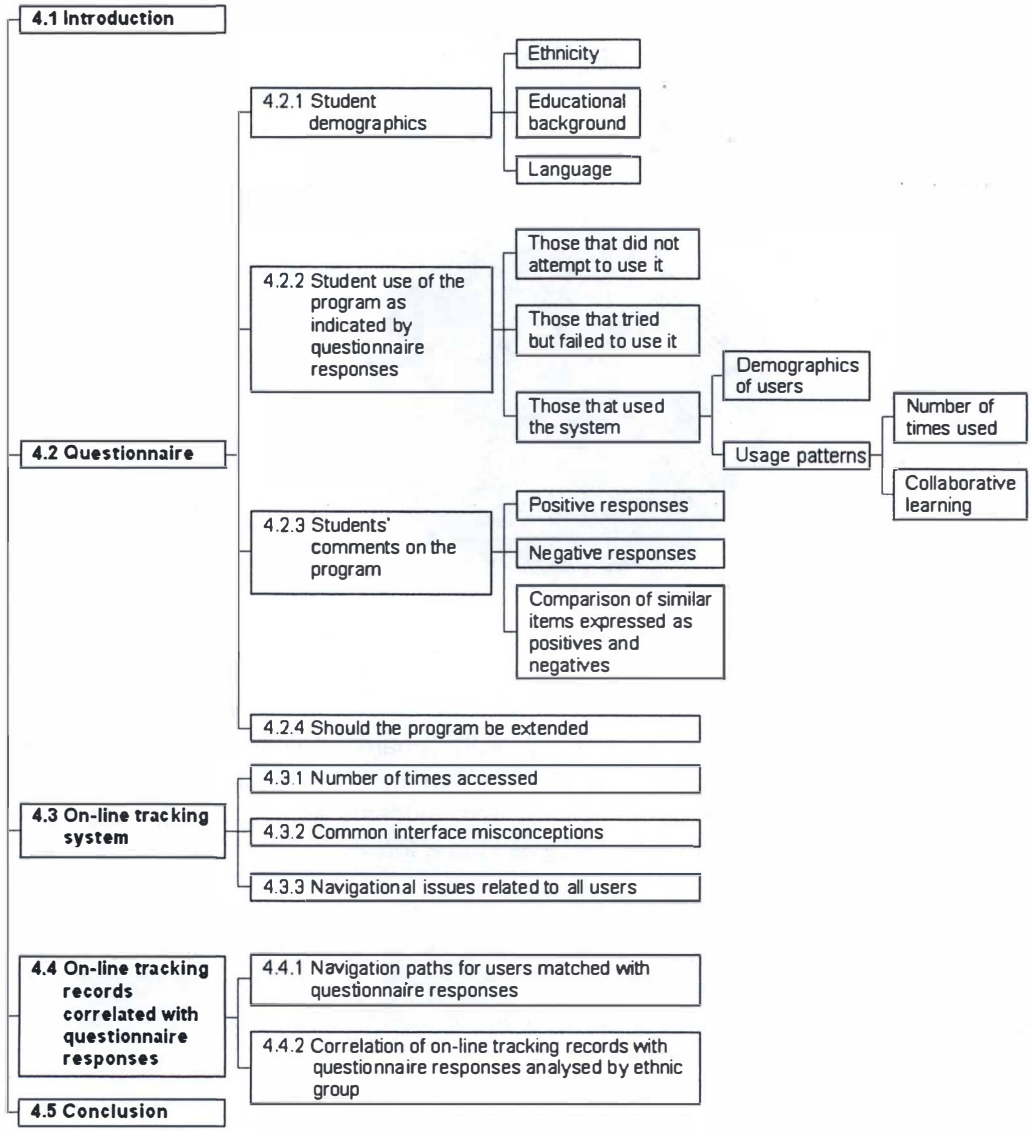
This chapter merely records the design phase of the project and points out the concerns that were addressed in the conceptualisation of the program. Although the design phase was advised by the literature available and subject experts, as well as being checked with formative evaluation and continual modifications, the finished product was not without its problems as is reflected in the summative evaluation records in chapter four. However, as Willis (1995) correctly points out, the process is neither linear nor finite and changes in any of the social, educational, subject matter or technological variables will influence the acceptance and use of the program.

CHAPTER FOUR
CASE STUDY – RESULTS

4.1 Introduction

This chapter gives a breakdown of the data obtained from the questionnaire and a summary of the recorded tracking within the program and is divided into three major sections (see Figure 4.1). Section 4.2 considers the results obtained from the questionnaire describing the student demographics in terms of ethnicity, educational background and home languages; the ways these students used, or did not use the program; as well as their comments on the program. The subsection on the students who used the program is more detailed than those that did not as there is more information to analyse, and looks specifically at the demographics of students who chose to use the program and pattern of usage as reported in the questionnaire. Section 4.3 analyses the data collected from the online tracking system, and section 4.4 ties the two information sources together, where possible. Throughout the analysis repeated reference is made to student demographics in terms of ethnicity, language and educational background to discover how these elements may influence the use of the program.

Figure 4.1
Pictorial representation of sections in chapter four



4.2 The questionnaire

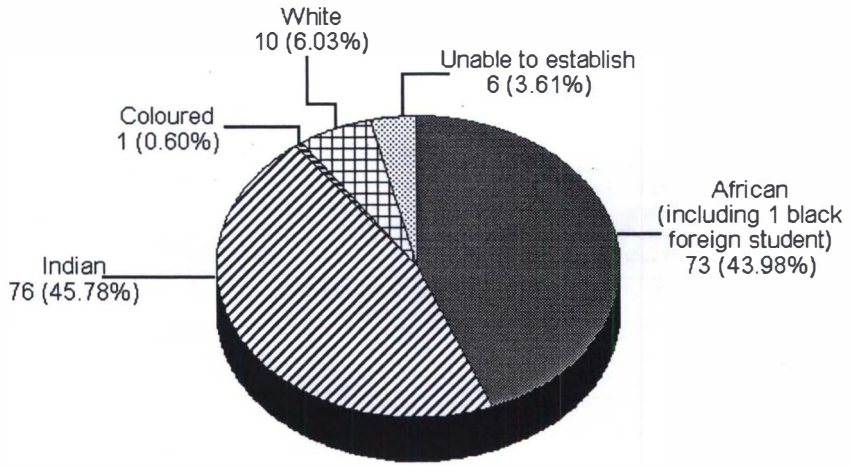
On the recommendation of a subject expert the questionnaire was handed out to students at the end of a final year-end examination. This encouraged all students to respond and allowed for easy distribution and collection. 171 questionnaires were returned of which 5 were blank.

4.2.1 Student demographics

Ethnicity:

Students were not asked to describe race group according to the apartheid structures as this is often viewed as offensive and, with the changes in legislature, many people's perception of culture and race are changing. However, as educators are still concerned with addressing the needs of 'disadvantaged' students, the researcher derived the ethnicity of students where possible. When this was not possible the race was recorded as not known. The racial breakdown of the whole group is reflected in Figure 4.2, showing that African and Indian students are almost equally represented and the other groups compose a small minority.

Figure 4.2
Racial breakdown of students determined from response to name, culture and educational background.
(n=166)

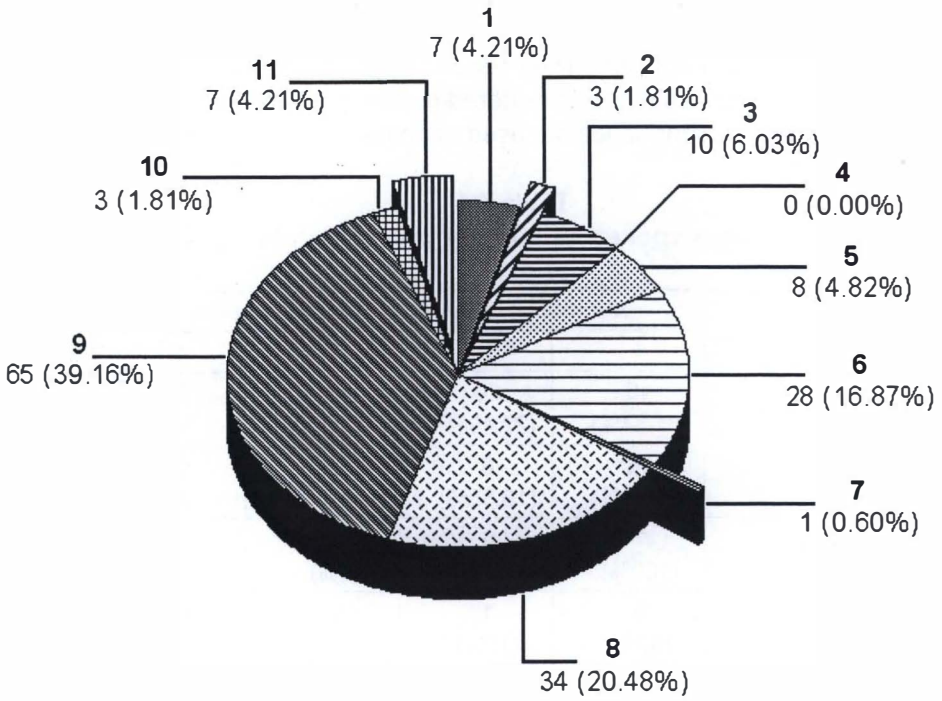


Educational background:

The questionnaire attempted to identify as many of the apartheid school structures as were likely to be attended by the students, but schools run by the House of Representatives ('Coloured') were omitted from the questionnaire. Two students specified that they attended House of Representative schools and 1 student attended a foreign international school.

The students came from diverse educational backgrounds and no clear trends were noted within the 'apartheid' structures (Figure 4.3a); however, when the schools were regrouped by funding sources (Figure 4.3b) a clearer division was noted with privately funded schools making up less than 20% of the total. For this classification the one foreign international school was grouped with the privately funded schools.

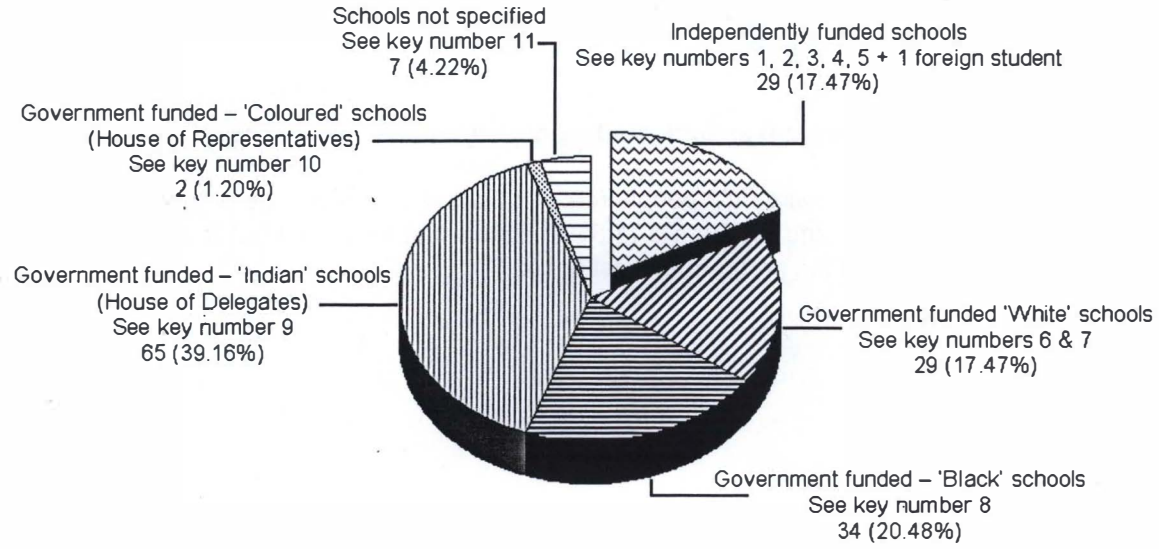
Figure 4.3a
Type of school attended as reflected in the questionnaire



Key

1.	Historically advantaged independent school	2.	Privately run cram college/school
3.	Historically religious run "black" school	4.	Historically religious run "white" school
5.	Historically religious-run "Indian" school	6.	Historically government-English "white" school
7.	Historically government-Afrikaans "white" school	8.	Historically government-"black" school
9.	Historically government-"Indian" school	10.	Other (including House of Representatives & foreign school)
11.	Not specified		

Figure 4.3b
Type of school attended grouped according to funding sources.



Language:

Multilingualism:
As mentioned in the literature review subject experts at the University of Natal have identified fluency in English as an area of concern. The questionnaire asked specifically what languages were spoken at home as these were then considered mother-tongue languages. No information was obtained regarding second languages not used at home.

Table 4.1
Number of languages spoken at home as reflected in the questionnaire

Group	Number of languages spoken at home				Total
	1	2	3	4	
African **% of African students**	45 (61.64%)	20 (27.40%)	6 (8.22%)	2 (2.74%)	73 (100%)
Indian **% of Indian students**	66 (86.84%)	8 (10.53%)	2 (2.63%)	0 (0%)	76 (100%)
Coloured **% of Coloured students**	1 (100%)	0 (0%)	0 (0%)	0 (0%)	1 (100%)
White **% of White students**	9 (90%)	1 (10%)	0 (0%)	0 (0%)	10 (100%)
Unknown **% of students whose ethnicity was unknown**	6 (100%)	0 (0%)	0 (0%)	0 (0%)	6 (100%)
Total **% of total student group**	127 (76.51%)	29 (17.47%)	8 (4.82%)	2 (1.20%)	166 (100%)

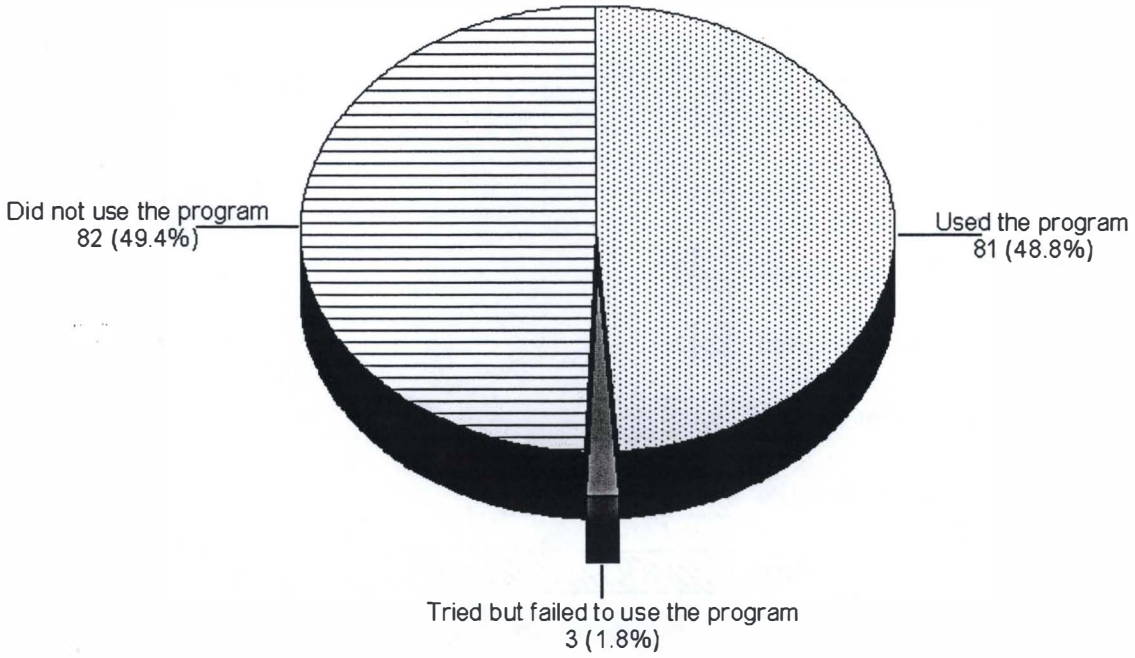
These figures, seen as percentages of each ethnic group, indicate that the group with the largest proportion of multilingualism are African (38.36%). 13.16% of the next largest group, Indian students. describe their home environment as multilingual. Most of the other two groups of students are monolingual, with 1 white student who speaks English and Afrikaans at home.

English spoken at home:
All monolingual students speak English at home except within the African group where 1 monolingual African student has English as a home language. 114 of the 166 respondents (68.67%) spoke English at home, but all 52 respondents (31.33%) who did not speak English at home were African.

4.2.2 Student use of the program as indicated by questionnaire responses

Of the 166 completed questionnaires, 82 people (49.44%) chose not to use the program. Of the 84 people who wished to use the program 3 (1.81%) stated that they tried but it did not work and 81 people (48.80%) used the program at least once.

Figure 4.4
Overall breakdown of program usage.



Those that did not attempt to use the system

Eighty-two respondents stated that they did not use the system at all. The reasons for choosing not to use it varied from those who claim they did not know about the system (38 respondents, 4 of whom thought it had something to do with a program that should have been available at school) to those who claimed that there was insufficient time available (31 respondents). Only two respondents indicated that they had a dislike of computers and one of these specifically stated it was the speed of the computers in the student LANs that made the experience uncomfortable;

> "*I meant to and was genuinely interested but the computers here are painfully slow and frustrating*" [122].
> "*I didn't have the time, I don't really like computers and would rather learn from a book*" [134].

These comments reinforce the point made in the literature review that the system must be easy to use, transparently available and provided in a manner conducive to quick and seamless access.

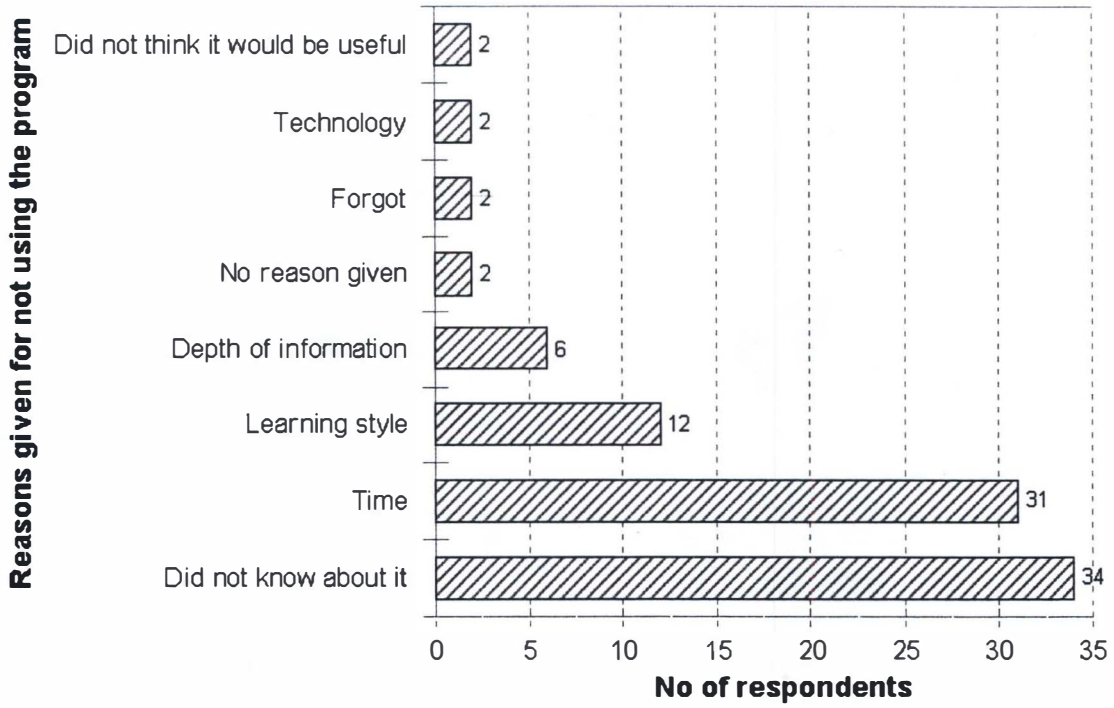
Twelve respondents stated that computer systems worked against their specific learning styles, for example:

> "*I found using D.H.*[8] *dissections more useful and also using the textbook and moreover I didn't get a chance to go to the LAN due to some reason*" [012]
> "*I did not think that it will be different from what we do in the DH*" [064]
> "*I prefer text book style to computer aided learning packages*" [090]
> "*It was only visual which is boring*" [099]
> "*Computer aided learning as a means of learning is not very effective*" [135]

Figure 4.5 indicates the number of people who gave various reasons for not using the program, with some people giving more than one reason.

[8] D.H. Dissecting Hall.

Figure 4.5
Reasons given for not using the program



Those who tried but failed

In Chapter 3 it is noted that for some time the program would not run as the Xtras directory had been removed. It appears that during this time four students attempted to use the program. Three of these students simply left it and used other media, for example the respondent on questionnaire 092 states that he did not use it and comments "*Tried but the program wasn't working properly. I got frustrated and gave up*". The one user who returned to retry the program states that on one of the two occasions " ... *the pictures were not appearing on the screen! This disappointed me greatly*" [091].

No complaints were reported to the developer although at the demonstration it was agreed that they could contact the developer directly, make representation via the class representative, or send a message through the lecturing staff if they wished. It is clear that if a system is not easily and immediately accessible people will give up and use another medium unless there are external motivating factors such as the material forming an integral and potentially examinable part of the course.

Those that used the system

Eighty-one respondents (48.80%) indicated that they had used the system. These were further analysed against student demographics and usage trends.

Demographics of users

An analysis of the demographics of students[9] who did and did not use the program was done using The Pearson Chi-Square test calculated with SPSS™ (Fielding and Gilbert, 2000) with the following results:

---

[9] Note for the purpose of this analysis the 'Coloured' and unidentifiable and single foreign student were removed as they were small numbers

		Ethnic Groups			
		African (n=72)	Indian (n=76)	White (n=10)	Total (n=158)
Did not use the program	Count	28	47	6	81
	% of ethnic group	39%	62%	60%	51%
	Expected count	36.9	39.0	5.1	81.0
	Expected % of ethnic group	51%	51%	51%	51%
Used the program	Count	44	29	4	77
	% of ethnic group	61%	38%	40%	49%
	Expected count	35.1	37.0	4.9	77.0
	Expected % of ethnic group	49%	49%	49%	49%

	Value	Degrees of freedom	Significance Level
Pearson Chi-Square	8.123	2	.017
N of Valid Cases	158		

The significance level of .017, less than the required .05 indicates that there is an association between ethnicity of the users and the likelihood of the program being used. More African respondents used the system than would be expected if ethnicity and usage were not related. Conversely fewer Indian respondents indicated they used the system than would have been expected had there been no correlation between ethnicity and usage. Similar tests for association between usage and English as a home language as well as usage and educational background indicated no significant association.

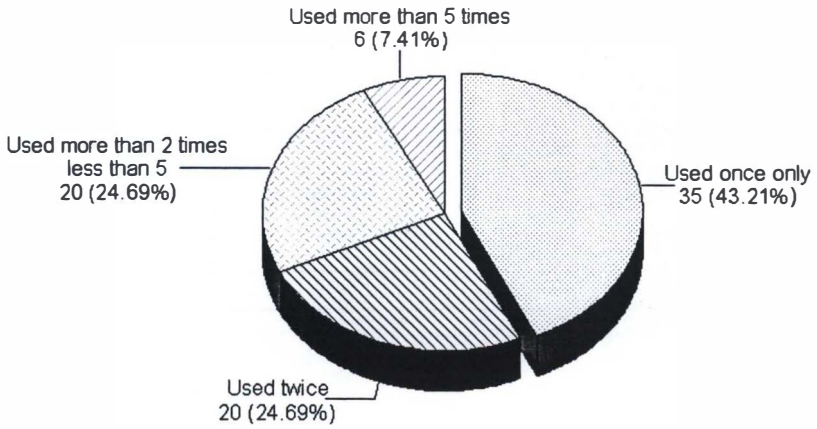
The commonly expressed fear that 'disadvantaged' students could be further disadvantaged by the use of technology in the learning process is shown to be unfounded by this significance level. However, further investigation is required to understand why the other group appears to be reluctant to use the system as neither language nor educational background emerge as reliable predictors.

Usage patterns

Number of times used

Of the respondents who used the program, more than half (56.79%) returned and used it again.

Figure 4.6
Number of times the program was used



Collaborative learning:
Group work is an essential part of the problem based learning curriculum that the medical school is introducing in 2001. Although this program was not specifically designed to ensure cooperative learning, it was thought that students might work on the program together. Careful analysis of this usage pattern was undertaken to see if there were any reliable predictors for collaborative learning. Fifty-five of the respondents who used the program stated they had used it on their own; 8 used it with someone else and 17 had used it on their own and with someone else. One respondent [005] indicated an ambivalent use of the system ticking and crossing out options making it difficult to interpret the questionnaire.

Table 4.2
Usage of the system

Usage	No of respondents
Used on their own exclusively	55
Used with someone else exclusively	8
Used with someone else and on their own	17
Unable to interpret	1
Total	**81**

These figures indicate a trend that students are more likely to work alone with only 25.77% of users choosing to work with someone else.

An analysis looking for the significance of language, ethnicity and educational background showed language and ethnicity as worthy of further investigation, but educational background did not seem to play a role.

Language: The Pearson Chi-Square test (ibid) showed that a significant proportion (0.013) of students who stated that they used the program with someone else did not speak English at home. Conversely, significantly more people who indicated they spoke English at home were likely to use the program exclusively on their own.

		Was English spoken at home?		
		No (n=29)	Yes (n=51)	Total (n=80)
Used it on own only	Count	15	40	55
	% of group that only used it on their own	27.3%	72.7%	100%
	Expected count	19.9	35.1	55.0
	Expected % of those that only used it on their own	36.2%	63.8%	100%
Used it with someone else	Count	14	11	25
	% of group that used it with someone else	56.0%	44.0%	100%
	Expected count	9.1	15.9	25.0
	Expected % of those that used it with someone else	36.4%	63.6%	100%

	Value	Degrees of freedom	Significance Level
Pearson Chi-Square	6.138	1	.013
N of Valid Cases	80		

Ethnicity: A similar tabulation against race groups divided between African and 'other' (excluding the group where race was unknown) also shows a significant difference (.007) in that more African students were likely to use the program with someone else than could be expected if the two groups had the same study habits. Conversely 'White', 'Indian' and 'Coloured' students as a group were more likely to work on their own than their African counterparts.

		Grouped by 'African' and 'other' excluding the group whose ethnicity could not be established		
		African (n=44)	Other (n=34)	Total (n=78)
Used it on own only	Count	25	29	54
	% of group that used it on their own	46.3%	53.7%	100%
	Expected count	30.5	23.5	54.0
	Expected % of those that used it on their own	56.5%	43.5%	100%
Used it with someone else	Count	19	5	24
	% of group that used it with someone else	79.2%	20.8%	100%
	Expected count	13.5	10.5	24.0
	Expected % of those that used it with someone else	56.3%	43.8%	100%

	Value	Degrees of freedom	Significance level
Pearson Chi-Square	7.301	1	.007
N of Valid Cases	78		

Educational background: An attempt to correlate the educational background of the students against those who chose to work on their own or those who chose to work with someone else showed no significant difference. The first test run against schools grouped by financial sourcing had the following insignificant results:

		Type of school (excluding the 5 unknown)		
		Independent (n=12)	Government (n=64)	Total (n=76)
Used it on own only	Count	8	44	52
	% of group that used it on their own	15.4%	84.6%	100%
	Expected count	8.2	43.8	52.0
	Expected % of those that only used it on their own	15.8%	84.2%	100%
Used it with someone else	Count	4	20	24
	% of group that used it with someone else	16.7%	83.3%	100%
	Expected count	3.8	20.2	24.0
	Expected % of those that used it with someone else	15.8%	84.2%	100%

	Value	Degrees of freedom	Significance Level
Pearson Chi-Square	.020	1	.887
N of Valid Cases	76		

A further recalculation on these figures to serve as a crosscheck against schools grouped by historical educational departments also proved to be insignificant (.449) as shown below:

	Type of School (see key below)										
	1 (n=2)	**2** (n=2)	**3** (n=5)	**5** (n=3)	**6** (n=14)	**7** (n=1)	**8** (n=23)	**9** (n=24)	**10** (n=2)	**11** (n=5)	**Total** (n=81)
Used on their own only:											
Count	2	1	2	3	9	0	15	19	1	4	56
% of group that only used it on their own	3.6%	1.8%	3.6%	5.4%	16.1%	0%	26.8%	33.9%	1.8%	7.1%	100%
Expected count	1.4	1.4	3.5	2.1	9.7	.7	15.9	16.6	1.4	3.5	56.0
Expected % of those that only used it on their own	2.5%	2.5%	6.3%	3.8%	17.3%	1.3%	28.4%	29.6%	2.5%	6.3%	100%
Used it with someone else											
Count	0	1	3	0	5	1	8	5	1	1	25
% of group that used it with someone else	0%	4.0%	12.0%	0%	20.0%	4.0%	32.0%	20.0%	4.0%	4.0%	100%
Expected count	.6	.6	1.6	.9	4.3	.3	7.1	7.4	.6	1.6	25
Expected % of those that used it with someone else	2.4%	2.4%	6.4%	3.6%	17.2%	1.2%	28.4%	29.6%	2.4%	6.4%	100%

Key

Where

1	=	Advantaged private school
2	=	Private cram college
3	=	Religious 'Black' school*
5	=	Religious 'Indian' school
6	=	English 'White' school
7	=	Afrikaans 'White' school
8	=	'Black' government school
9	=	'Indian' government school
10	=	'Coloured' government school
11	=	Unknown.

* Note that category 4 of the questionnaire "Religious 'White' school" had no entries.

	Value	**Degrees of freedom**	**Significance Level**
Pearson Chi-Square	8.876	9	.449
N of Valid Cases	81		

To summarise, in analysing collaborative learning patterns, both language (0.013) and ethnicity (0.007) were significant, while educational background was not. Further research should be conducted to fully understand the association between language and ethnicity in collaborative learning patterns.

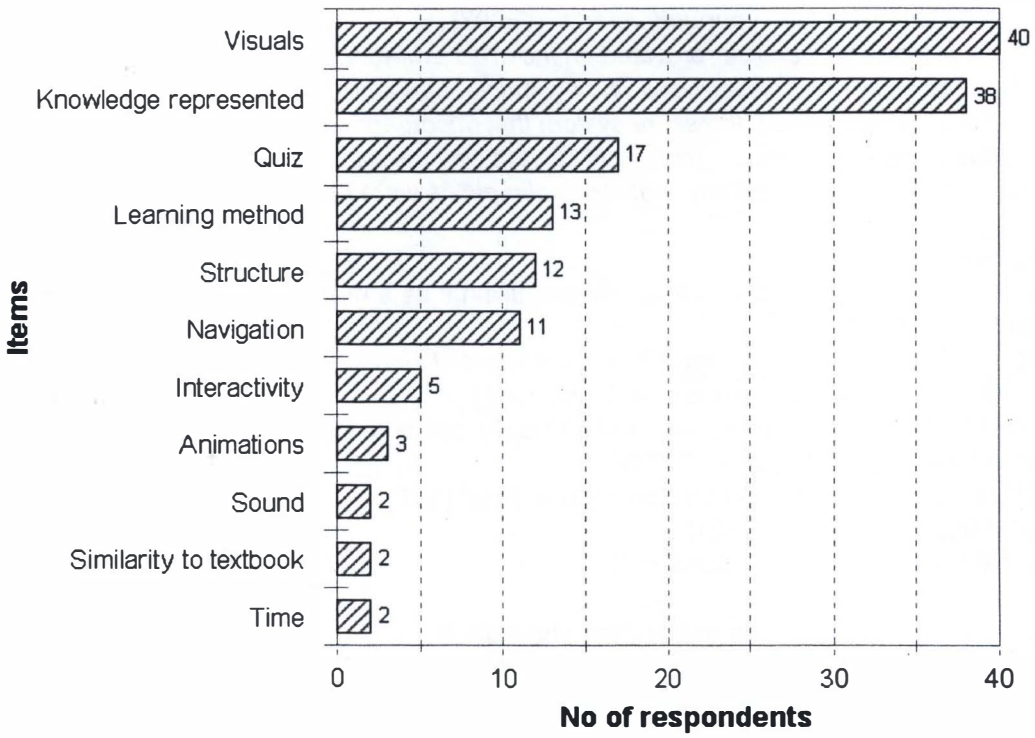
4.2.3 Students' comments on the program

The questionnaire allowed open-ended responses for students to comment on what they liked and disliked. These were divided into common threads and analysed using NVivio™.

Positive responses

Two questions were asked in the questionnaire relating to positive feedback, question 8 which asked what the users liked and question 7 requesting feedback on what the users found useful. Many interpreted this to mean the same thing, and it is thus represented here as a combined response. Common themes were analysed using NVivio™ and counted to show what respondents commented on as the most useful and liked elements of the program. These are represented in Figure 4.7 and correspond with the design issues discussed in Chapter 3.

Figure 4.7
Items specified as 'liked' or 'useful' by respondents who used the program



Visuals
Forty respondents specifically mentioned the visual aspects of the program indicating they enjoyed the visual representation of the subject material. Comments that were categorised in this section were similar to the following:

"*Pictures made sense and were well placed in context*" [003]
"*The different planes of view*" [007]
"*Labelled diagrams*" [020]
"*Easy to follow diagrams*" [065]
"*Visuals made it easy to understand and remember*" [086]
"*Easy reference to pictures*" [116]
"*Good illustrations made learning easy*" [121]
"*..the visual approach was a better way of understanding*" [164]

Knowledge representation

Thirty eight respondents mentioned the information and manner in which it was presented as particularly useful. Comments such as the following were scored in this category:

"*Highlighted important points in the text book*" [065]
"*It gives you a very good idea of the leg before you use the textbook*" [070]
"*The information was precise and to the point*" [078]
"*It gives all the muscles and their attachments*" [079]
"*Gave a good overview*" [103]
"*Summarized theory*" [125]
"*Summaries, concise, easy to understand*" [147]
"*The fact that it was compiled in different sections i.e. arterial supply/muscle groups. Consolidation of info was easier*" [164]

Quiz

Seventeen students found the revision options useful commenting along similar lines to the following:

"*..the quizzes help with your understanding*" [007]
"*The questions with answer provided on incorrect answer*" [017]
"*Gave me a chance to test myself on how much I had learnt*" [043]
"*... the questions asked; the score system that encourages one to continue using it*" [093]
"*... and some questionnaire* (sic), *I did like the way they are asked*" [124]
"*Helped me to test myself and that the explanations were easy to understand*" [136]

Learning method

Thirteen respondents indicated that they enjoyed using it as a method of learning. Examples of these comments are:

"*It is motivating even if a person is not in a mood of learning*" [039]
"*It was better than looking into a textbook*" [057]
"*That since its in the computer, I don't easily get bored and sleepy. Unlike using the book, were the above applies*" [093]
"*It is computer based and I do it on my own time*" [105]
"*... made learning easy*" [121]
"*..make learning fun not a burden*" [129]

Of particular interest was the one respondent who stated:

"*It is interesting when you are doing it with another person*" [070]

Structure

The manner in which the program and knowledge was structured was mentioned as being useful by 12 respondents. Some of their comments were:

"*It puts all the information we need together*" [047]
"*The structured way in which the section was covered help* (sic) *in my revision*" [066]
"*All the info and the diagrams were together*" [076]
"*Explained concepts in sequential order which elicited a good understanding of the leg*" [116]
"*It keep everything together, rather than Moore*[10] *of which you have to jump from page to page*" [129]

---

[10] This is a reference to their textbook, Moore, K.L., (1992) *Clinically orientated anatomy: Third edition.* Williams and Wilkens, Baltimore

Navigation

The ability to move around the program was seen as a key element of the design process underpinned by Nelson's 'ten-minute rule' of learning time (Baeker & Buxton, 1987: 47). Eleven students indicated that they found the program easy to navigate, commenting:

"*User friendly, quick and easy*" [065]
"*nice and easy to find what I was looking for*" [073]
"*That I go directly to the section that I want to treat*" [080]
"*...topics are easy to find*" [150]

Interactivity

Five students suggested that they liked the program because they felt that it was interactive. These comments were not particularly helpful in stating which aspects they thought were interactive they rather made simple statements such as:

"*The interactivity and the quizzes help with your understanding*" [007]
"*The graphics were interesting and it was interactive*" [008]
"*Diagrams corresponded to the text and interactive*" [028]
"*Interactive*" [089]
"*Interactive, could test self, informative*" [144]

Animations

Three respondents specifically mentioned the animation sequences as positive aspects of the program:

"*looking at nerve [and] blood vessels*" [040]
"*Showing of blood going through the arteries*" [062]
"*Nice animation*" [076]

Sound

Two students specifically mentioned that they liked the use of sound in the program. 062 stating that "*the fact that there was sound*" was useful and 065 liked "... *pronunciation bits*".

Similarity to the text book

The design deliberately used some images and elements from the recommended textbook in order to make the standard material more accessible to the students. Two students commented on this similarity as a positive element of the design when responding to the question asking what they found useful about the program.

"*it was very much like the text book*" [021]
"*The diagrams are not too different from what we see in an atlas so, they more or less give you the required orientation*" [110]

Time

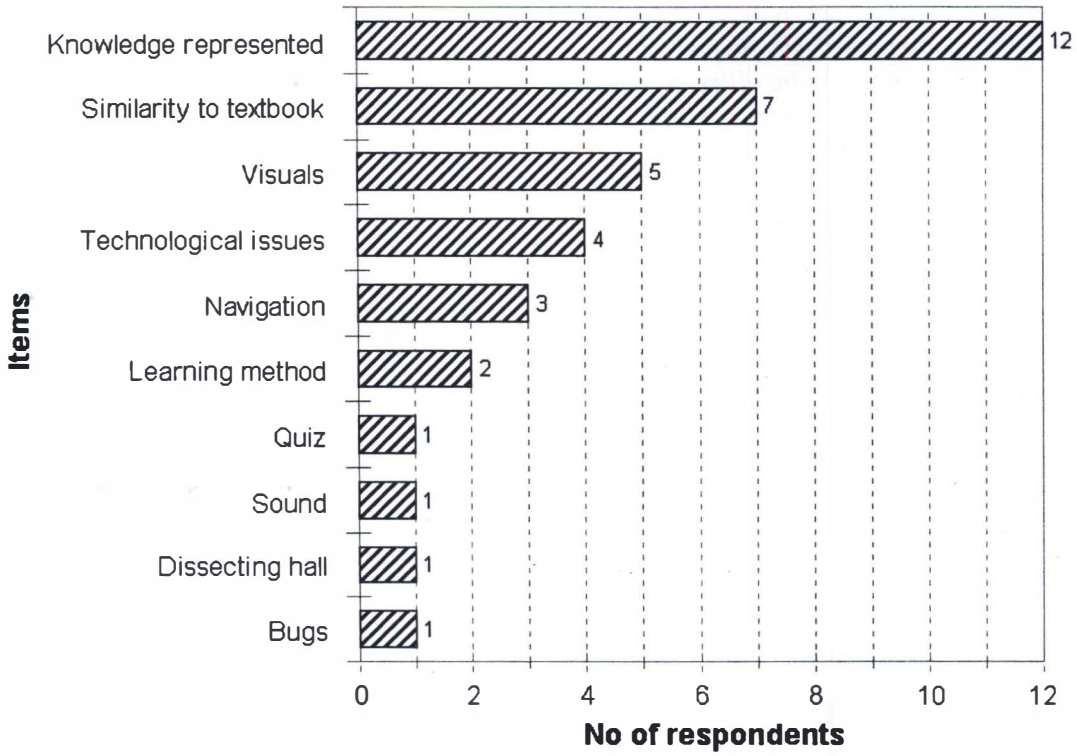
Two students mentioned time as a positive element of the system.

"*...it also saves time*" [047]
"*...it is not time consuming as well*" [071]

Negative responses

The responses to question 9 of the questionnaire asking students to comment on aspects of the program that they did not like were interesting in the manner they contrasted with items others viewed as positive. A similar coding process took place on this question, using NVivo™, and the following reflect the major concerns of people who used the program.

Figure 4.8
Major items specified as 'not liked' by respondents who used the program



Knowledge representation

The major criticism of the knowledge base represented by the program was that the respondents did not feel it was in depth enough for the region covered, whilst others felt the program should have covered more regions. Examples of these comments were

"*Very superficial*" [004]
"*... too basic for what we need to know*" [015]
"*It is not enough, comparing it in the way Anatomy is questioned. It is enough for first year Anatomy*" [068]
"*... not explicit enough*" [124]

"*Does not integrate the info of the leg with other regions*" [094]
"*Thought it could perhaps entail other modules as Thorax etc.*" [133]
"*Should have covered thigh region as well*" [144]

Similarity to textbook

Whilst some saw the similarity to the textbook as an advantage, and the program was designed to supplement and lead the student into the use of the textbook, 7 people commented on the similarity as a negative aspect of the program. Some of these commented as follows:

"*Too much of 'Moores' text ... not different from ordinary text*" [003]
"*Same as pictures and images as Moores*" [006]
"*Same as my book by K. Moore*" [046]
"*...the text and pictures are the same with those in 'Moore'*" [083]
"*It is just our prescribed book ... as it is*" [126]

One respondents commented that the program should be extended "*Only if it were enhanced and not a mere extension of the textbook*" [159].

Visuals

Whilst the most popular element of the program was the pictorial representation of the knowledge base, 5 respondents specified that this was an element that they did not like or should be improved.

"*There weren't enough illustrations especially for the first few sections*" [010]
"*It was only visual which is boring*" [099]
"*Picture not totally clear should be more realistic*" [116]
"*No 3-d orientation*" [127]

Surprisingly one respondent did not like the "*cross section micrographs*". [118].

Technological issues

Respondents who mentioned technological problems as a negative aspect of the program demonstrated contrasting levels of computer literacy. For instance one respondent did not like the fact that one "*cannot download it*" [007], whilst another stated "*the pictures were not very clear and difficult to see*" [066] which suggests the PC being used was set to too few colours and the respondent was unable to diagnose and/or correct the problem. Interestingly enough these two comments were both from 'Indian' respondents and whilst statistically irrelevant it does indicate that race is not necessarily an indicator of computer literacy. A further comment that is of particular relevance to those planning to introduce CAE as a major component of their course is "*I meant to and was genuinely interested, but the computers here are painfully slow and frustrating*" [122].

Navigation

The literature reviewed on HCI highlights one of the key elements of any design to be easy and intuitive navigation through the information. It is thus disquieting to have any respondents find this aspect the program difficult. However, 3 respondents mentioned this a factor that they did not like.

"*Not easy to access info*" [024]
"*Not very user friendly*" [125]
"*Difficult to navigate*" [147]

All the above respondents were classified as 'Indian', suggesting again that ethnicity has little bearing on the ability of students to use computer equipment.

Learning methods

Two respondents specifically stated that they did not like to use CAE, the first stating specifically a preferred learning style, whilst the second comments on either prior experience or reported knowledge;

"*I don't really like computers and would rather learn from a book*" [134]
"*Computer aided instruction as a means of learning is not very effective*" [135].

Quiz
The revision section was seen as one of the major motivating forces to use the program, but one respondent stated that there was a "*lack of questions*" [165].

Bug
In a similar vein, another user commented on the bug in percentage calculations as an item that was frustrating.

Sound
Sound was included in the program to indicate movement from one area of study to another, and to assist students in making a connection between the pronunciation and spelling of unfamiliar terms. However, one respondent found this minimalist approach problematic and suggested "*If there was a lecturer speaking via earphones it would have made the program more enjoyable*" [164].

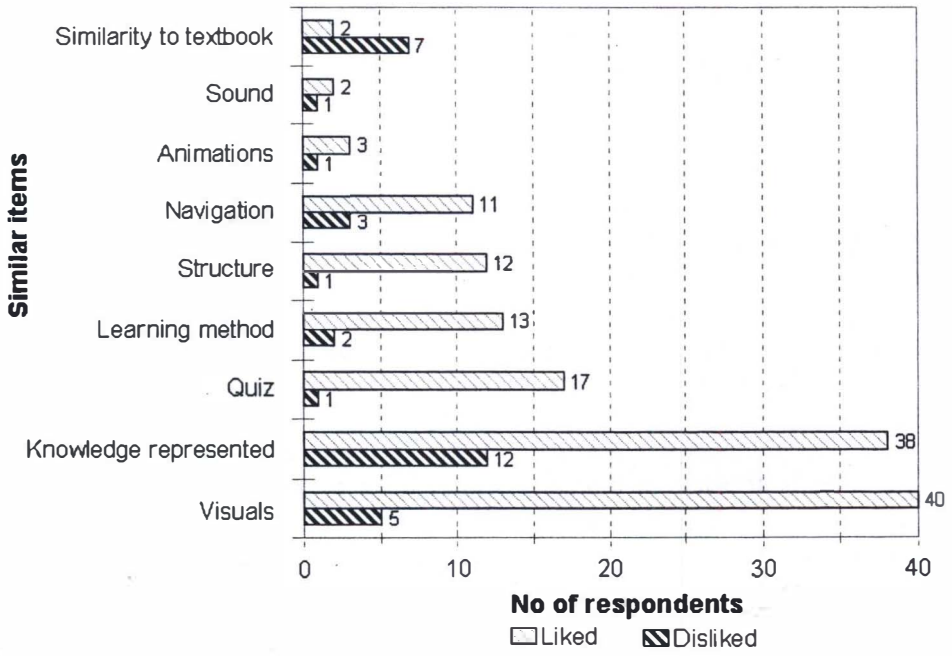
Dissecting hall
In commenting about what was not liked, one respondent [044] pointed out it "*is not a substitute for real experience with respect to cadaver in the Dissecting Hall*", clearly misunderstanding that the program was a supplement to the dissections rather than a substitute.

Other
There were other comments that were not particularly useful such as "*It was not very beneficial*" [159] and "*some things*" [050], but a point of interest to developers of CAE was the comment "*Before I enter I was asked to give my name and it said it doesn't know me*" [136]. It would be advantageous if systems developed did not require the students to register and login for each program, simply picking up their names and student numbers from their LAN logins.

Comparison of similar items expressed as positives and negatives

Not all the items mentioned as positives were reflected as negatives and visa versa, however, where common areas were mentioned respondents were generally more positive than negative, except in the area of similarity to the textbook.

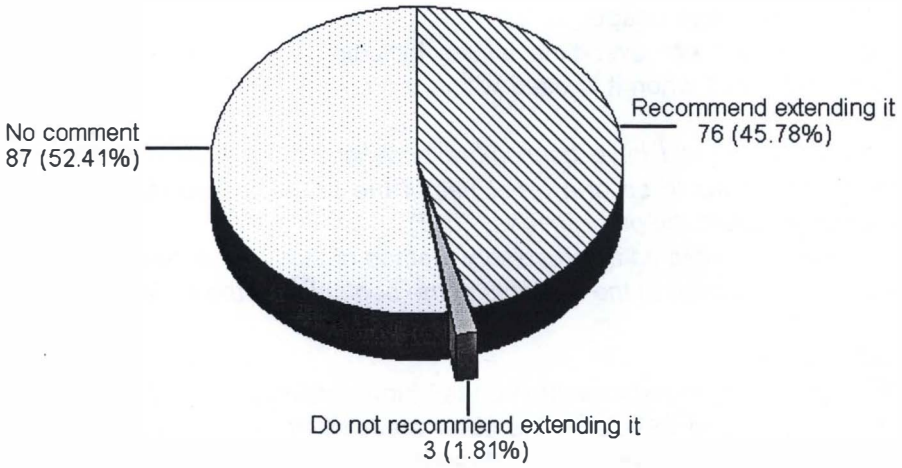
Figure 4.9
Common items recorded as likes and dislikes



4.2.6 Should the program be extended?

Seventy-six respondents recommended extending the program and only 3 suggested that it should not be extended, however, the majority (87) did not respond to this question. Unpredictably, some of the respondents who did not use the program indicated that they would like to see further development, particularly in the areas of anatomy they perceive as being more difficult. For instance respondent 141 states "*Never had the time to and textbook was sufficient easy enough to understand. Would have preferred a program for thorax and abdomen*".

Figure 4.10
Recommendations on extending the program



Responses recommending that the program not be extended

Of the 3 responses recommending that the program not be extended, 2 simply replied "*No*" [024 & 145], whilst respondent 127 added a comment stating "*3-d orientation is extremely impt* (sic) *in anatomy. I suggest a program that has 3-D models and allows us to go deep and explore the various levels of the body ourselves*".

Responses recommending that the program be extended

Of the responses that recommended further development 20 respondents gave simplistic yes answers with little useful elaboration. More specific answers suggested improvement to content (8), the display methodology (7), timing of implementation and usage (3), and extension to other topics (44).

Improvement to content
Eight users highlighted elements of content that they suggested could be extended. These were similar to the concerns expressed in the positive and negative views of the system.

"*Highlight MOST important aspects ... make it visually exciting*" [006]
"*Can extend it, and try to put only relevant information*" [069]
"*Increase question section*" [029]
"*You should try and add other text/info from other/different textbooks, not only Moore*" [062]
"*Also frequent spotter list/diagrams*" [125]

Display methodology

Seven comments related to the way in which information should be displayed on screen if the program was to be extended. These comments included:

"*use more pictures*" [003]

"*...nice pictures should be used. Make it visually exciting*" [006]

"*Yes, but put in 3-d pictures and a software that allow one to dissect on the PC*" [083]

"*... add more colour*" [098]

"*should be extended, makes learning easier because of emphasis being placed on referring to pictures*" [116]

"*...it should be more animated*" [118]

"*Yes, great contrib. to anat – also frequent spotter list/diagrams*" [125]

Timing of implementation and usage

Three users expressed concern over time issues including the time the program becomes available to the students and when it is used within the course. The comments recorded here were as follows:

"*Yes, although this would have been more beneficial if we had more time to use the programme (sic). It would be of a great help if the anatomy department could allocate some time for us to use the programmes.*" [017]

"*It should be implemented as a compulsory method of study for Anatomy*" [039]

"*...It should be introduced to the students at the beginning of the course*" [065]

Extension to other topics

The majority of respondents (44) who recommended further development stated they would like to see the program developed to incorporate other areas of the anatomy curriculum, with the head, neck and thorax regions mentioned frequently, and less frequent mention made of embryology and neuro-anatomy.

"*Would have preferred a program for thorax and abdomen*" [141]

"*Yes especially head and neck*" [139]

"*Thought it could perhaps entail other modules as Thorax etc.*" [133]

"*Yes, especially head and neck which seem so long and stressing*" [129]

"*Yes I think that will be a good idea if the program could be extended and cater for some other topics like head and neck*" [124]

"*Yes. Please try to do the HEAD and NECK, (although it might be very challenging).*" [114]

"*Do it for harder section in Anatomy like Head, Neck, Thorax etc.*" [112]

"*Yes, especially to head and neck sections, brain*" [073]

"*Yes, should include embryology and neuro-anatomy*" [165]

"*I personally feel that these would be helpful if they included difficult topic e.g. embryology and Neuro.*" [159]

"*Yes neuro-anatomy course would be beneficial*" [147]

Simplistic yes responses

There were 20 responses that gave a resounding "Yes" response to this question, but did not add any particularly areas of concern. Examples of these comments are:

"*Absolutely*" [010]

"*Yes, why not!*" [079]

"*Yes, computer learning tends to be more successful than learning from a book*" [150]

4.3 The on-line tracking system

Another source of information for analysis was the text files that recorded the students' navigation through the program, marks obtained on the revision exercises and time spent in each unit. The initial intention was to make a comparison between the marks scored in the quiz section with marks scored in the final examination. However, this was not feasible as the test banks were too small for valid statistical analysis and there was a bug in the percentage calculation of the self-quiz module.

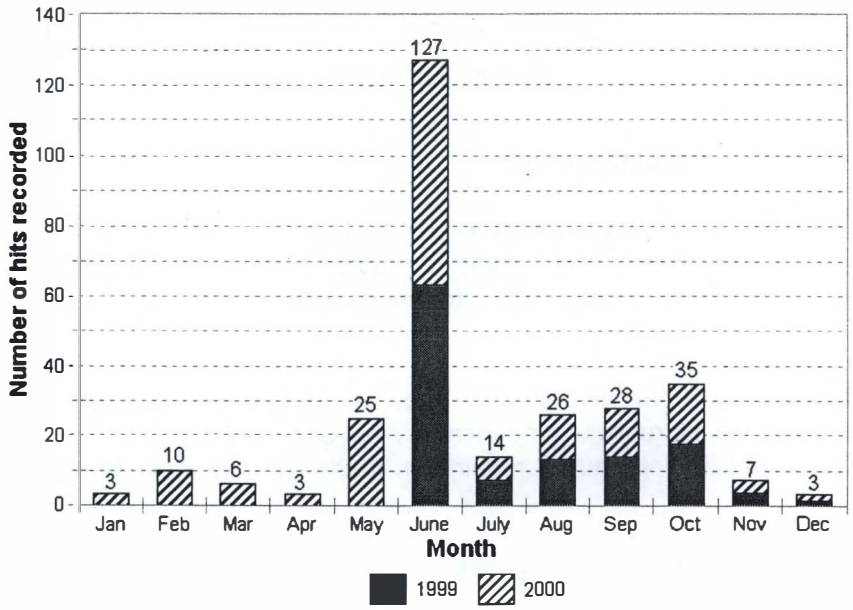
The tracking system recorded each user's movement through the program, but as it does not record how useful the movement was to the user it was necessary to link these records with questionnaire responses wherever it was possible to match students numbers on the questionnaire to login details on the tracking system.

4.3.1 Number of times accessed

The tracking records for the period June 1999 to December 2000 were analysed. The people accessing the program during this period included the second year students for whom the program was designed, other students and staff members and system administrators. During this time a total number of 292 'hits' on the program were recorded, excluding those hits by administrators testing the system. Of these 172 are clearly repeat hits with users using the same student number for logging in. The remaining 120 cannot be presumed to be first time users or unique logins as some users have used fabricated logins and they may have used different ones on separate occasions. Of these 5 records contained no data.

The most active months for use were immediately prior to and during examination times with monthly hits displayed in Figure 4.10.

Figure 4.11
Number of hits per month for the period June 1999 to December 2000.

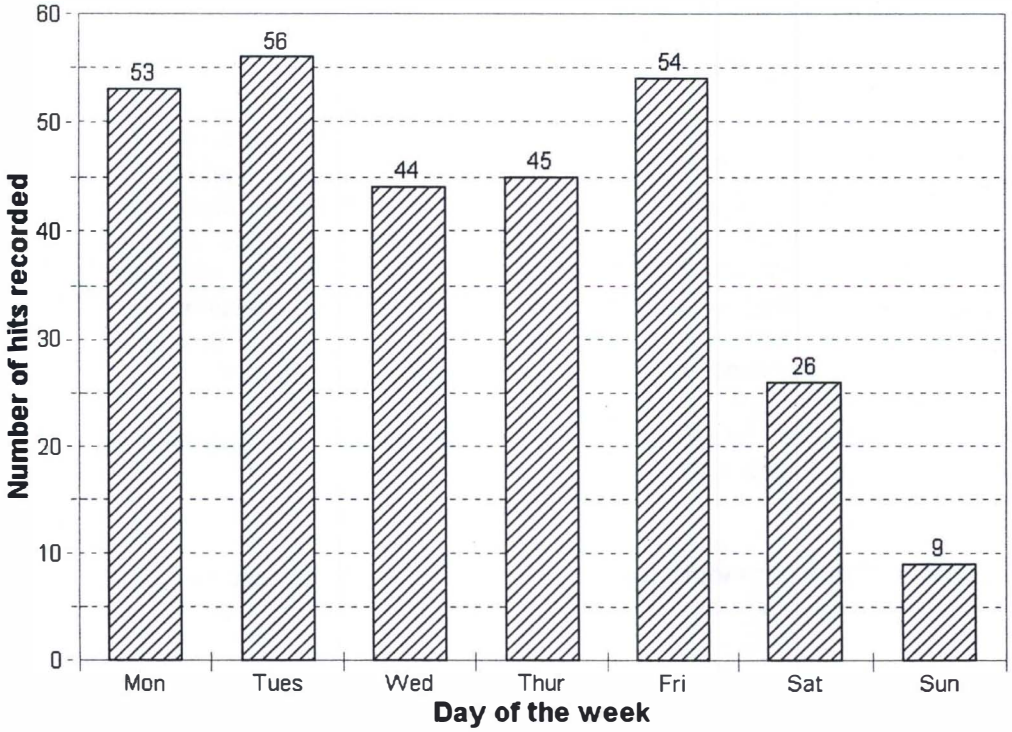


The navigation records did not record the year of use so it was not possible to separate the 1999 June – December records from the 2000 June – December records (shown in Figure 4.11 as an average), but taking this into consideration June and October records indicate more

frequent access. There is also indication of greater usage in February prior to supplementary examinations.

Given that the student LAN is open on a Saturday evening and Sunday during exam periods only, the analysis of daily hits showed no definitive trends, except that students used it slightly less on Wednesdays and Thursdays as shown in Figure 4.11.

Figure 4.12
Number of hits recorded per day of the week
for the period June 1999 to Dec 2000.



4.3.2 Common interface misconceptions

There were two buttons that were commonly misused. The first was the 'Quit' button which appears to have been used to exit out of a section, rather than exit the entire program. The second was the 'i' button which was taken to mean instructions rather than contextual information about the section in use.

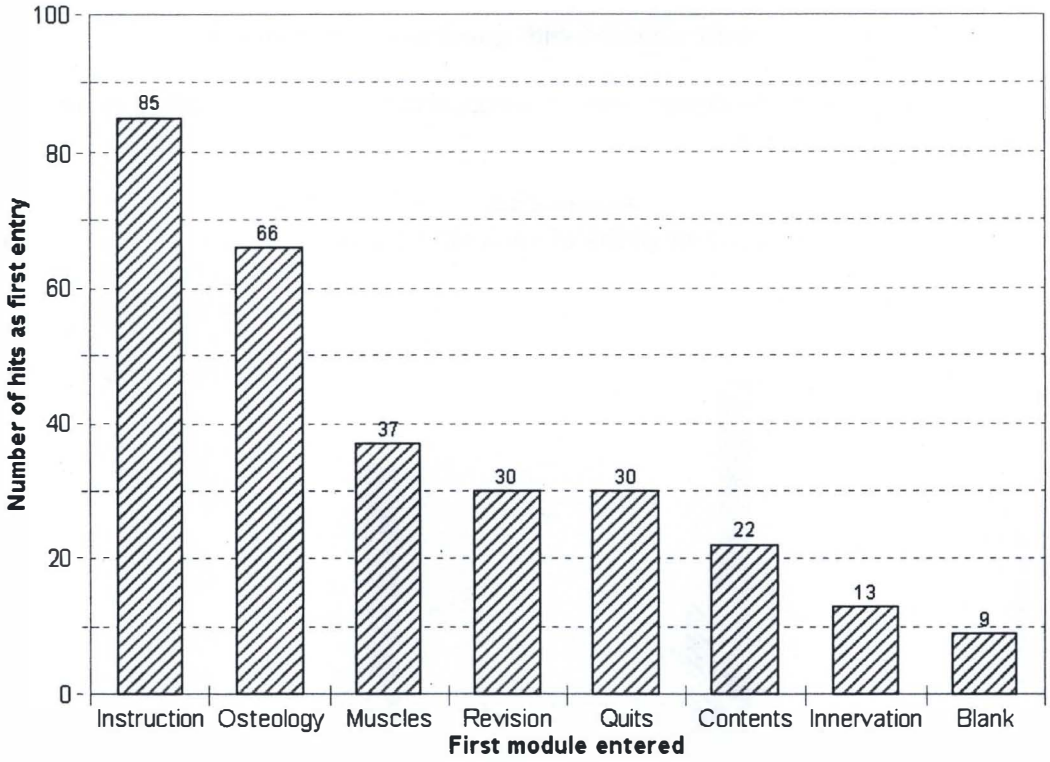
The backtrack button was used extensively. This indicates that the students got lost within the system and did not read the instructions for continuing that appeared at the bottom of each text area. Extensive revision of the interface is required in these areas to make it more intuitive to the users.

4.3.3 Navigational issues related to all users

Another focus of interest of this research was to see if there were any patterns in navigation through the program, the premise being that students were likely to use the book metaphor on initial entry followed by a more index driven navigational path on subsequent entries. Figure 4.12 shows the first area students visited for each session. Predictably the Instructions were the most likely to be used first, but the selection of Osteology (the most simplistic of all the modules) as the second highest entry point, shows students tended to go directly to the tutorial.

The relatively high level of immediate Quits could be indicative of people entering the system out of simple curiosity and then deciding not to continue.

Figure 4.13
First entry scored by number of hits for each session



Eighty-five of the 292 hits started with a foray into the Instruction module; it is not clear if this was intentional from the students' point of view, but it indicates the necessity for such a section. However, despite repeated displays of the instructions students still appeared to get lost. Further research is required to investigate why this occurred and if necessary additional explanation of the structure of the program should be developed.

Navigation paths for all users

Paths were determined by the order in which students accessed the pages. If they followed the next page navigation path beginning with either the Instructions or Osteology to Muscles, Anterior, Lateral and Posterior and possibly on to Innervation then they were deemed to be logical path users, if they jumped between these sections they were deemed to be mixed path users, if no path was discernable e.g. Instructions, Contents Quit, then they were recorded under indiscernible. The following table outlines the usage accordingly.

Table 4.3
Navigation paths of all users

Mixed	Logical	Indiscernible
141	83	69

Of the 53 people who had multiple entries 12 people used mixed paths only, 3 used logical paths only and 4 people had indiscernible paths in all entries. The remaining 36 had combinations of paths for their different entries, thus most people who used the program more than once made use of different navigational paths through the information.

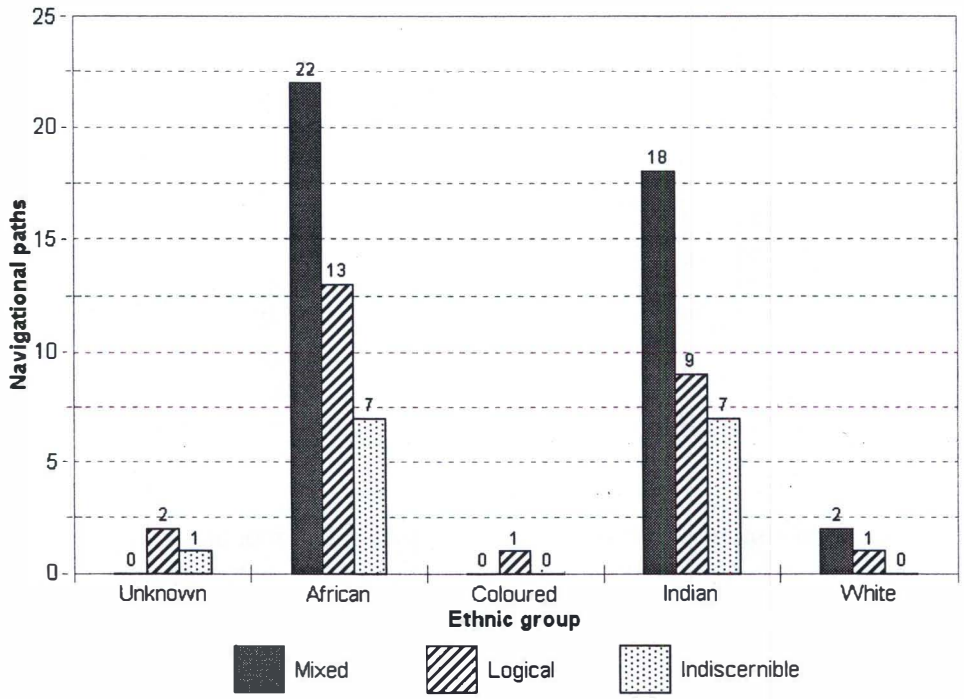
4.4 On-line tracking records correlated with questionnaire responses.

Eighty-three of the hits into the program could be matched by student number to the questionnaires and of those entries 42 different people were identified, some with multiple entries.

4.4.1 Navigation paths for users matched with questionnaire responses

The navigational paths of these entries were grouped according to the ethnicity of the user identified within the questionnaire.

Figure 4.14
Navigational paths of each ethnic group.



Discounting the White, Coloured and unknown groups because of small sample sizes a comparison between the recorded navigational paths of African and Indian students once again shows a difference in approach to the material. Although statistically insignificant, slightly more African students (30.95%) use the book metaphor and logical paths than Indian students (26.47%).

4.4.2 Correlation of on-line tracking records with questionnaire comments analysed by ethnic group

The on-line tracking records that were matched to the questionnaires showed 21 African students, 16 of whom made generally positive statements about the program, 3 were negative or unimpressed with the program and 2 could not remember using it at all. One of these forgetful students used a logical path through the program, but could not remember using it, the other had used a mixed path but claimed to be unaware of the program when filling in the questionnaire.

The 1 Coloured user was positive about the program, saying it was "user friendly" and used a logical path through the information.

Of the 16 Indian users 11 were positive about the program, 1 was generally negative stating that it was too similar to the textbook and would have preferred 3-D images. Four Indian students stated they had not used the program, 1 of these had gone in twice once using a logical path through the information, the second time using a mixed path, all of the others had used mixed paths once.

Three different white students accessed the program once only, 1 used a mixed path, 1 a logical path and the other stated that the program was malfunctioning. The latter student was clearly computer literate as the comment reflected that the server was running but the program was not running. This entry coincides with the time that it was discovered that the xtras directory had been deleted. The first two white students were generally positive about the program, with the student who followed a logical path stating that the program was easy to follow.

The one student whose ethnicity could not be verified, entered on three different occasions, two of these entries followed a logical path, the other had an indiscernible path, but this student was generally positive about the program recommending that it be developed further.

Of all the multiple entries traced back to the questionnaire, only one African student used the predicted navigational paths i.e. initial paged navigation followed by other mixed navigation entries. Two African students had mixed paths only as did one Indian student. The rest had a mixture of navigational paths for different entries but no discernible pattern could be established, except for 1 Indian student whose multiple entries were all indiscernible, but who still expressed a positive opinion about the program.

4.5 Conclusion

The most surprising result within this analysis was the significant difference between the African and Indian students reported use of the system. The initial premise was that African students, usually perceived as being disadvantaged, would be less likely to use technological interventions than other students. However, the results reflected here are the exact opposite with African students being significantly more likely to make use of the system.

The on-line tracking system indicates that students will find their own paths through a system, which could be contrary to designer expectations, and will automatically concentrate on areas that they deem most beneficial.

What was particularly heartening was the percentage of students within the test group who were prepared to use a system that was not integral to their course work, and the surprising number of 'browsers' outside of the sample group who were not officially informed of the program's existence.

CHAPTER FIVE
DISCUSSION

5.1 Introduction

This research was conducted to investigate the issues related to the development and implementation of CAE in general as well as to investigate the potential use of CAE at the University of Natal and its medical school in particular. It attempts to highlight some of the underlying pitfalls that should be avoided if the institution is to successfully position itself as a "digital university" of note (Bawa, 1999). This chapter of the dissertation discusses the connection between the results obtained from the case study and some of the information reported in the literature reviewed. It also poses some concerns that need to be addressed by faculty and the University's infrastructure planning committees before embarking on full-scale development of digital media. However, throughout the research it has been evident that recognition should be given to the argument raised by chaos theorists. In research of this nature there are many variables that may skew or radically transform the results. It would be naive to expect the results to be a definitive predictor of educational success.

It is also important to comment that in a field where the technology advances at such a rapid pace each year's intake of students is likely to be technologically more sophisticated than current students and this could impact on the validity of the study across subsequent years. This argument should not be used to negate the benefit and use of investigations such as this, but alert faculty against drawing conclusive decisions and urge them to undertake continual evaluation, re-evaluation and modification as courses are developed, implemented and maintained.

The research conducted during the course of this project highlights some important factors to consider when introducing CAE into the curriculum, but also poses some questions that could be revisited and acted upon to ensure the continuing benefits of such interventions.

5.2 Pedagogical issues

5.2.1 Educational theory

The debate between Instructivism and Constructivisim is often seen as one of polarized positions in the field of education, with evangelists for either position intractable in their stance. However, a valid argument is made (Cronje, 2000 and Henderson, 1994) that these two positions need not be mutually exclusive and that there is a place for a combination of both modes in various educational settings. The Medical School is currently identifying these levels as they move from a highly instructivist methodology to a more constructivist approach in their Problem Based Learning curriculum. The initial research and development was conducted whilst the traditional teaching methods were being applied, but a program such as this should be useful in both modes if the costs of development are to be recouped.

The instructional strategy used in the program enhances the use of visual aids, verbal cues, self-directed exploration and self-testing. What is entirely missing in this program, however, is the communication tools required for true collaborative learning. Whilst some students indicated that they worked together, some form of Computer Mediated Communication could have enhanced the learning experience. More to the point, the various elements of this program lend themselves to mastery learning with little evidence of the values, attitudes and opinions emphasized in the criteria for Outcomes Based Education. The students' comments reflect this in the way they said they used the program for self-evaluation and testing. There is also little evidence or support for situated learning experiences. PBL is only accommodated as far as some clinical issues are presented but, if the program is to be used in a PBL environment, direct

links to the clinical cases should be made available to the students. Whilst the methodology applied was applicable for the curriculum and teaching strategies used during the research period, the lack of alternative PBL navigational options will limit the use of the program for future students.

5.2.2 Learning styles

Learning styles that were met by the program included Pask's holistic and serialistic movement through the modules. Gardner's multiple intelligences were accommodated to a lesser extent allowing for some aural and visual learning which would not otherwise have been available in traditional print media. These were mostly viewed in a positive light by the students' responses in their questionnaires. It is more difficult to review Kolb and Gregoric learning strategies, but the navigation records show that students were able to do more practical review tests or theoretical learning when they required. However, the comments from students about the dissecting hall and practical work should not be ignored and the program should be available to students before, after, and during such practical exercises to allow for these learning strategies. It is clear, however, that CAE can be used to support various learning styles without detracting from the importance of more traditional methodologies where appropriate.

5.3 Instructional design and media production

The ID model used in the development of this program was based primarily on Willis' R2D2 concept (Willis, 1995), however, with a project of this nature a certain level of closure and summation was necessary along the lines of the Dick and Carey's 1996 ISD model (Dick, 1996). Richey's communication theory model (Richey, 1990) informed the structuring and presentation of information, and the planning phase and criteria for evaluation phase were advised by Richey's conceptual model (ibid). However, in general, work of this nature is always likely to be modified and changed as the body of knowledge within the discipline expands and as the student demographics, culture and learning backgrounds alter. Any CAE modules will need to undergo continual upgrades and modifications and can never be viewed as a completed work in themselves. Thus iterative formative evaluation is likely to be the norm, following Willis' R2D2 model (Willis, 1995), and the ability to continually modify the program should be an essential part of the process. As the technology becomes more sophisticated and particularly as Internet delivered programs mature, this iterative approach is more feasible.

The instructional design phase of this project drew attention to the need to have faculty committed to the project during the ID, development and implementation phases. A major barrier to the successful conclusion of this particular research project was faculty's minimal participation and the fact that the program did not form an integral part of the learning process. The University has demonstrated a commitment to the fiscal requirements for development and during the latter part of this research university staff have indicated a greater willingness to encompass technological interventions in their curricula; however, more accessible mechanisms are required to ensure that faculty have access to the technological skills for local development.

5.3.1 Choice of development software

Some of the major strengths of the computer medium is its ability to display high quality graphics cheaply, to allow the user multiple paths through information sources and enhance asynchronise communication between course participants. Authoring systems are able to exploit different areas to greater and lesser degrees. For instance, both Authorware™ and HTML developed material allow for the use of high quality graphics and multiple paths. Authorware™, however, does not lend itself to easy modification and use of communication technology, whereas Internet delivered material composed in HTML excels in these areas, but may be limited by bandwidth problems. On the other hand, Authorware™ has superior abilities in allowing developers to easily integrate interactive simulations, models and record keeping.

Decisions regarding the most suitable software need not be made on an all or nothing basis as Authorware™ programs can be compressed and delivered via the internet forming part of a HTML delivered course. The choice to use Authorware™ in the development of this program was made at a time when it was premature to view the Internet as an integral part of the learning process but this decision should be revisited given the maturation of the internet as a delivery tool. The final choice of development software will always vary depending on current developments in computing technology, and these decisions should be reappraised continually to determine the most cost effective choice in terms of delivery, training, development and maintenance. No final decision can be made here about suitable authoring systems except to point out the strengths and weaknesses of the various media.

5.3.2 Interface design

Cultural issues

The interface design of this program was heavily influenced by the research reported by Amory and Mars (1994) as well as Andrews (1994), including the fact that all directions were given in text and that iconic representations were not culturally exclusive and clearly labelled. However, notwithstanding the ongoing formative evaluation of the design elements, some misconceptions were still apparent; in particular the use of the Quit button to exit a module rather than the program as a whole.

To complicate the issue culture is not a static separate entity that stands in isolation. As South Africa moves to a more integrated society both locally and internationally, cultural identity will change. Formative evaluation on these issues will highlight the changes as they develop over time.

Learning time

Generally the program required little learning time, with many students expressing satisfactory use of the system after being exposed to a short demonstration. However as some students expressed difficulties navigating the system more formative evaluation of design elements must take place to ensure intuitive use for all students. It is essential that students are able to use the systems intuitively and they should not require further training for different CAE modules.

Prior experience

Conjectures about students' prior experience in the use of computer equipment influencing the way they would use the program, were seen to be inaccurate, where students who were presumed to be less computer literate more willing to use the system. Further research is required to find the reason for this trend, but clearly the University need not be unduly concerned that the use of technology in the teaching process will further disadvantage under-prepared students.

Use of metaphor and navigation

The book metaphor was not raised as an issue in the questionnaire responses, and is thus assumed to have worked well with all student groups. However, as this metaphor was intended to assist in the navigation of the information it is of particular interest that a few students found the program difficult to navigate, particularly as these three students came from the group that were perceived to be more likely to be computer literate than the others. This raises the suggestion that hypertext may not be as universally understood as initially presumed and further research is required to verify this.

The inability to find significant differences between students using a mixed and logical path through the information suggests that there is merit in offering multiple paths to the students from all backgrounds.

Using the textbook as a model and starting point for content was an aspect on which the students expressed divergent views. Although the program had more information than was available in the text, and the information that was from the textbook had been modified and restructured considerably, many students seemed to view it as a mere replica, whilst the students presumed to be less sophisticated learners saw it as a useful introduction. Satisfying both sets does not seem to be a possibility here, and using an existing text as an entry point should not be ruled out as the benefits to the less sophisticated students appear to be of considerable merit. However, the formative evaluation should ensure that the benefits of using the program are greater than simply reading the text and that the program has clearly observable benefits for all students.

Sound

Other than the one student who would like a lecturer to add sound bytes, most students did not comment negatively on the sound aspects. However, a connoisseurial comment is necessary here in that with the sophistication and development of software over the period of this research, many of the transitional sounds are now outdated and should be removed from the program. The pronunciation of Latin and Greek terms was considered useful, and perhaps additional comments could be added in sound bytes to accommodate the aural learners.

Messages and feedback

The questionnaire responses elicited no negative comments regarding the messages and feedback systems applied within the program. It is thus presumed that the students appreciated the corrections to quiz responses. The need for immediate and accurate feedback is an essential component of computer delivered courses and should be born in mind when using computer mediated communication in Internet delivered material.

Maintenance

The production of the media was flawed by the lack of adaptability for ongoing maintenance and upgrades. The cost and time involved in the creation of this type of media must allow for continual upgrades, but once a program such as this is compiled it is extremely tedious to make alterations. This in itself will limit the shelf life of such a program. Furthermore, the ability to modify the program is often dependant on the originator being available to make the changes. Should that person leave the institution no further developments are likely. This is an issue that should be considered carefully when choosing a particular authoring system.

Copyright issues

Copyright issues were avoided in this program as it was seen to be a research project and text and images were used under the 'fair-use' copyright clause. However, if the program was to be developed further these issues would need to be addressed and would add considerably to the cost of the program as either all the images would need to be redrawn or permission would have to be obtained for their use. These costs would have to be weighed against the purchase price of a commercially available product such as An@omedia™ which is currently under development[11].

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[11] See http://www2.meu.unimelb.edu.au/Anatomedia/back_imaging.html [09 July 2001].

5.4 Implementation issues

5.4.1 Accessibility

Any program or CAE intervention is only as useful as it is available to those who wish to use it. Similarly the CAE program can only be used if it is readily and easily available to the students. The University of Natal's Medical School has a relatively sophisticated computer infrastructure but the computers available to the students are housed outside of their regular work area and are only available for limited times. Programs such as these should be made available either via the Internet or on CDs enabling student access from home if they have suitable equipment. It is also imperative that the institution ensures that sufficient funding is available for the continual upgrade and maintenance of equipment for general student usage.

Another aspect of accessibility that is easy to overlook is students' perception of personal safety. The medical school is some distance from the campus' residences and there is generally a lack of public transport to and from the campus. Students are reluctant to travel between the campus and place of abode after dark, which means that the time that they can spend on University facilities is limited further. The University's commitment to providing suitable equipment should be extended to the residences allowing continual safe access.

5.4.2 Organisational culture

The University of Natal has made an executive commitment to support the development of digital technology within its institution (Bawa, 1999), and is also encouraging faculty's participation by allowing academic staff to submit teaching portfolios, which may or may not include digital media, for consideration when applying for promotions.

Furthermore, this research has indicated that students are not only willing, but are also eager, to use technological interventions. However, there still appears to be a reluctance from faculty, many of whom appear to be either unable or unwilling to take on the extra burden of learning the technology and developing on-line course material. A more rigid look at issues related to the 'Digital Divide' focusing on the ability of educators to use the technology and develop suitable material may be more productive than simply looking at providing access to hardware and the computer literacy of students.

Faculty at the Nelson R. Mandela School of Medicine will be required to use such interventions when their students are based at distance hospitals. It is incumbent on both the support structures and staff members to ensure that they have sufficient skills to maintain the development of learning material for these students. University management has the fiscal responsibility to ensure that there are sufficient funds to continue and maintain such developments, including the bandwidth problems associated with Internet delivered material.

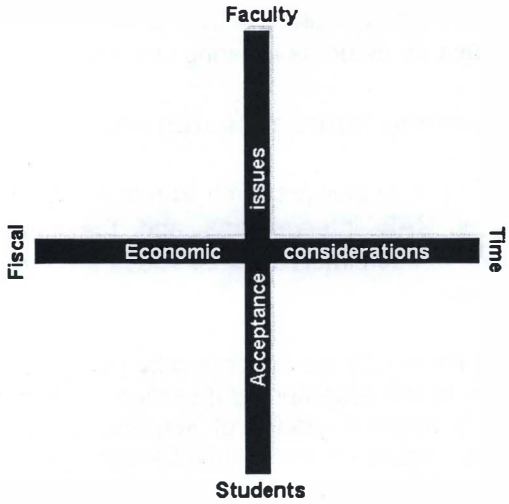
The re-occurring issue of 'who owns digital material' needs to be addressed as a matter of urgency. Generally any material generated by faculty, whilst in the employ of the University, is deemed to be owned by the University. This needs to be clearly stated in the University's employment contracts and specific mention must be made of digital media. In concert with this the ability and mechanisms for updating learning material needs to be ensured when the initiator or 'champion' leaves the University.

5.5 Evaluation

Thomas (Thomas and Kobayashi, 1987) states that research should comprehend the entire complexity of the learning process and environment, including items such as the characteristics of the learner, specifics of the subject being taught, the characteristics of the technology being used, most of which has been discussed above. However, his ultimate test is to measure the

acceptance of the technological intervention and its cost effectiveness. In these terms students demonstrated an acceptance in so far as they are willing to use the resources available to them, but faculty are more reluctant to demonstrate this acceptance and develop digital resources themselves. The economic factors need to be measured both in terms of the financial costs of hardware, software and delivery mechanisms and this also needs to be weighed up in terms of the time taken to develop and maintain the material. These could be scored in a matrix such as displayed in Figure 5.1, but, as in any accounting system, these should be balanced against the benefits. Whilst the costs of such developments are high in both monetary terms and faculty time, the benefits are not easy to define and should be measured against the changes facing university education.

Figure 5.1
Matrix of evaluation criteria



5.6 Changing face of university education

Whilst recognising that teachers often teach the way they were taught and change is always difficult, the University must include support for this type of development if it is to be a player in the 21st century. The literature reviewed shows that not only are more educational institutions adopting technology in their teaching, but that students are also selecting institutions that demonstrate a commitment to providing technology to their students. Furthermore, tertiary educational institutions are marketing their courses to life-long-learners and corporate employees. In order to capture this market they need to be able to adapt to a flexible delivery method, with particular emphasis on the delivery of courses 'any where' at 'any time'. It is not sufficient for the University to pay mere lip service to these developments. If the institution is committed to moving away from the methodology so scathingly described by Kadar Asmal (Brand, 1999) it will need to focus on both technology as a tool for research and reporting, much as pen and paper are a tool, as well as technology used to support the dissemination and construction of knowledge.

A further concern for education in Southern Africa is the impact that the HIV/Aids pandemic is likely to have on student numbers and new faculty. The skills crises facing South Africa is likely to increase as more people succumb to the disease and fewer students are likely to have the financial resources to attend tertiary educational institutions as full time students. The need to study in the 'Post Fordist' model described in the literature review will become a necessity for many students. Furthermore, educational institutions wishing to recruit new staff members will find that they will be competing for a smaller number of new graduates in a highly competitive market. It is likely that it will become increasingly difficult for the University to attract well-

qualified graduates to replace faculty leaving from natural attrition. Whilst computers are not likely to replace the function of good educators, they are able to record the methodology and information used by existing faculty and support the teaching duties of less qualified and inexperienced educators.

Further research is required to fully understand the issues related to the significant difference in the way students of different ethnic backgrounds used the program. It is possible to hypothesis that the more advantaged students resist using slow communal equipment, and their level of sophistication makes them critical of home grown products. Or that the less advantaged students have had to struggle to such an extent to get accepted into a medical faculty they are willing to use whatever resources are available to them. However, the lack of significant difference in educational background immediately throws suspicion on these hypotheses. What should be born in mind is that the 'African' students in this group who schooled at government funded institutions would only have had access to Model C government education for their high school studies. The patterns of use for students entering University in 2007 may be different.

5.7 Recommendation regarding future research and developments

There are several areas that require further research to more fully understand the way South African students make use of CAE interventions and the barriers for the successful development and implementation of such interventions. These are mentioned in the discussion, but are summarized here for clarity.

- It is desirable to understand more fully the role ethnicity plays in predicting the likely use of CAE interventions. Research in this area should investigate if this trend has any correlation with culture *per se*; or is it more a matter of learning styles and Gardner's multiple intelligences with particular emphasis on the cultural background of the individuals.
- Follow up research is necessary to see if this trend continues with future students, particularly as the students who participated in this case study had only access to model C schools for their high school education.
- The navigation records suggest that students do not fully understand hyperlinked documents, and this needs further investigation and intervention if necessary.
- Further understanding is required in terms of the 'Digital Divide'. If students are willing and able to use technological interventions as shown by this research, and the University is providing suitable equipment for the students, then the barrier to successful technological developments rests with faculty. Critical research into the role of faculty and the implications for moving into a digital era is needed to clarify this issue.
- Concern has been expressed that the costs of development will be too large if the programs developed fall into disuse when the program's initiator leaves the employ of the institution. Practical interventions should be investigated to ensure that this does not happen.

In order for the University to make best use of the technological infrastructure already in place and to further develop the institution's presence in the information age it is recommended that the University:

- commit itself to continual review and evaluation of software programs and support their local development;
- initiate and support research in this area from both an academic development and financial perspective;
- enter into a suitable legally binding agreement with faculty regarding copyright of intellectual property;
- extend its computer network and infrastructure to the university residences and ensure that all materials used are accessible from remote sites;
- develop incentives to encourage reluctant faculty participation in the digitising of the institution;

- ensure continued support structures for faculty already engaged in the development of digital media and devise a mechanism whereby academic recognition is awarded for such participation.

5.8 Summation

The use of computers in tertiary education in South Africa can enhance the educational experience considerably. It is pertinent that the institution commits itself to a systemic inclusion of technology that takes into account both a fiscal commitment to the infrastructure requirements as well as the development of staff skills to sustain the development and maintenance of technological interventions.

The concerns expressed by many that these developments will exclude 'disadvantaged' students have proven groundless, but new faculty skills need to be developed and rewarded within the institution. Further systemic changes need to be introduced within departments that ensure the continued development and maintenance of computer mediated educational programs particularly when the 'champion' of a project is no longer available.

Careful consideration should be given to the local development of CAE programs. The advantage of customised software for the specific needs of a South African institution and its student population may be outweighed by the cost of such development, particularly in the light of the levels of sophistication required to engage the more technologically literate students.

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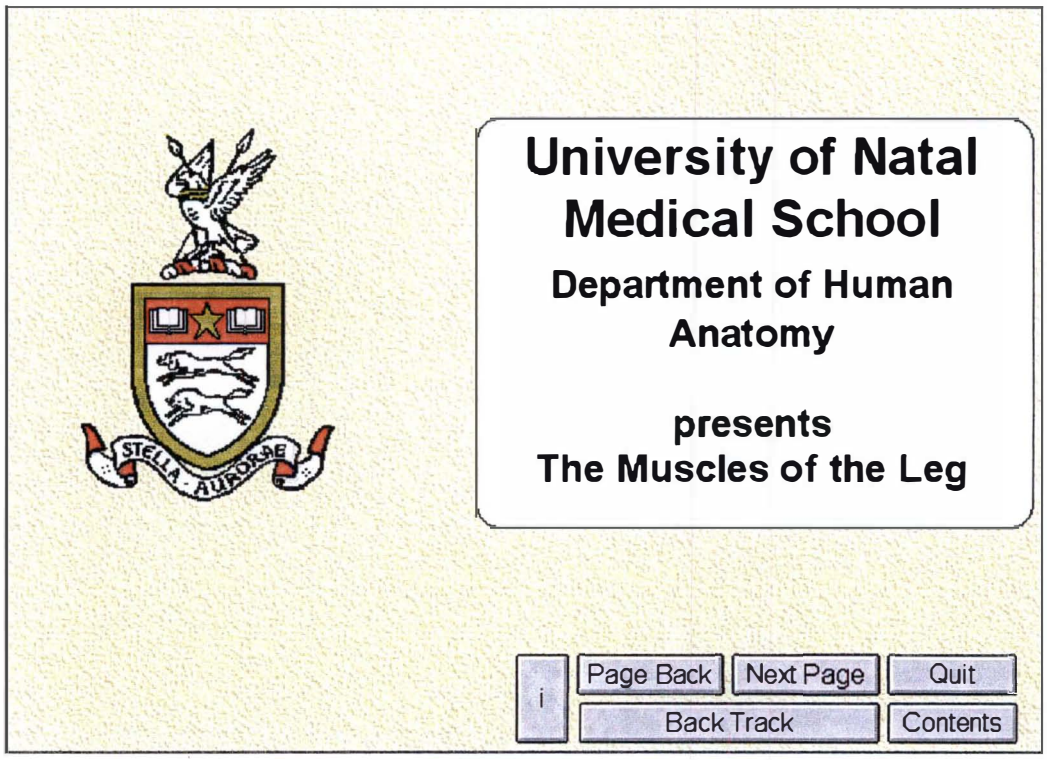
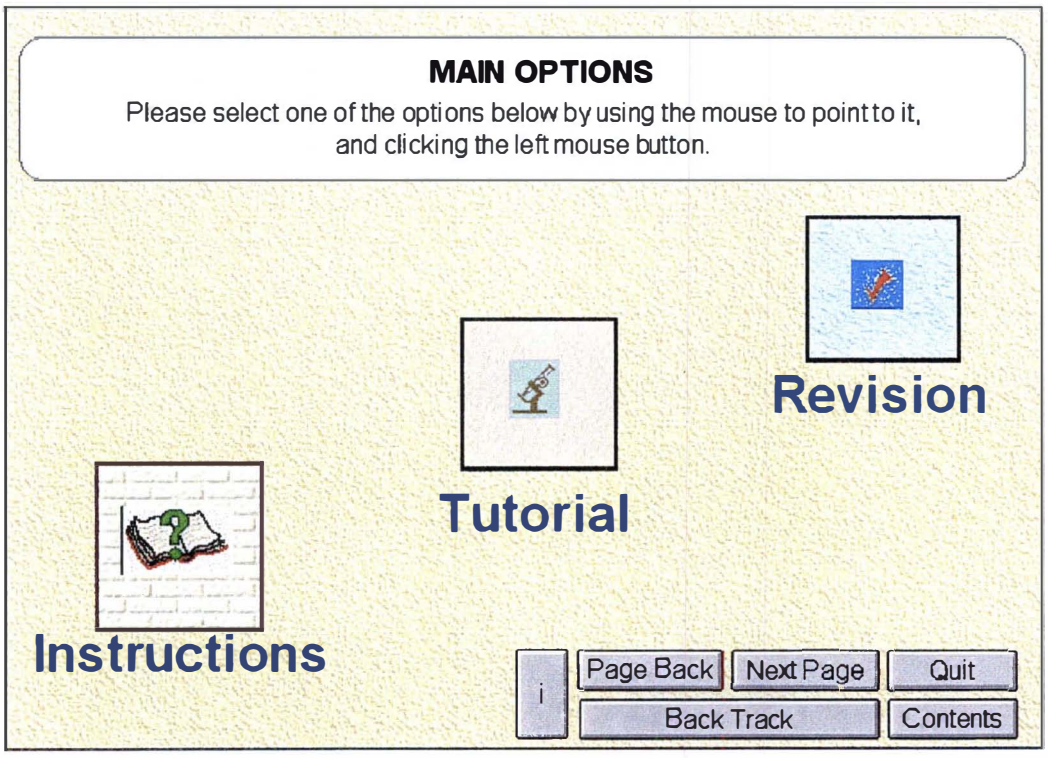
APPENDIX A

Screen dumps of page by page flow chart

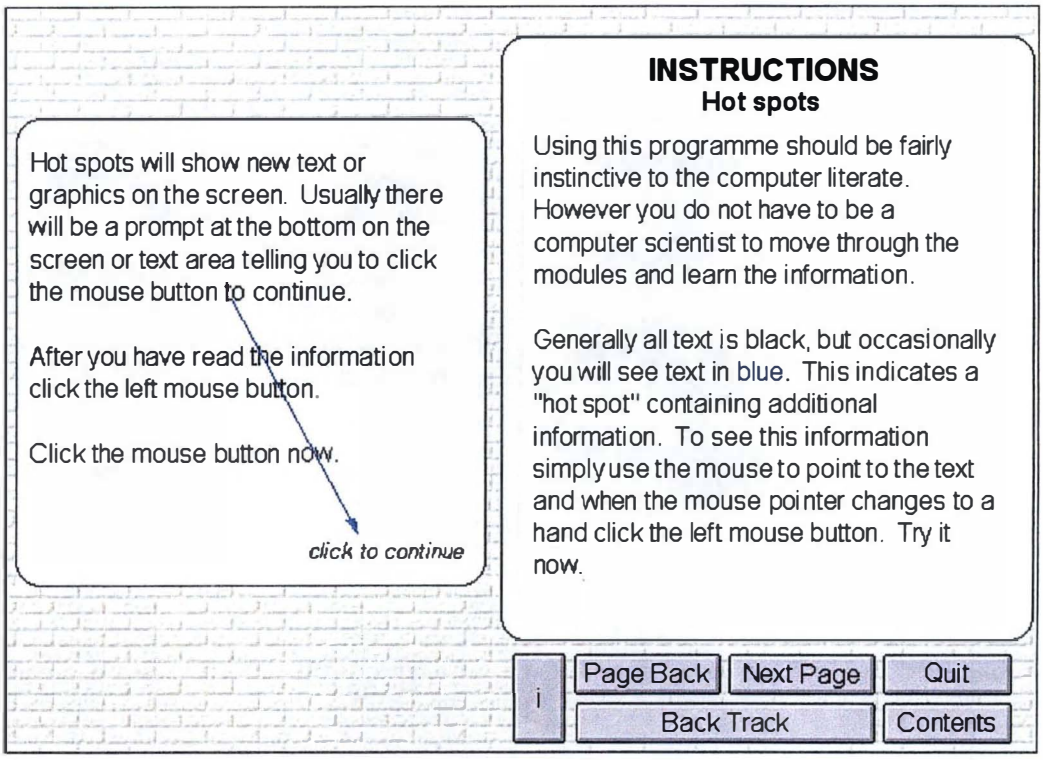
Title screen



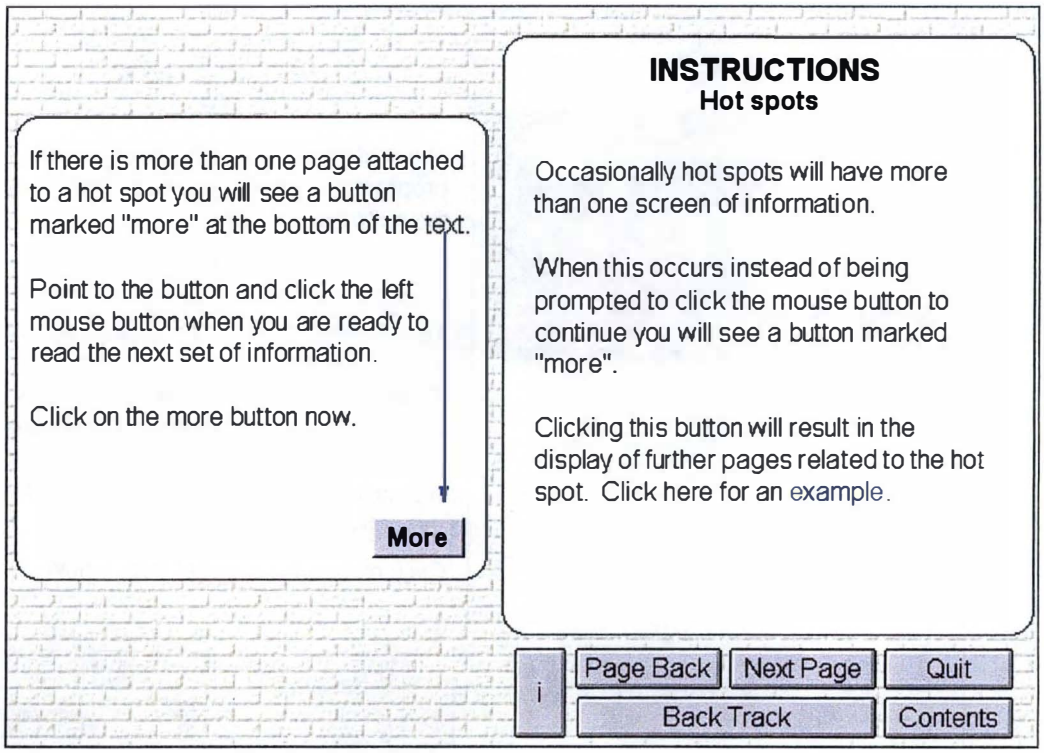
Main options screen



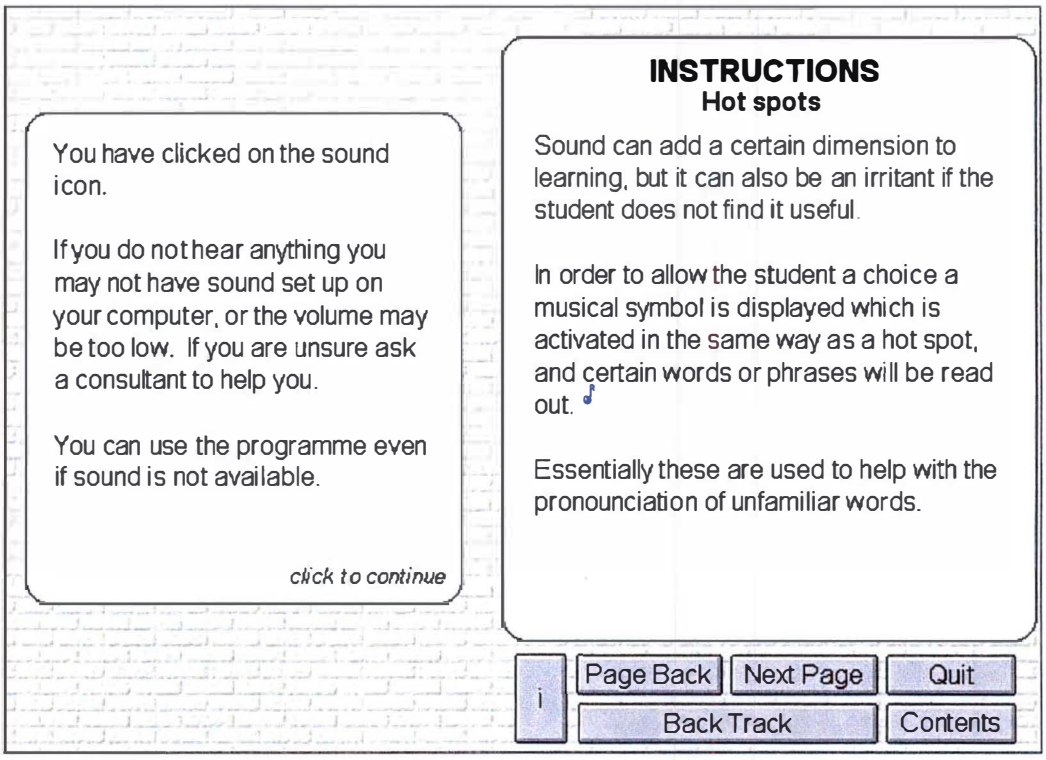
Page 1: Instructions on the use of hot spots



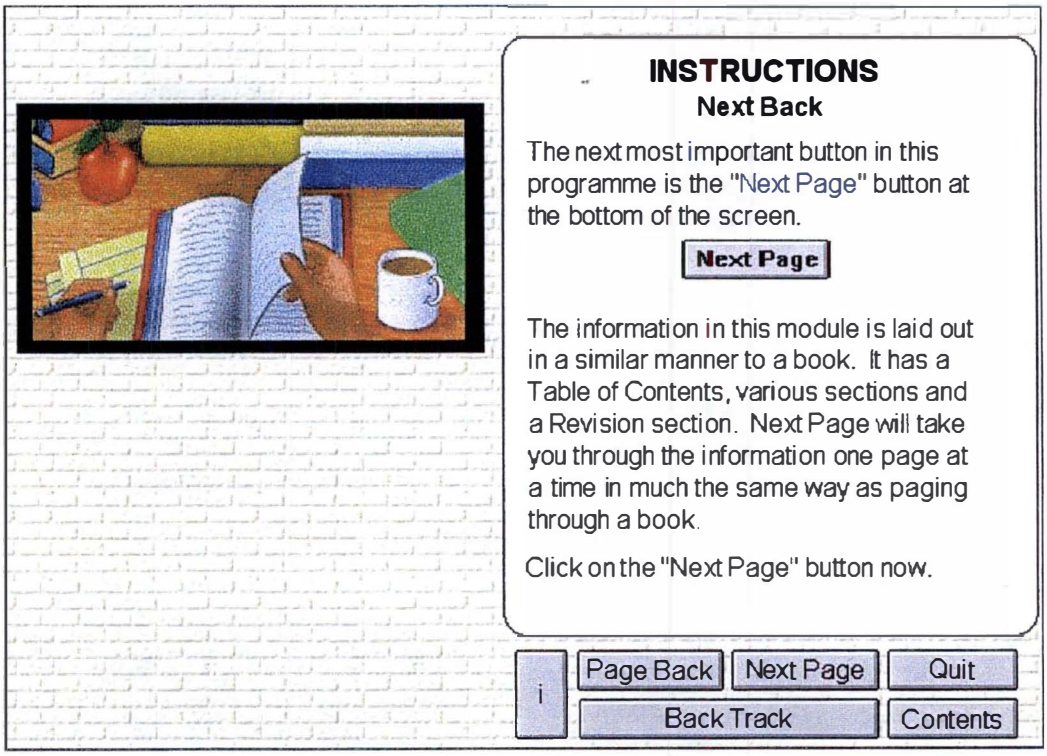
Page 2: Hot spots with more text



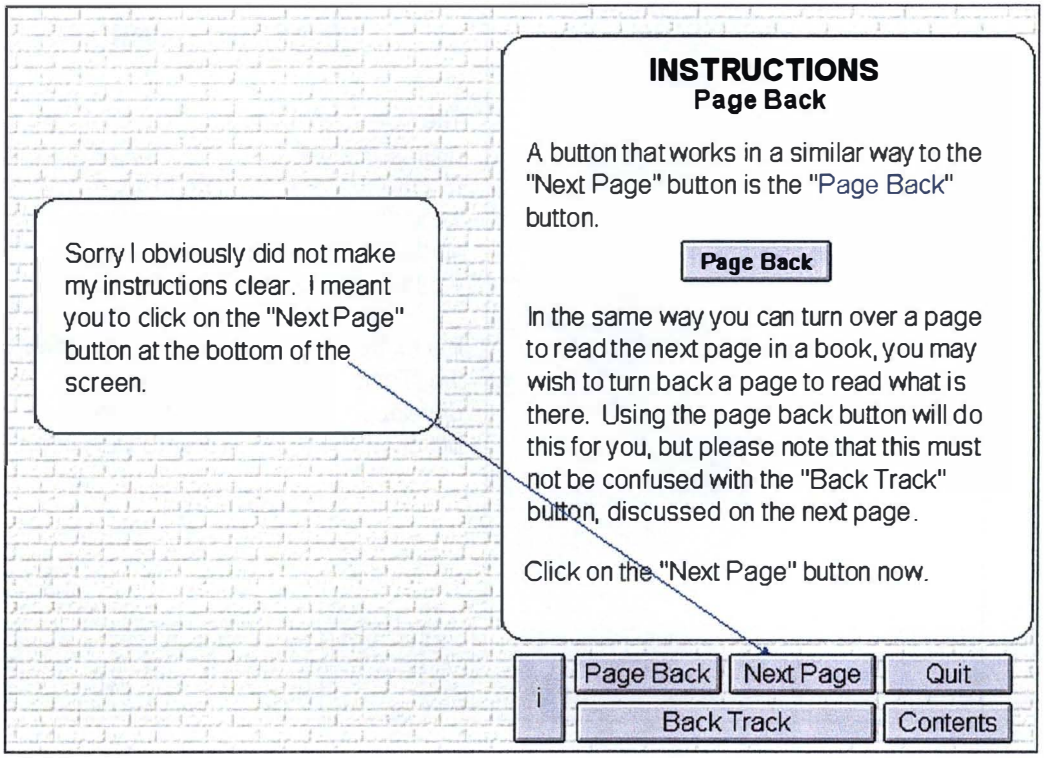
Page 3: Instructions on the use of the sound icon



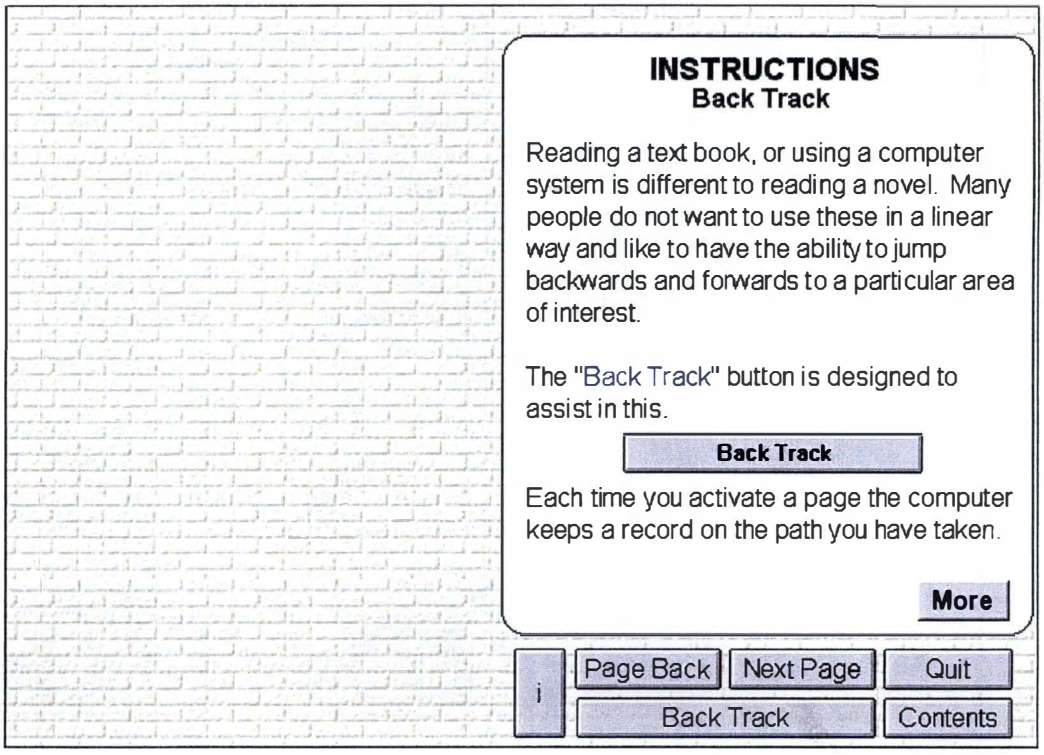
Page 4: Instruction on using the "Next Page" button



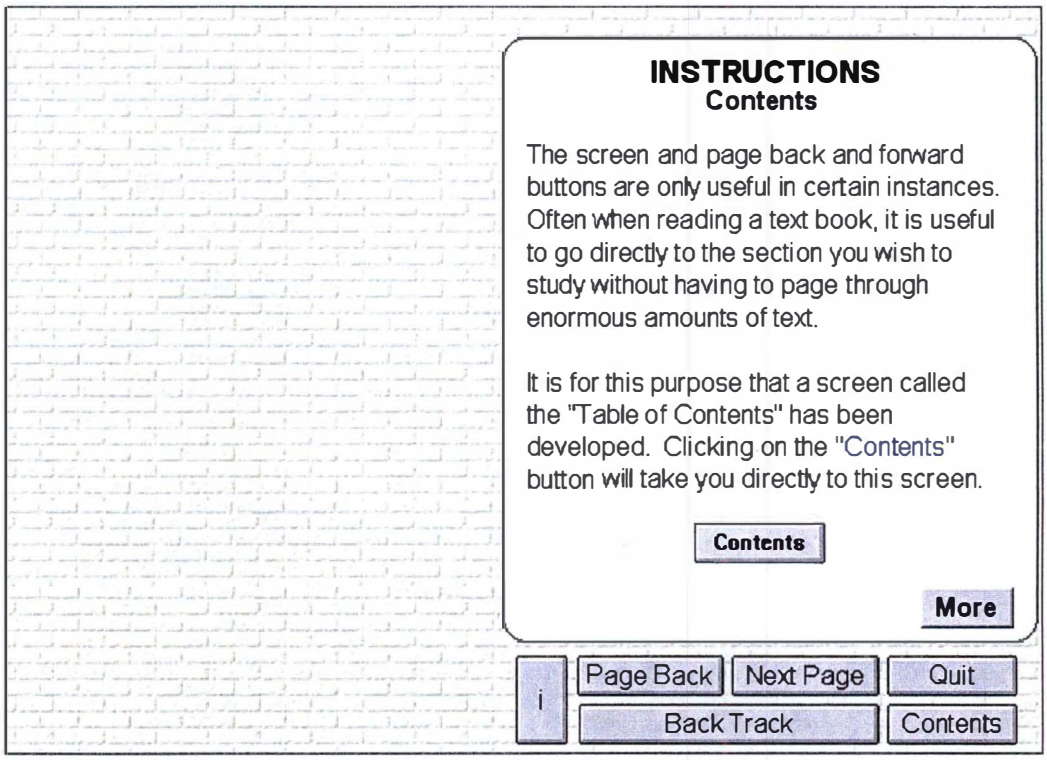
Page 5: Instruction on using the "Page Back" button, with example of an error message



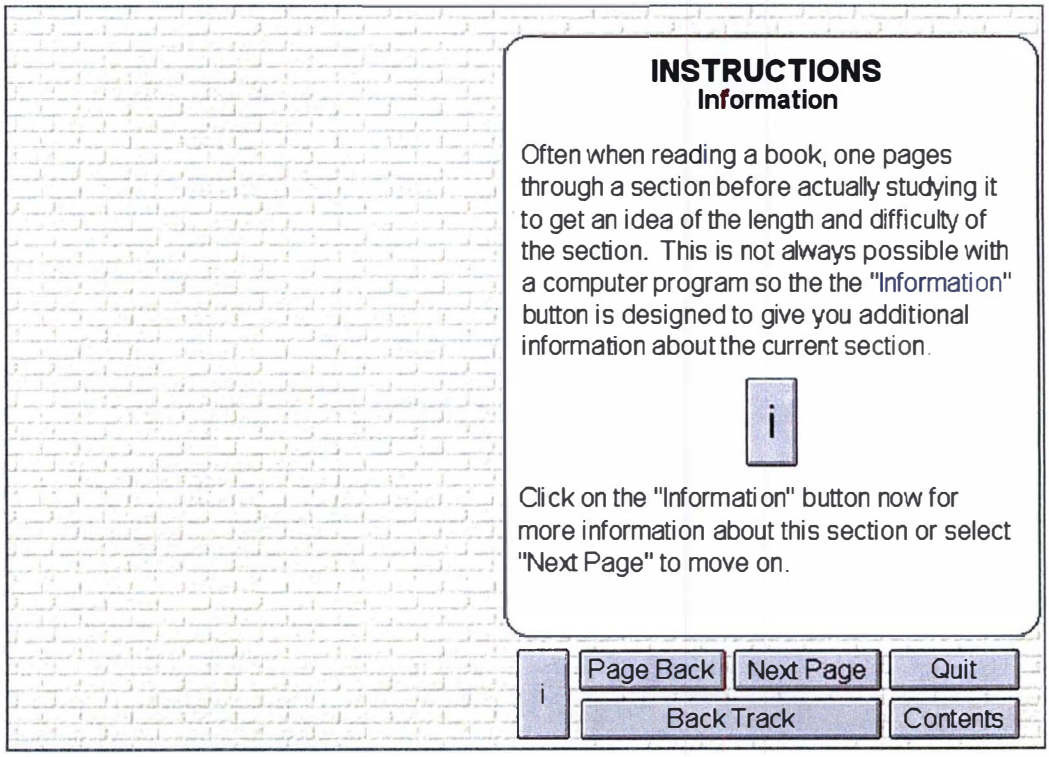
Page 6: Instruction on using the "Back Track" button



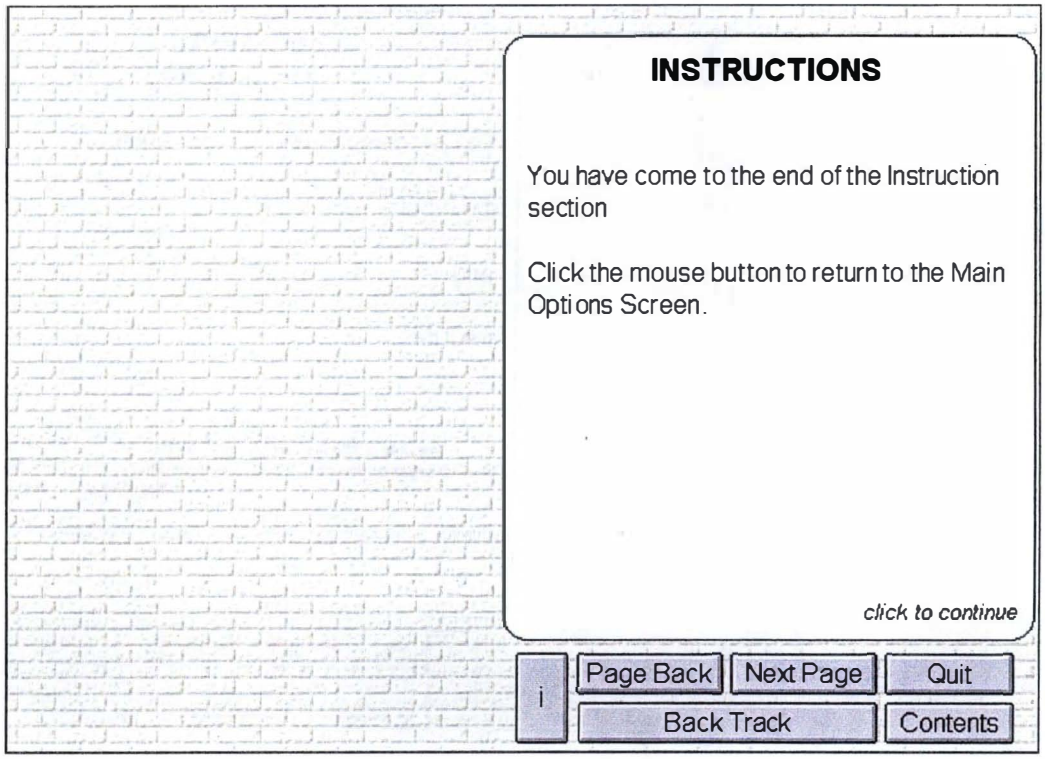
Page 7: Instructions on the use of the "Contents" button



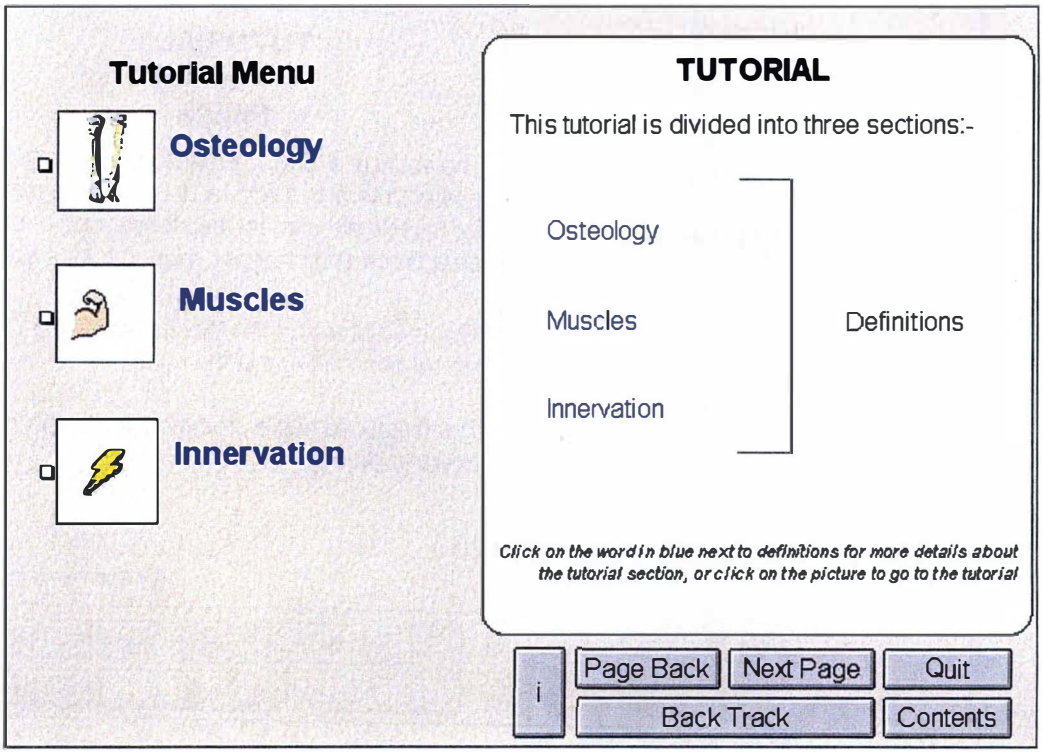
Page 8: Instruction on using the "i" (information) button



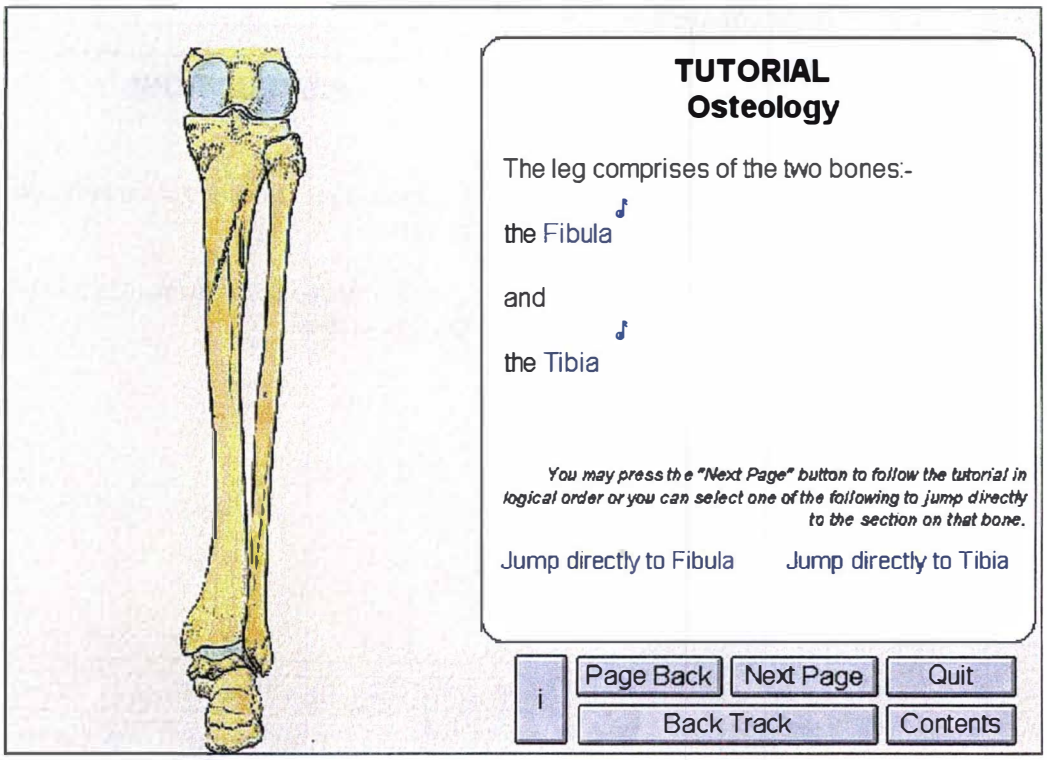
Page 9: Last page of instructions with message for proceeding



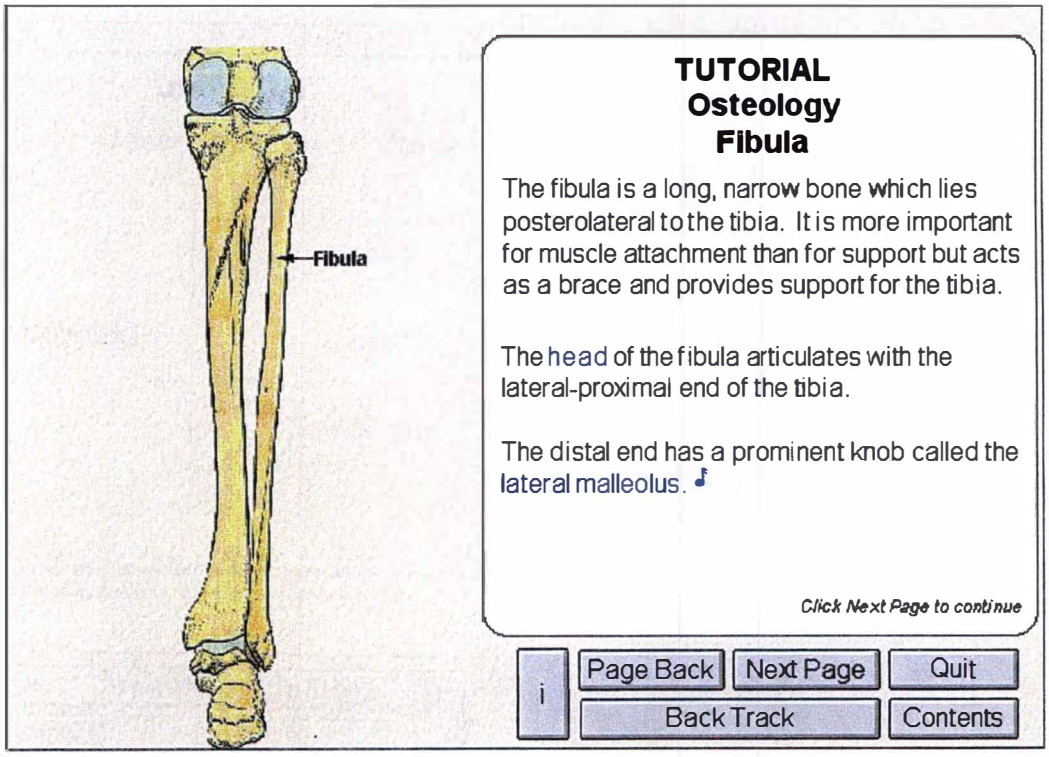
Page 10: Main options for the tutorial section



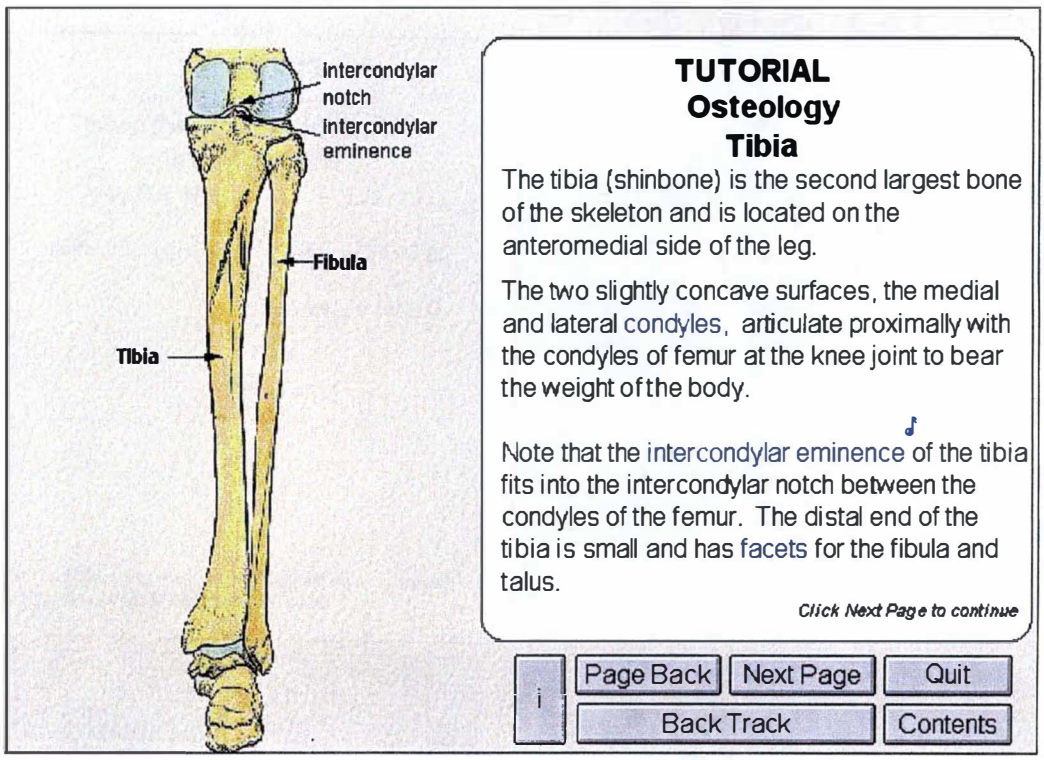
Page 11: Osteology main page



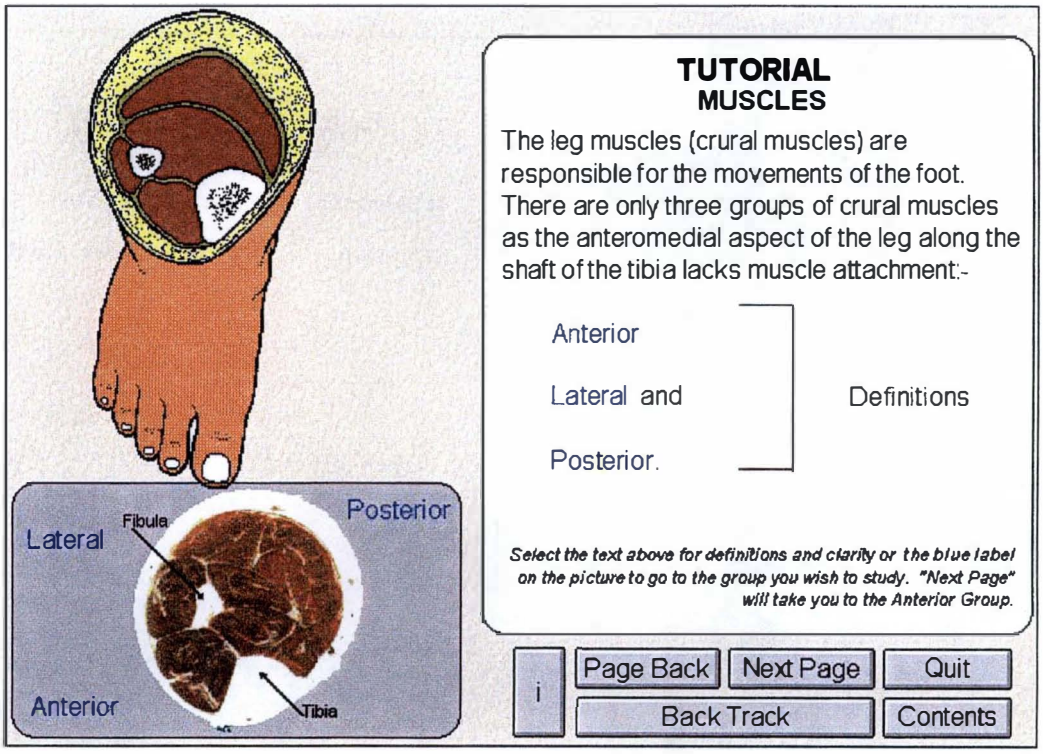
Page 12: Osteology – fibula



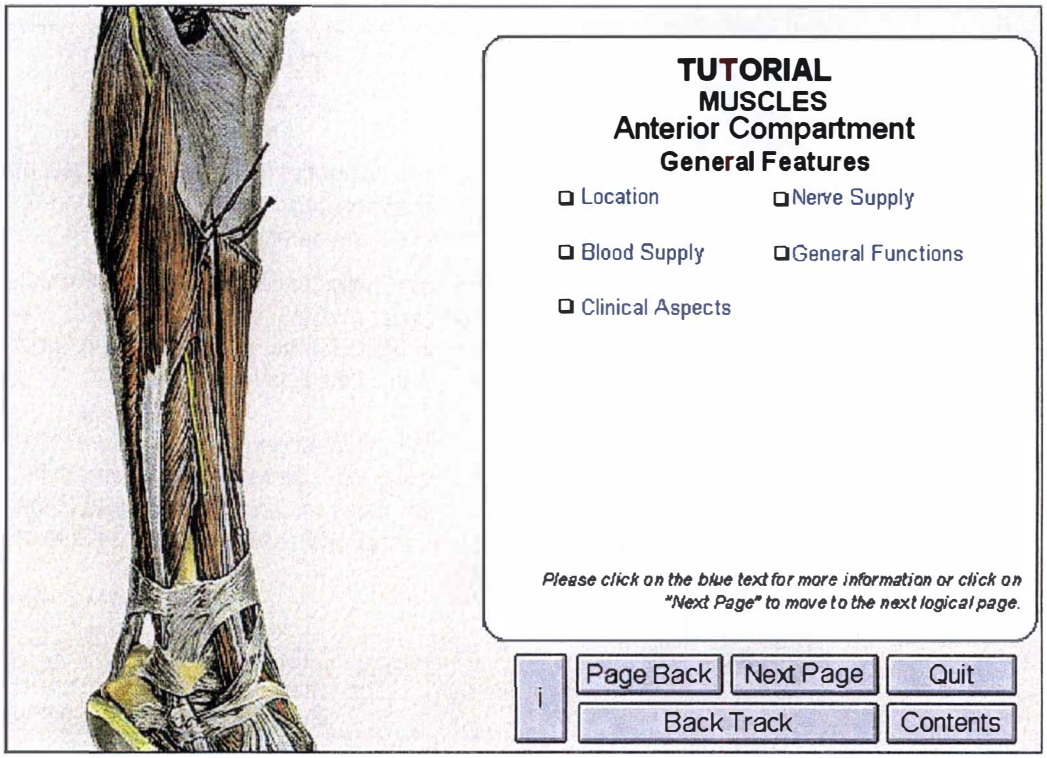
Page 13: Osteology – tibia



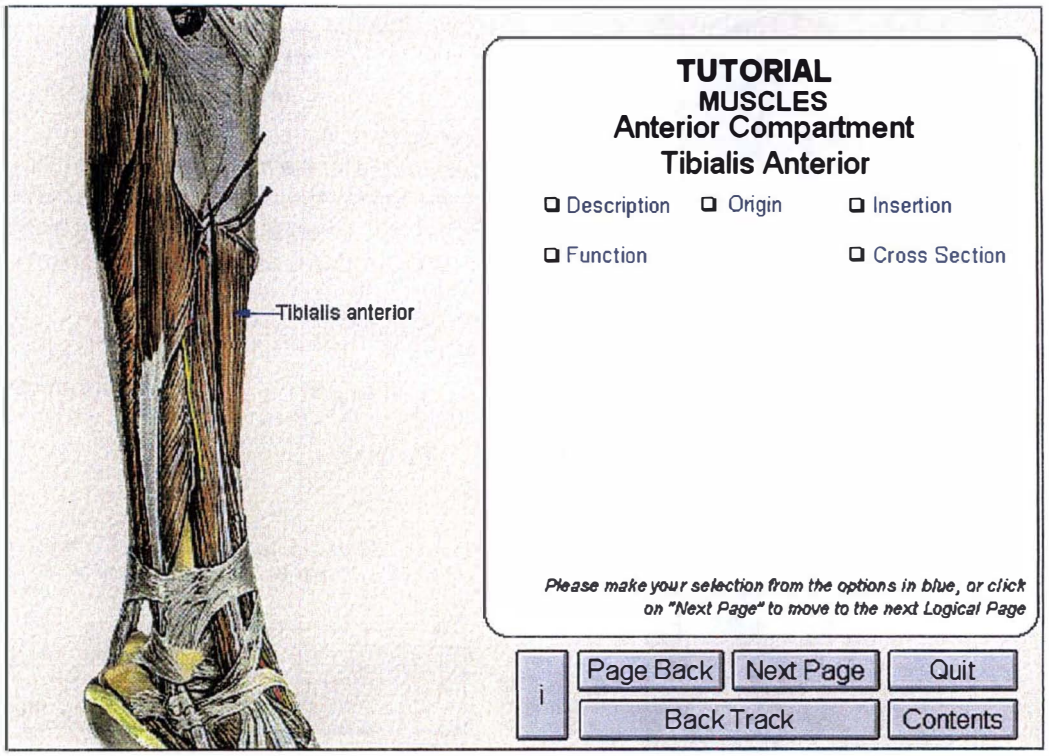
Page 14: Muscles – introductory page



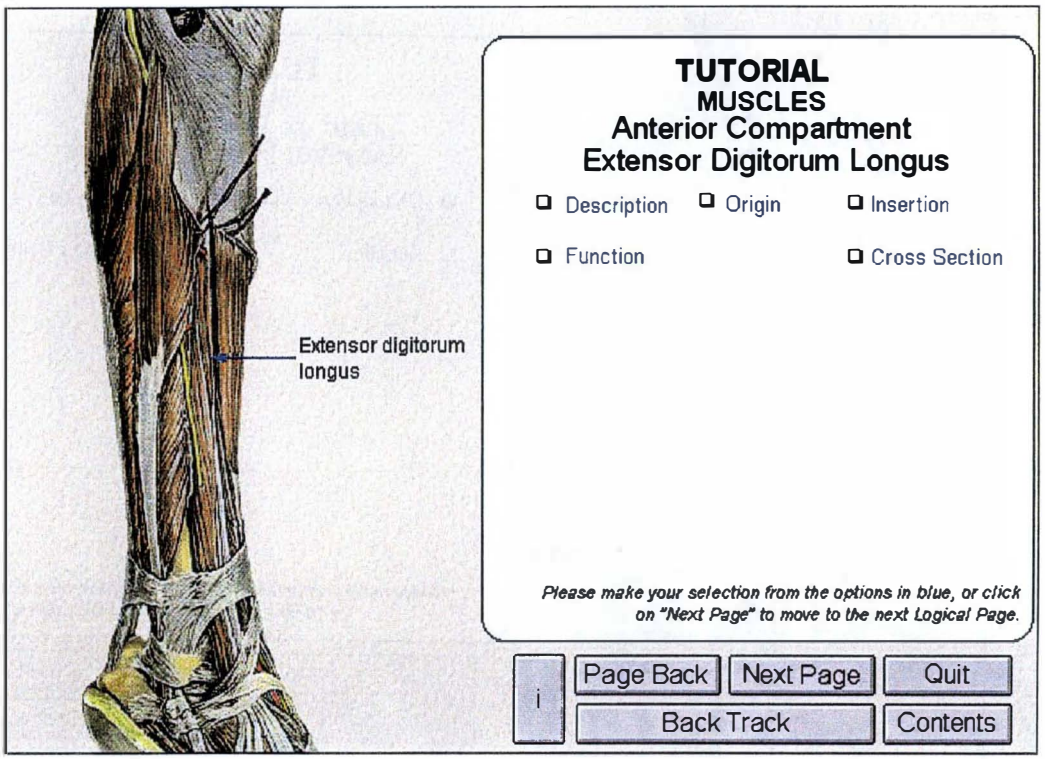
Page 15: Muscles – anterior compartment



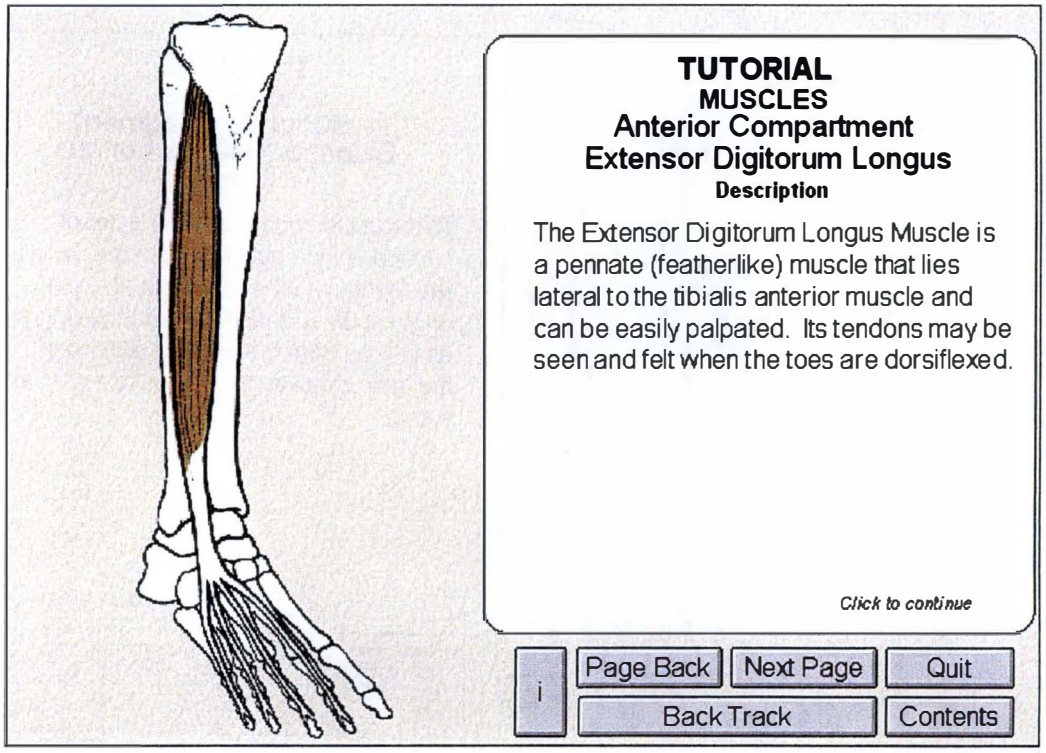
Page 16: Muscles – anterior compartment



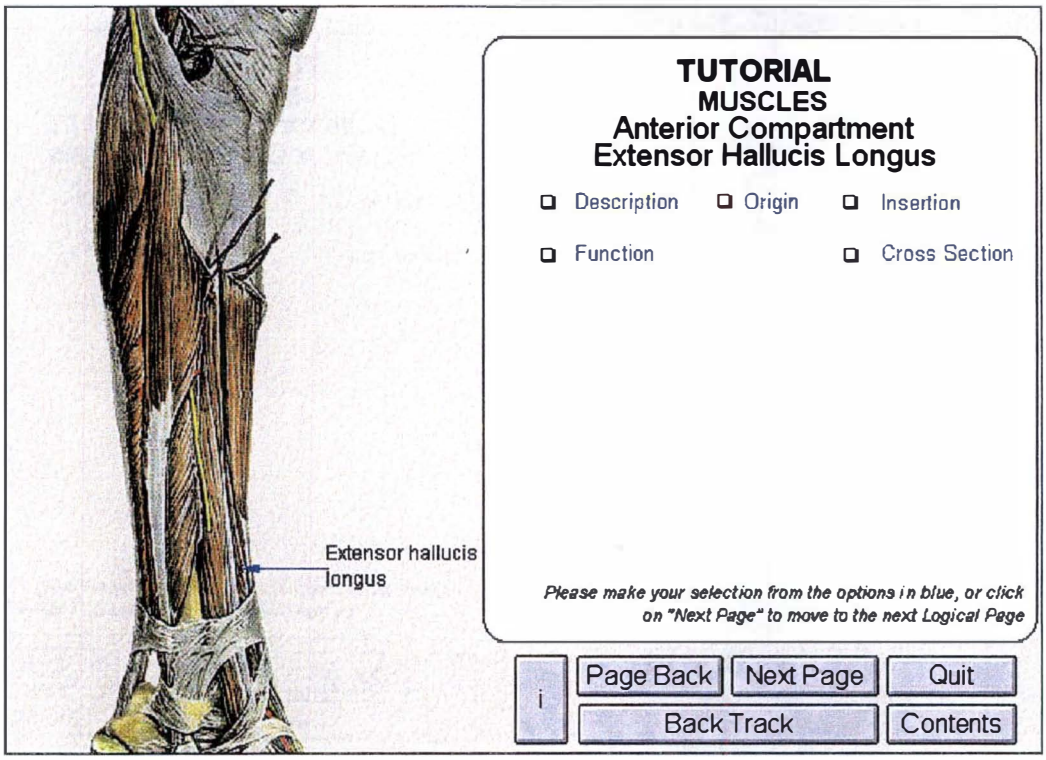
Page 17: Muscles – anterior compartment, extensor digitorum longus



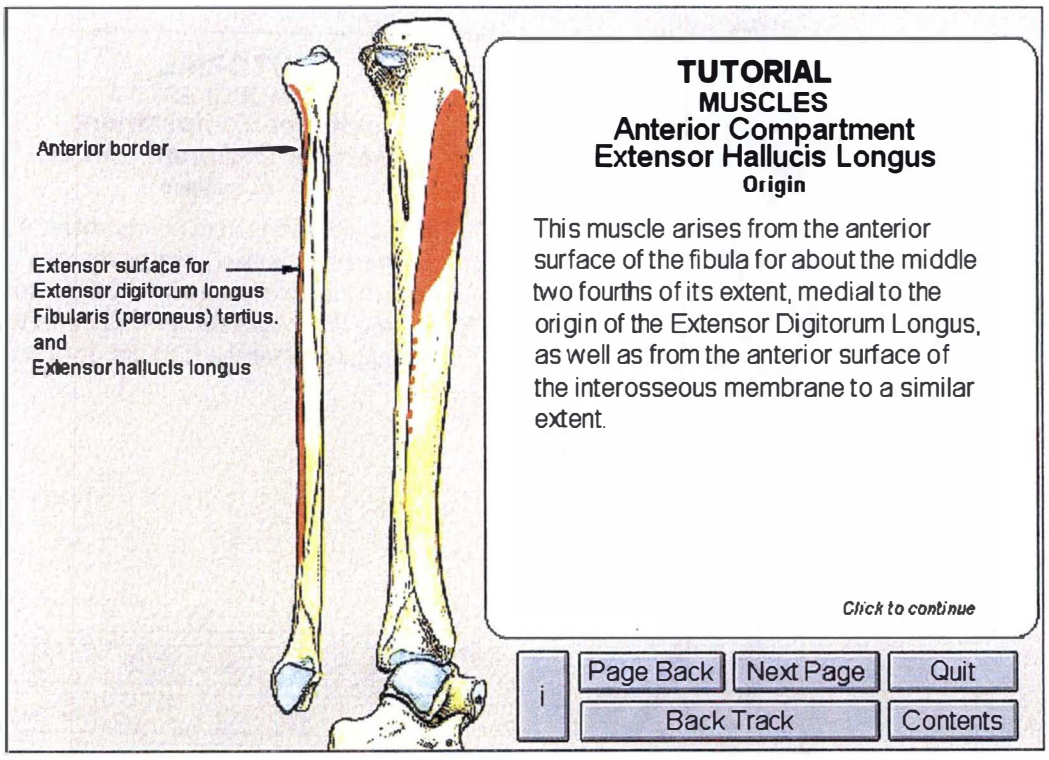
Page 17(b): Muscles – anterior compartment, extensor digitorum longus, description



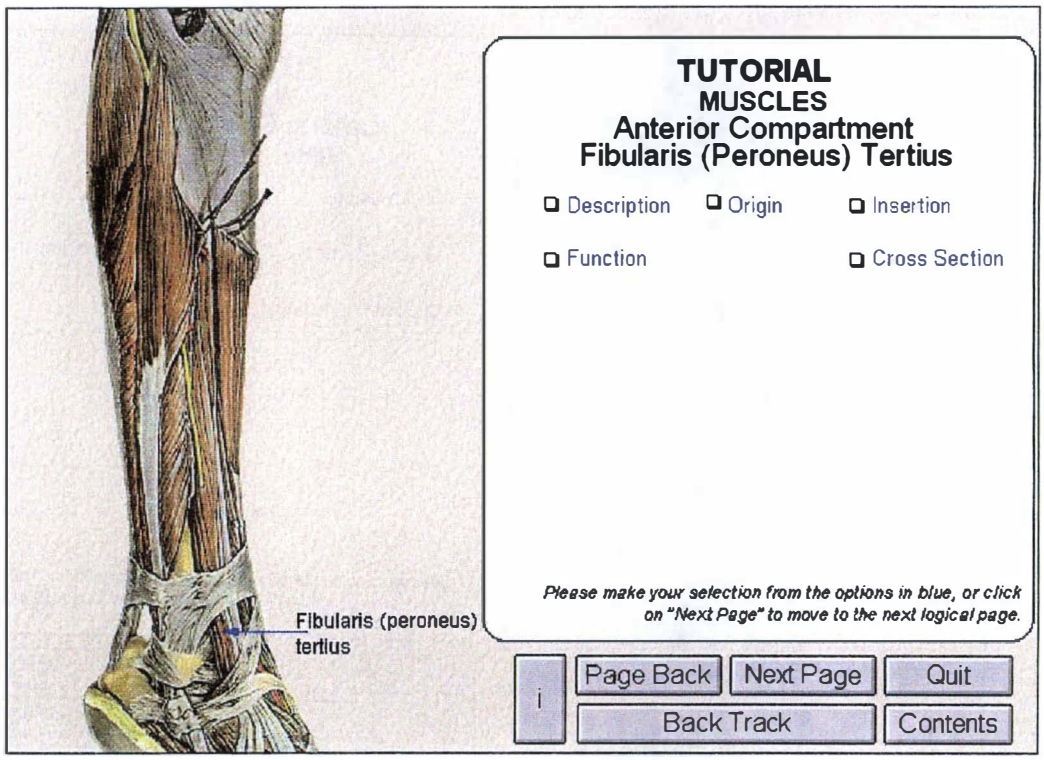
Page 18: Muscles – anterior compartment, extensor hallicus longus



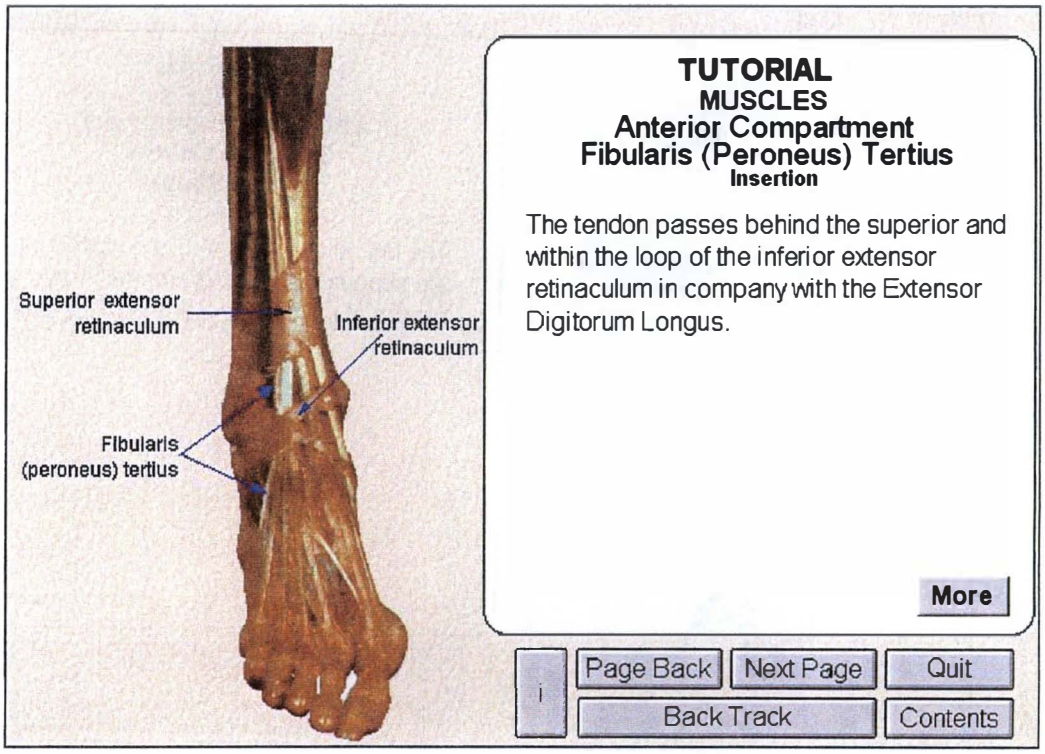
Page 18(b): Muscles – anterior compartment, extensor hallicus longus, insertion



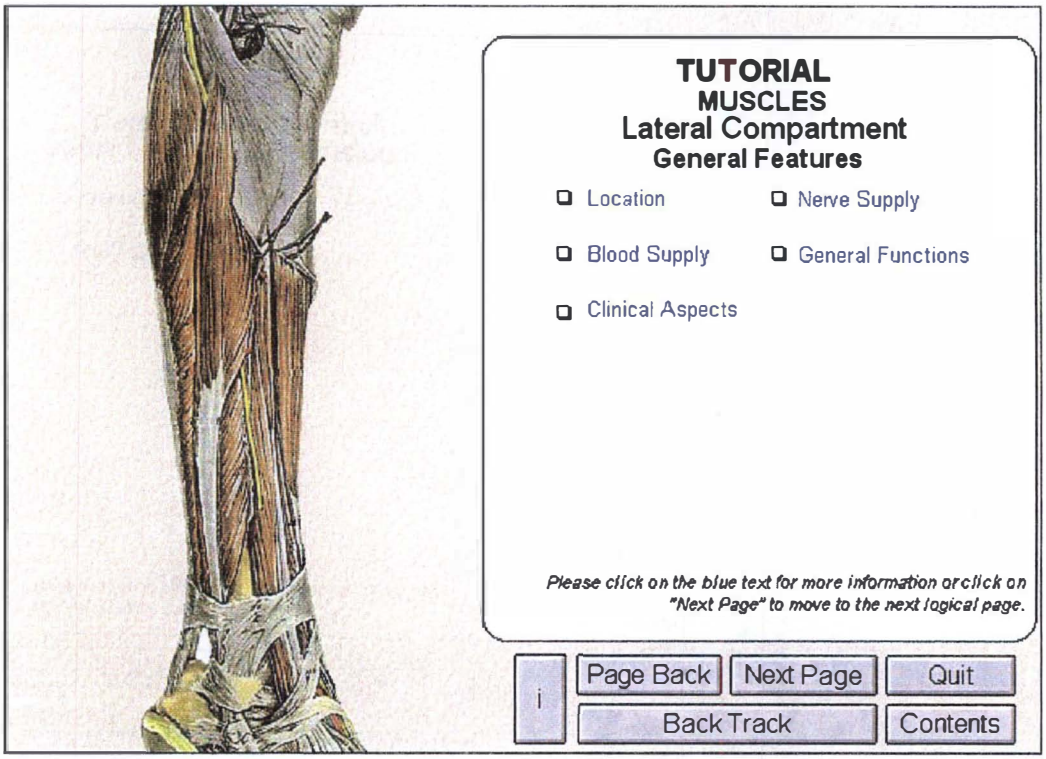
Page 19: Muscles – anterior compartment, fibularis tertius



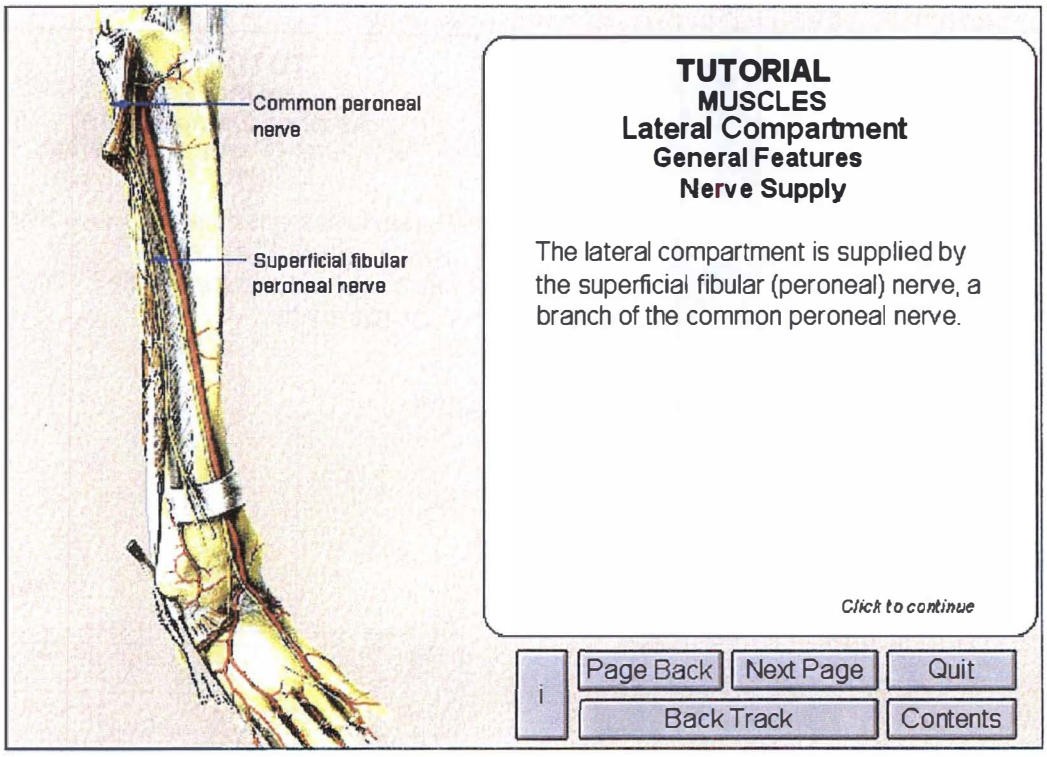
Page 19(b): Muscles – anterior compartment, fibularis tertius, insertion



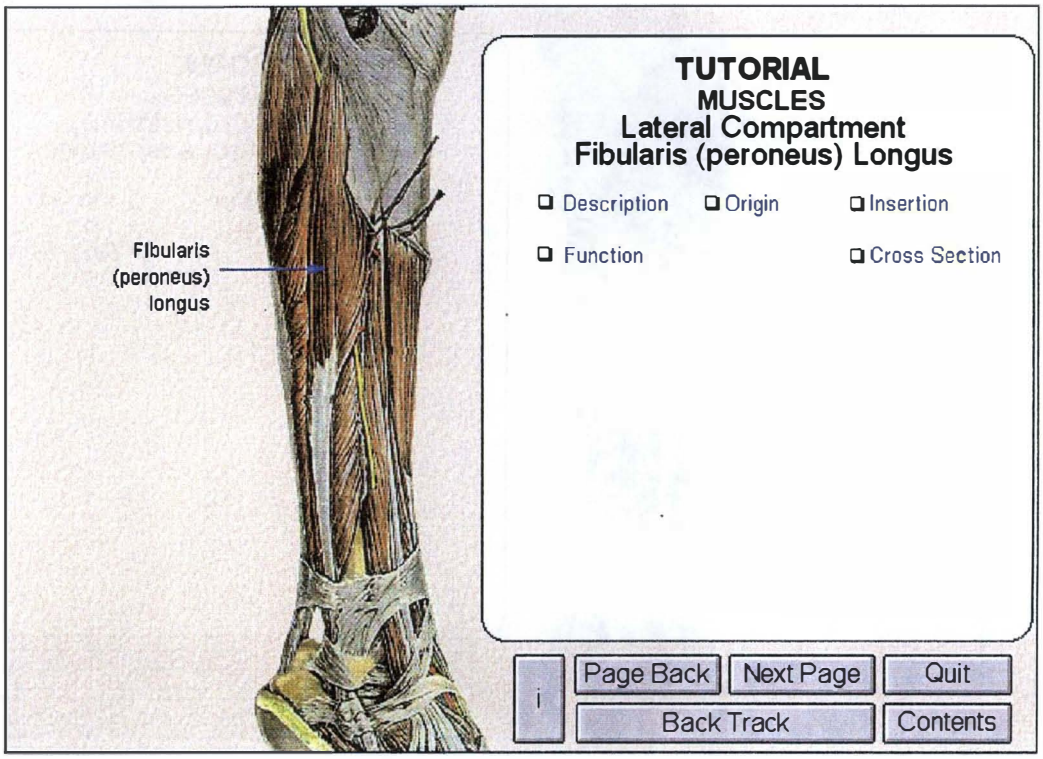
Page 20: Muscles – lateral compartment



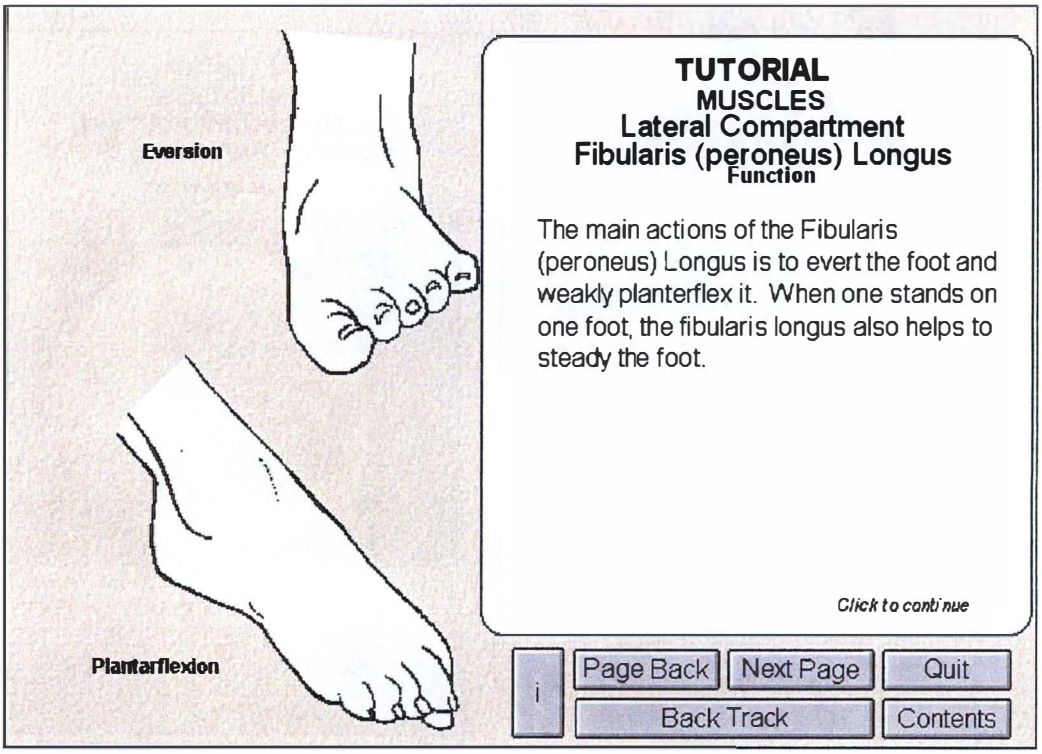
Page 20(b): Muscles – lateral compartment, nerve supply



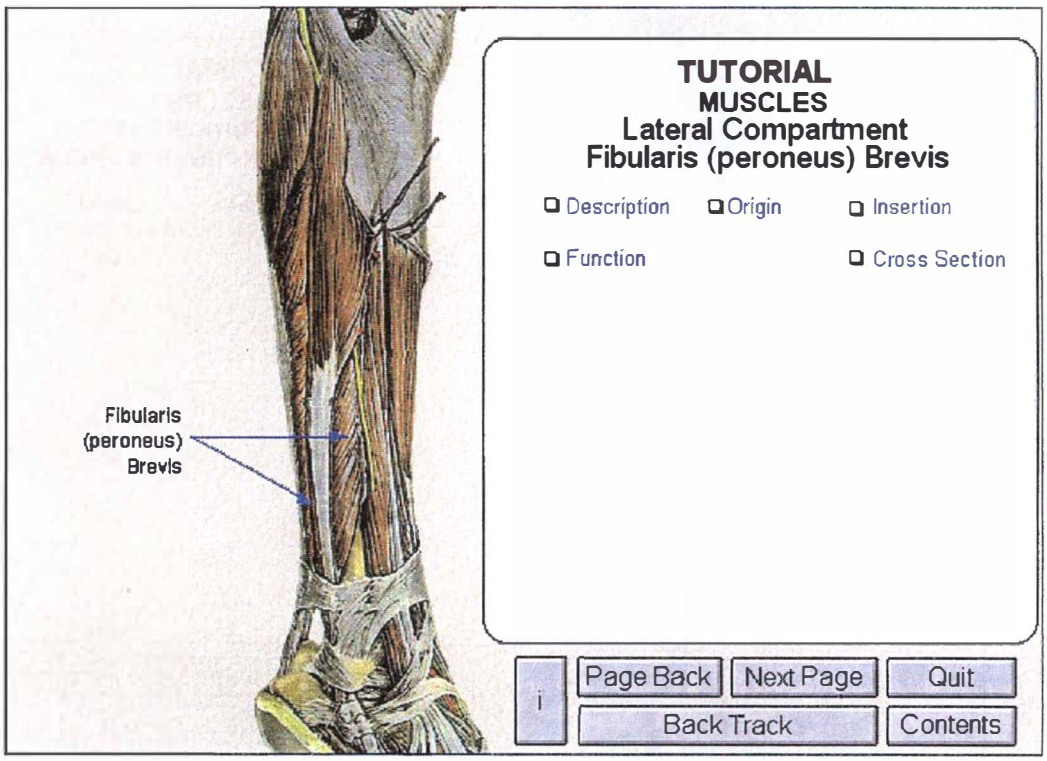
Page 21: Muscles – lateral compartment, fibularis longus



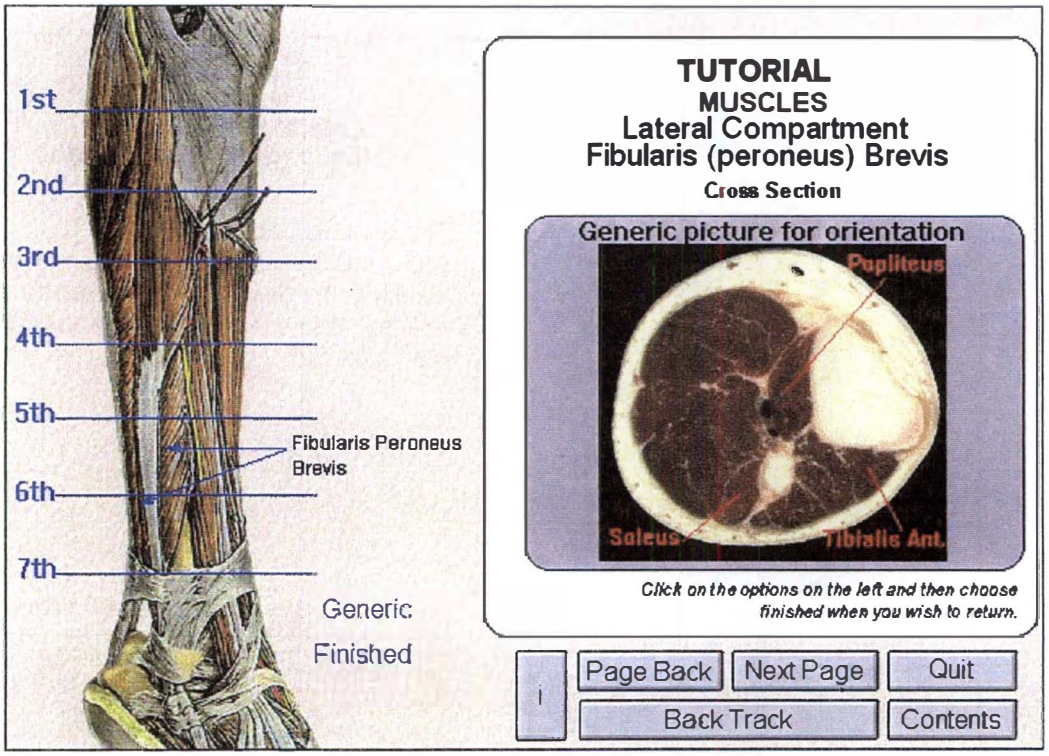
Page 21(b): Muscles – lateral compartment, fibularis longus function



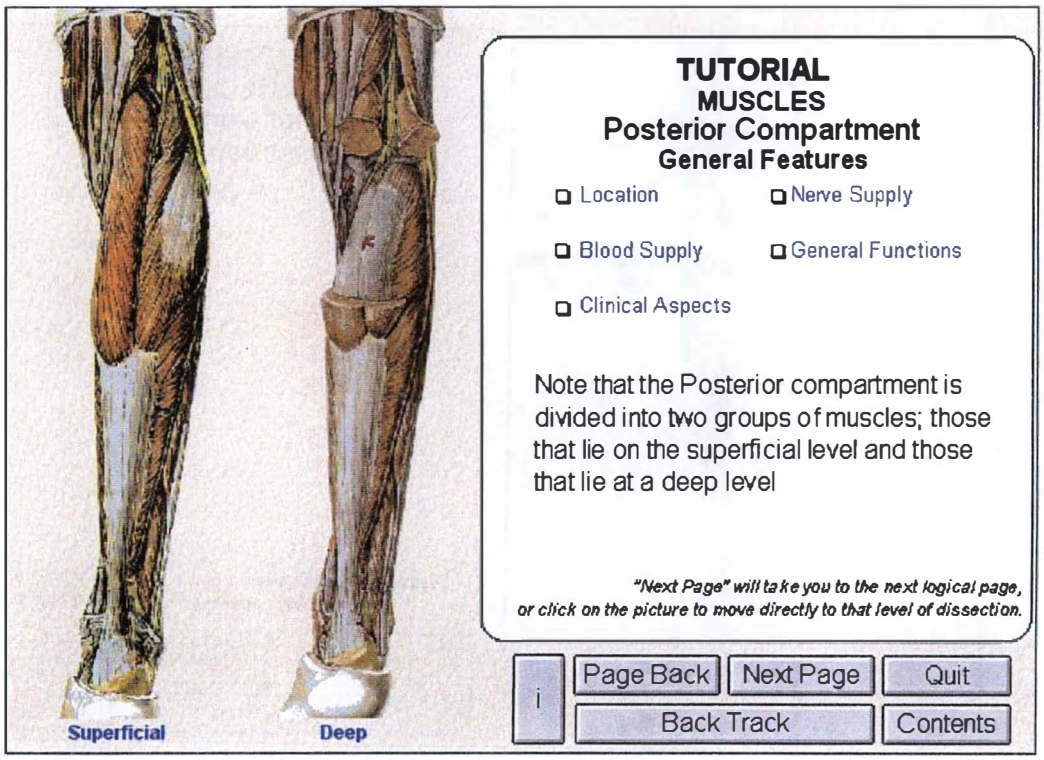
Page 22: Muscles – lateral compartment, fibularis brevis



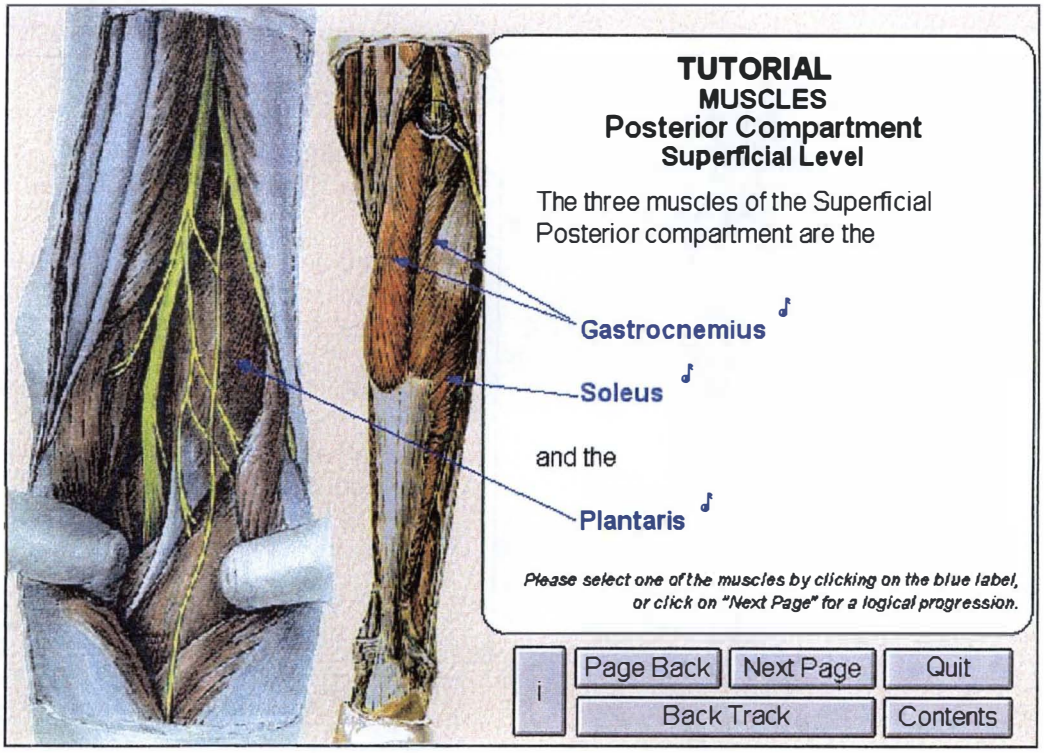
Page 22(b): Muscles – lateral compartment, fibularis brevis, cross section



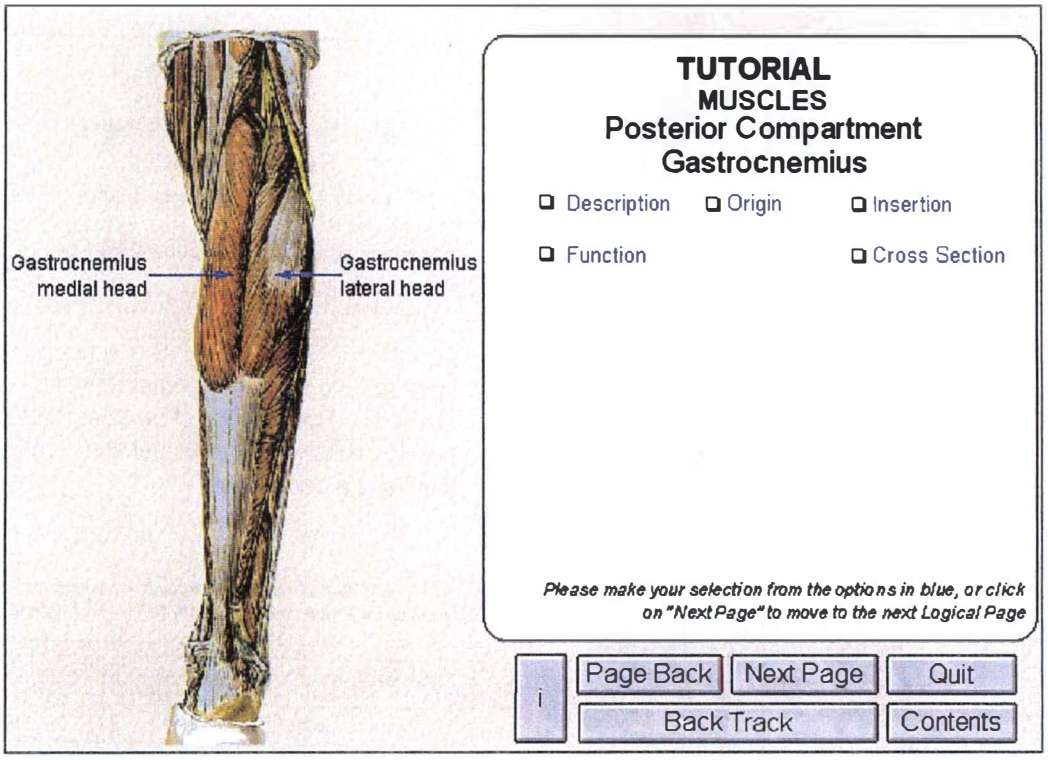
Page 23: Muscles – posterior compartment



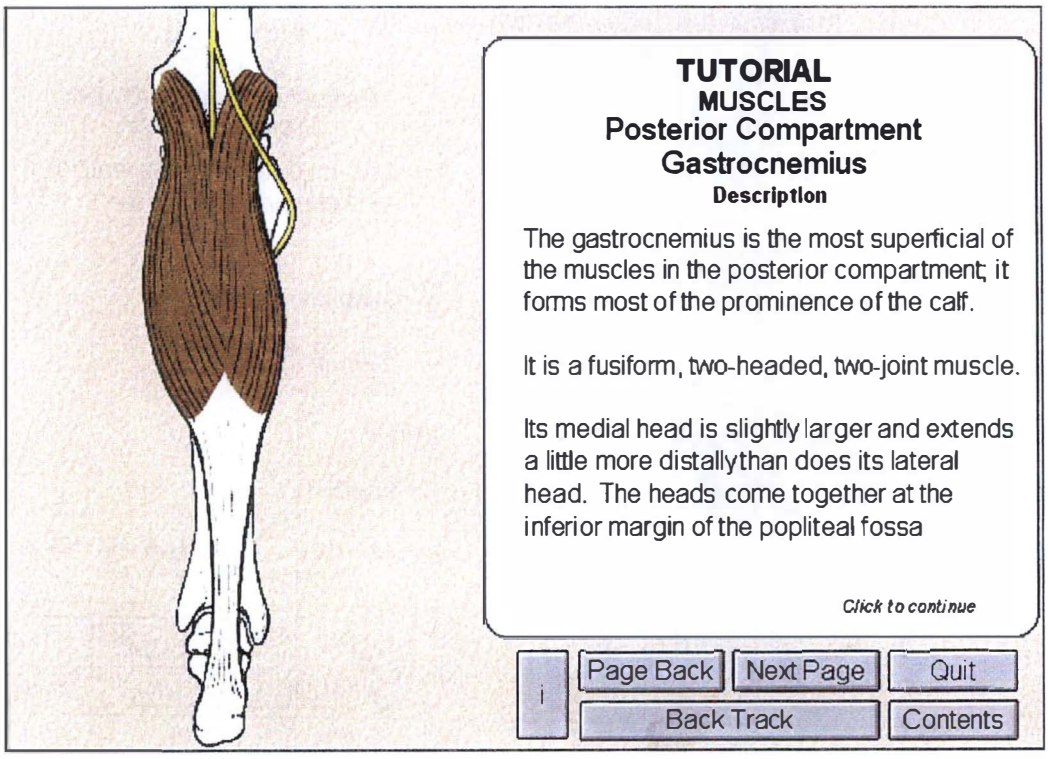
Page 24: Muscles – posterior compartment, superficial level



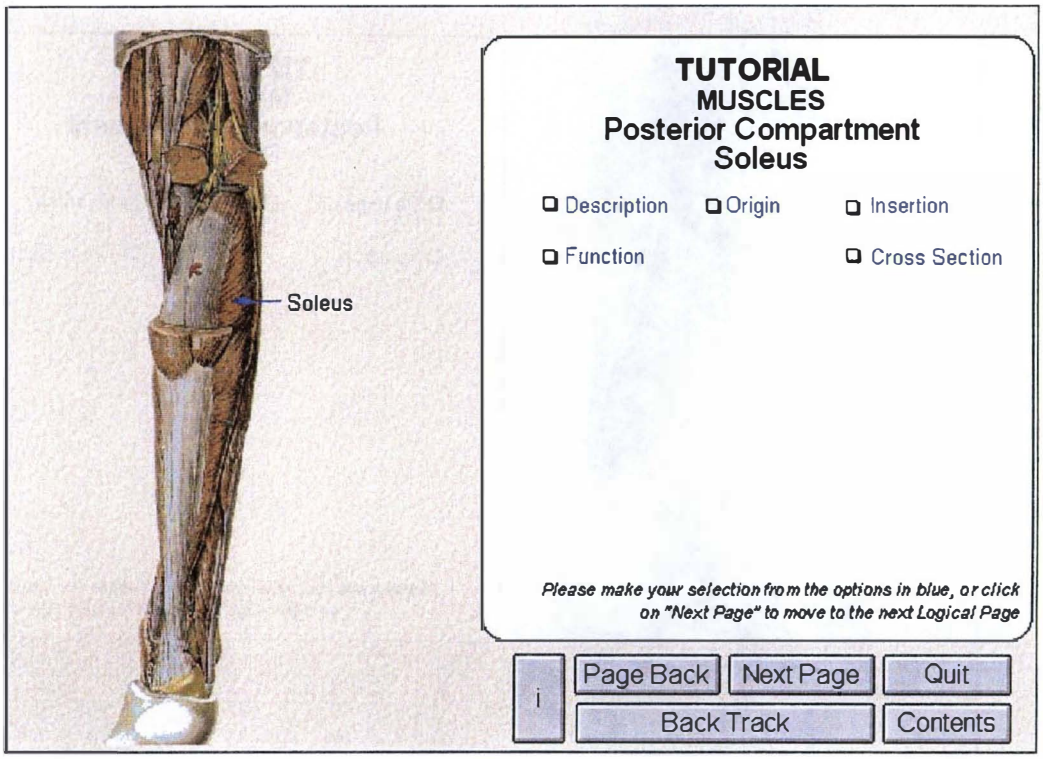
Page 25: Muscles – posterior compartment superficial level, gastrocnemius



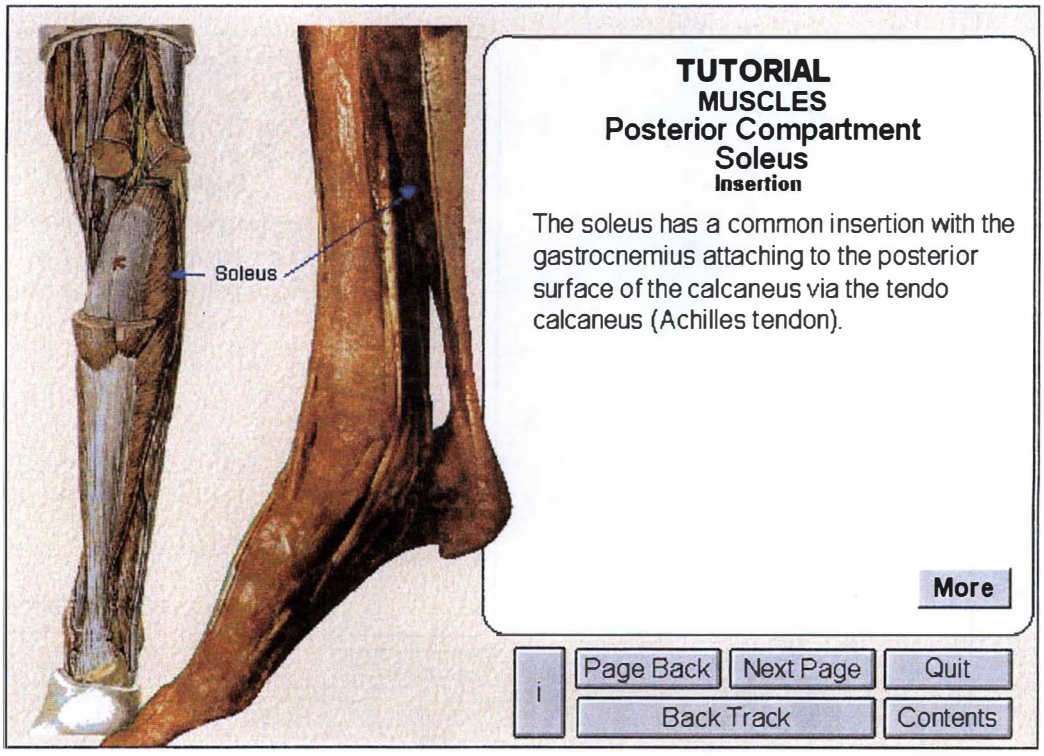
Page 25(b): Muscles – posterior compartment, superficial level, gastrocnemius description



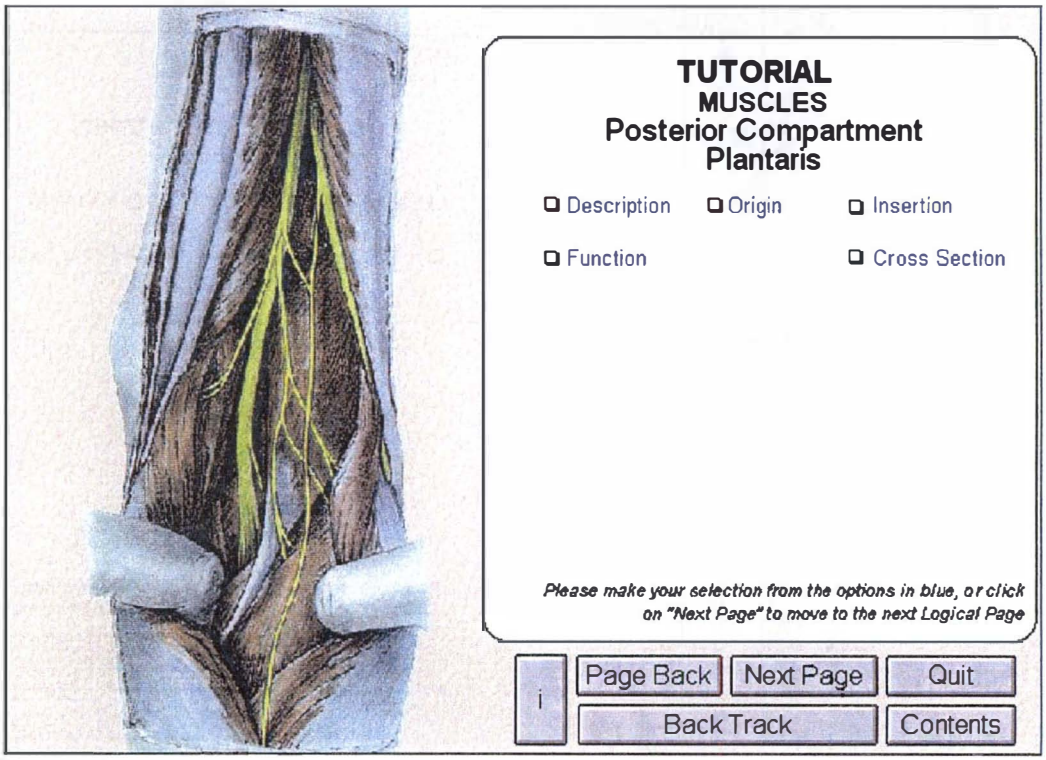
Page 26: Muscles – posterior compartment superficial level, soleus



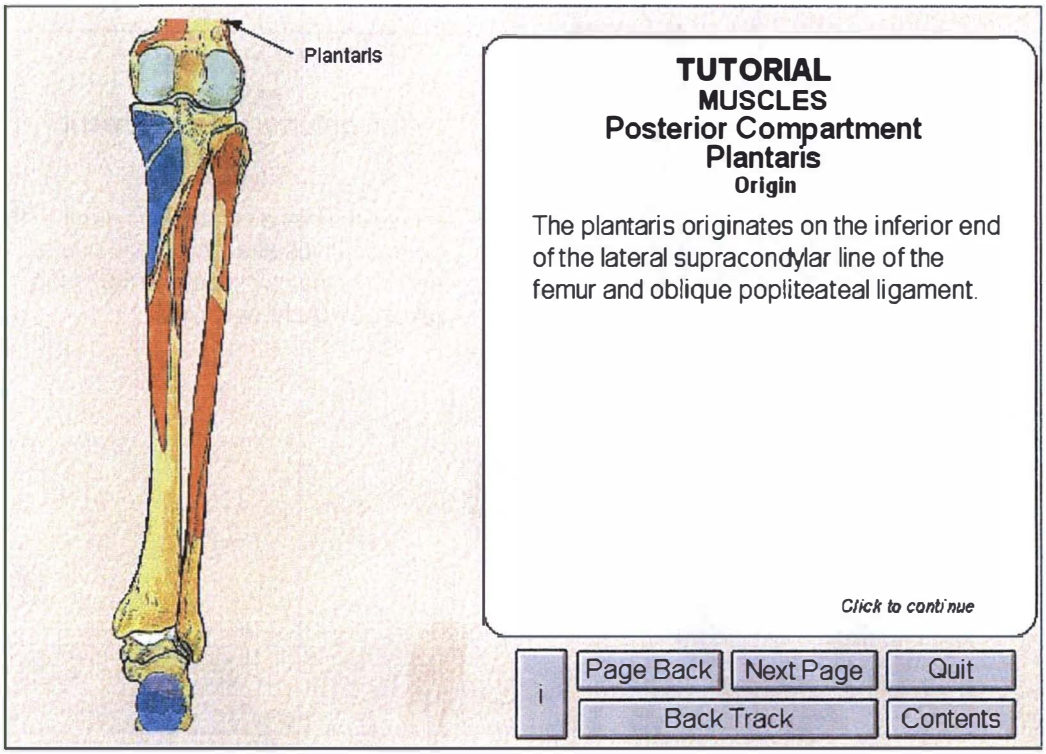
Page 26(b): Muscles – posterior compartment, superficial level, gastrocnemius insertion



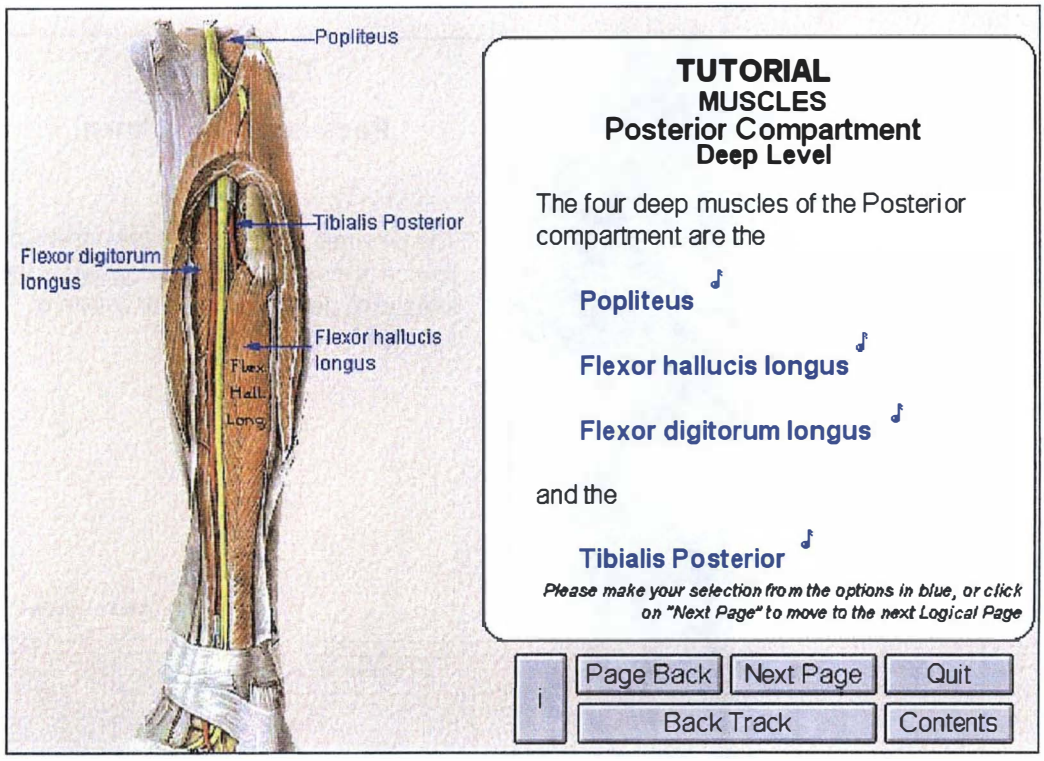
Page 27: Muscles – posterior compartment superficial level, plantaris



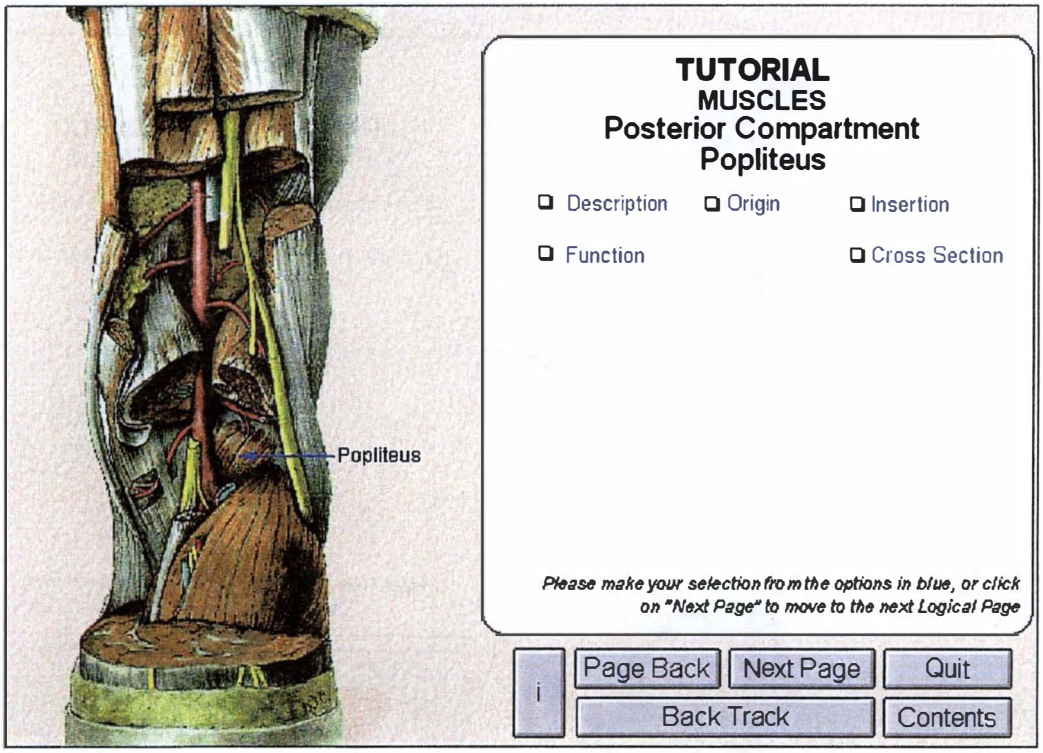
Page 27(b): Muscles – posterior compartment, superficial level, plantaris origin



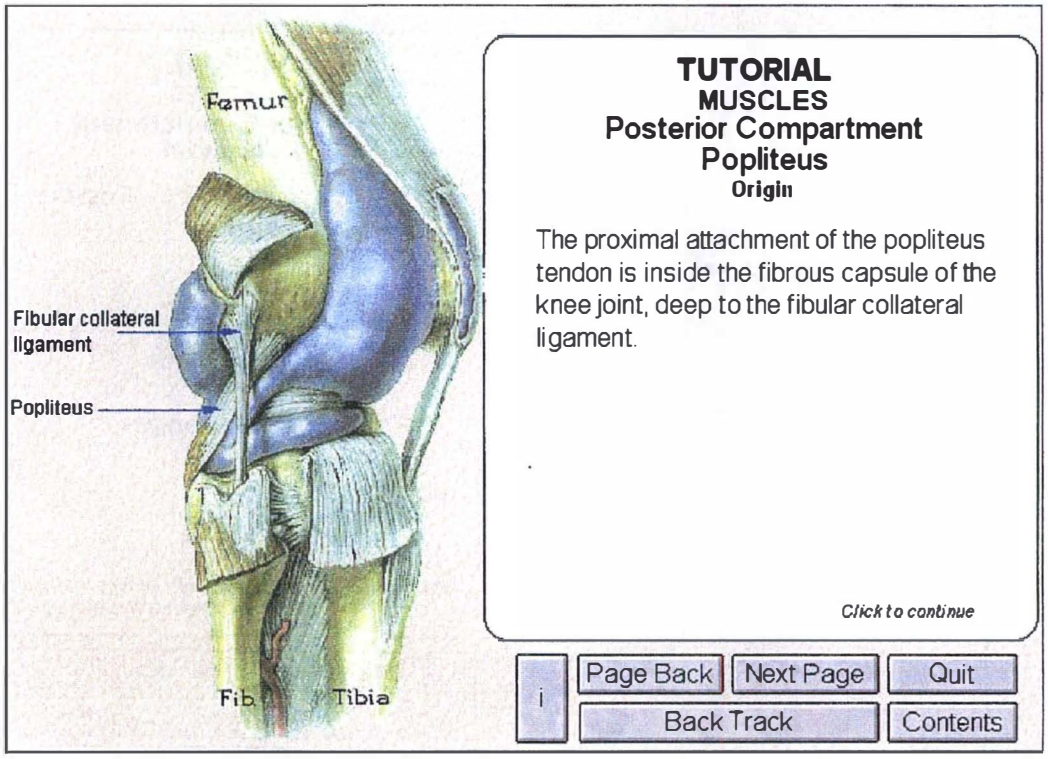
Page 28: Muscles – posterior compartment deep level



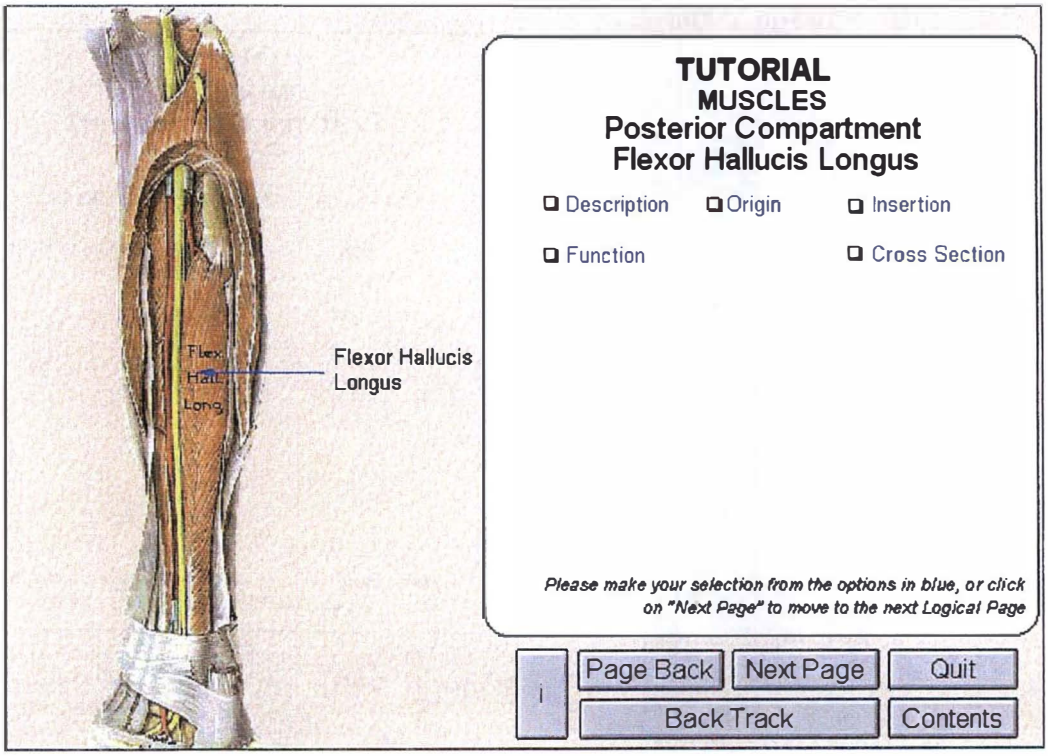
Page 29: Muscles – posterior compartment, deep level, popliteus



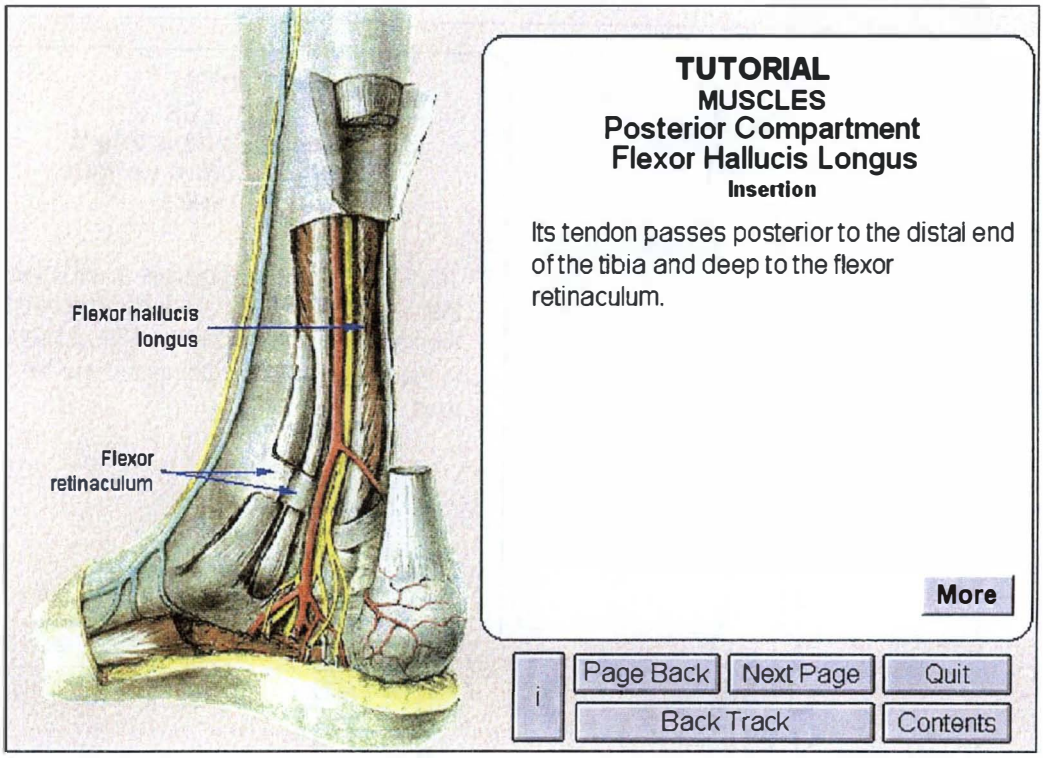
Page 29(b): Muscles – posterior compartment deep level, popliteus origin



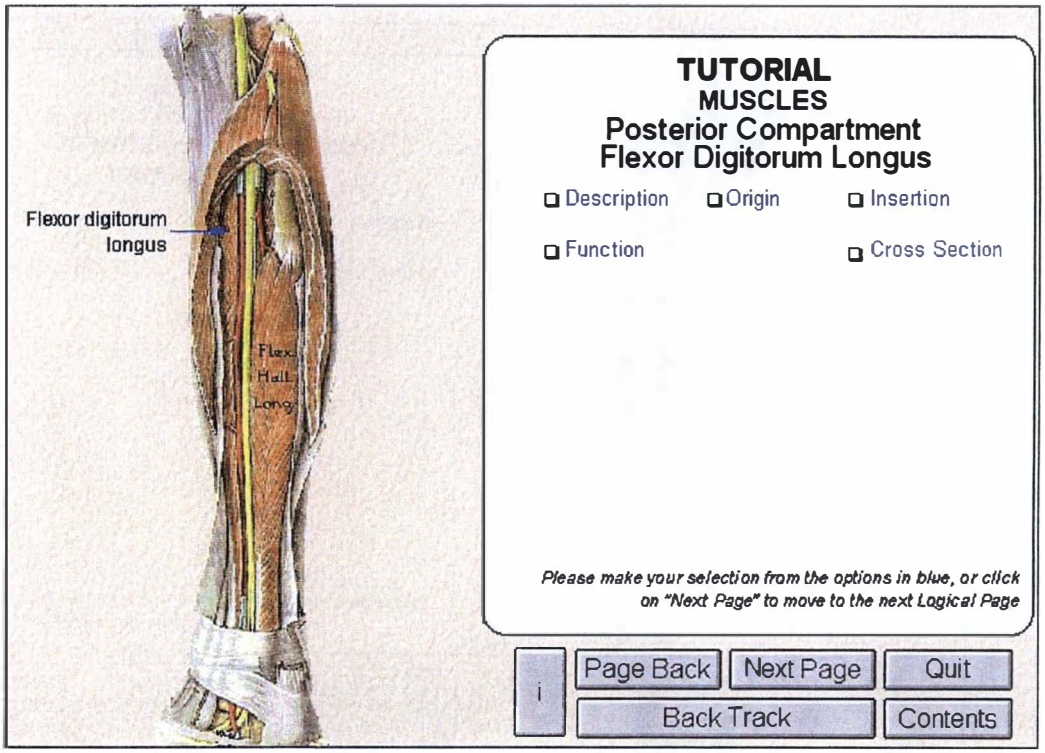
Page 30: Muscles – posterior compartment, deep level, flexor hallucis longus



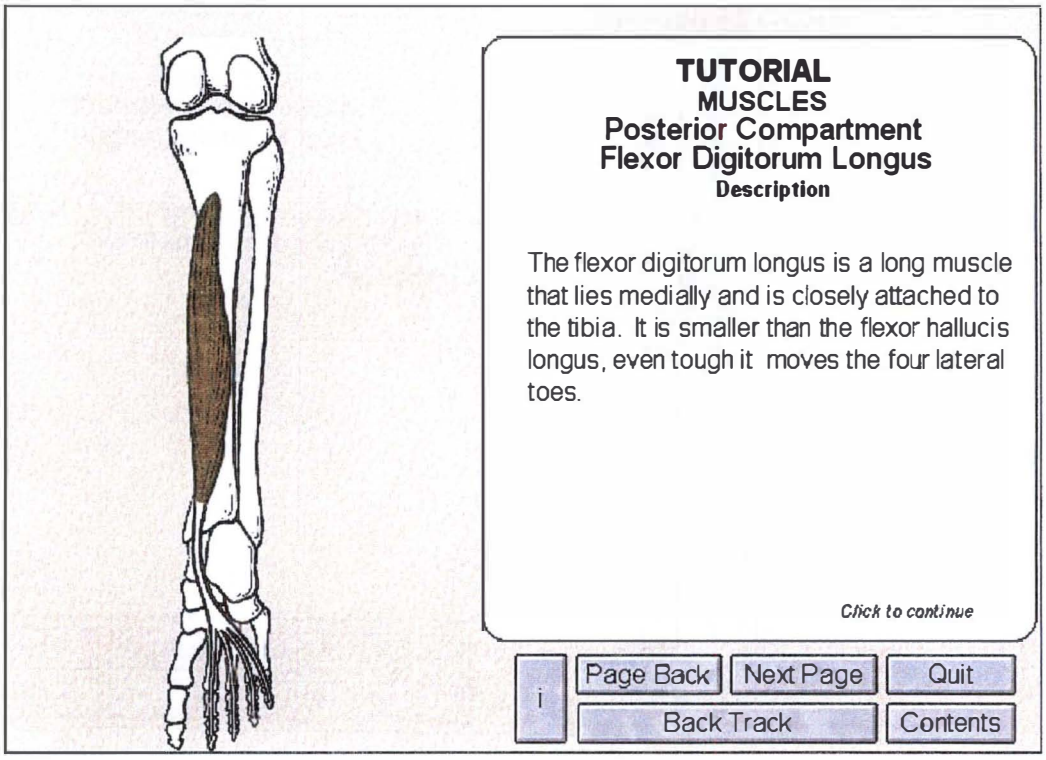
Page 30(b): Muscles – posterior compartment, deep level, flexor hallucis longus insertion



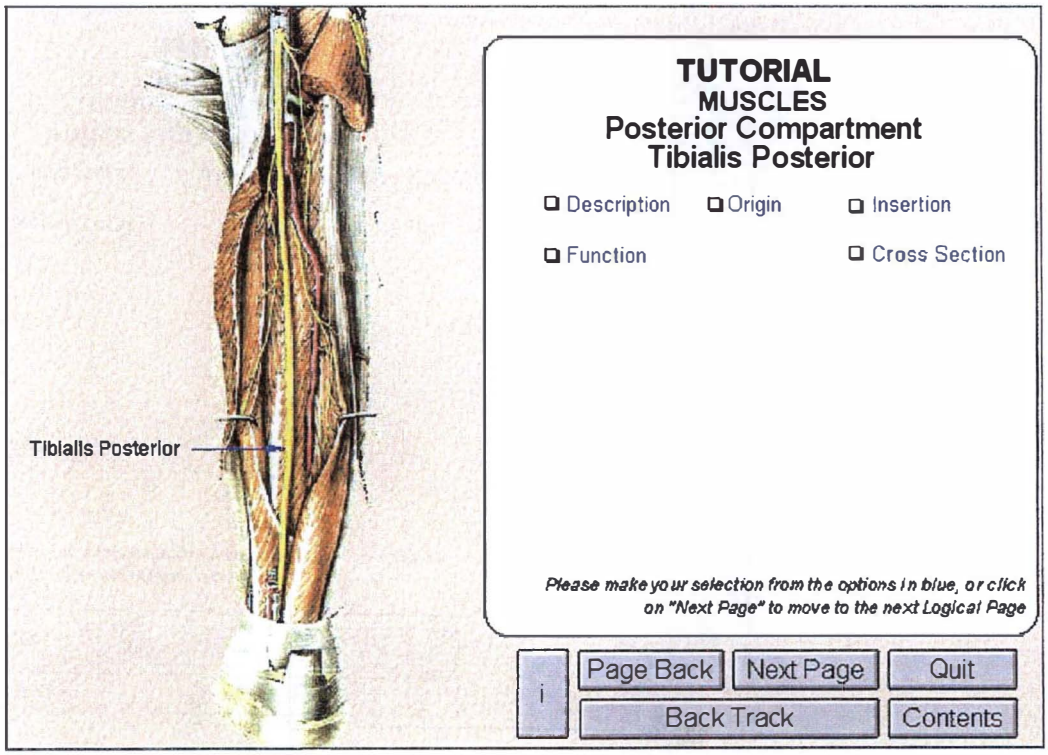
Page 31: Muscles – posterior compartment, deep level, flexor digitorum longus



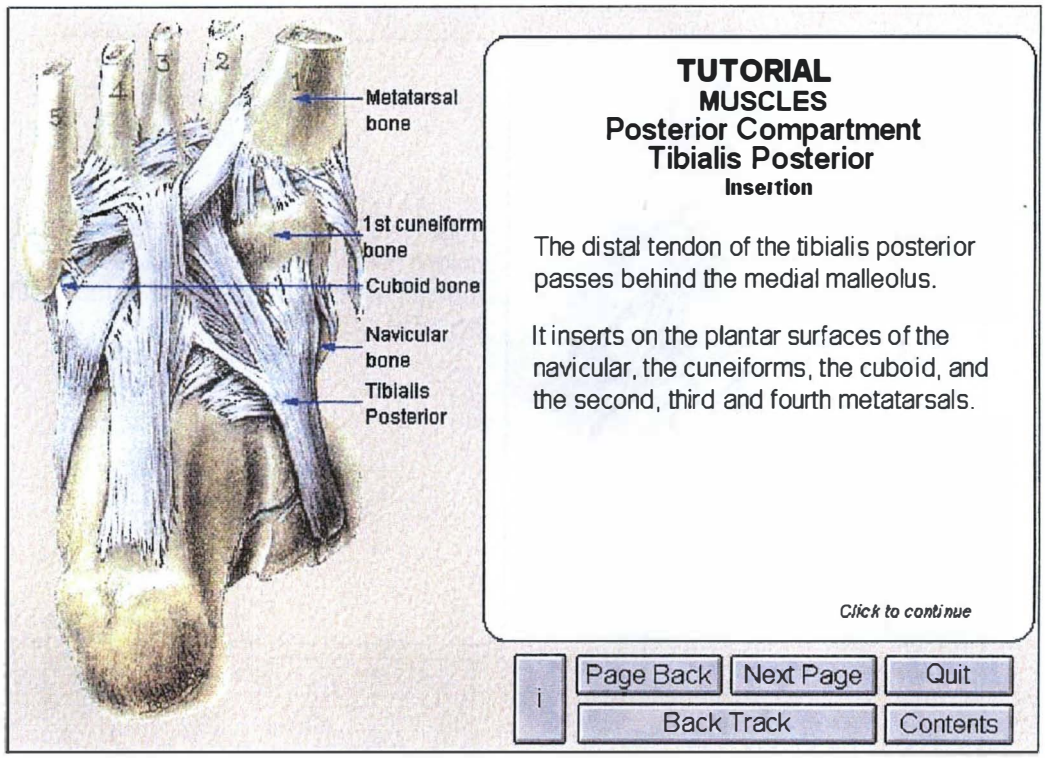
Page 31(b): Muscles – posterior compartment, deep level, flexor digitorum longus description



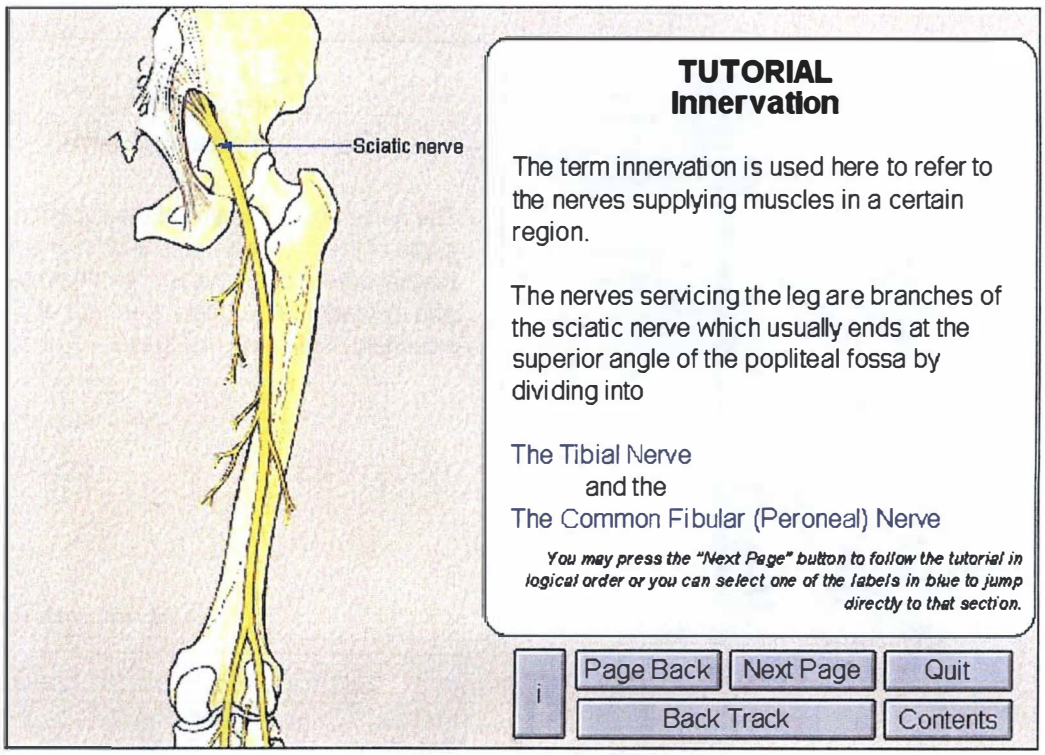
Page 32: Muscles – posterior compartment, deep level, tibialis posterior



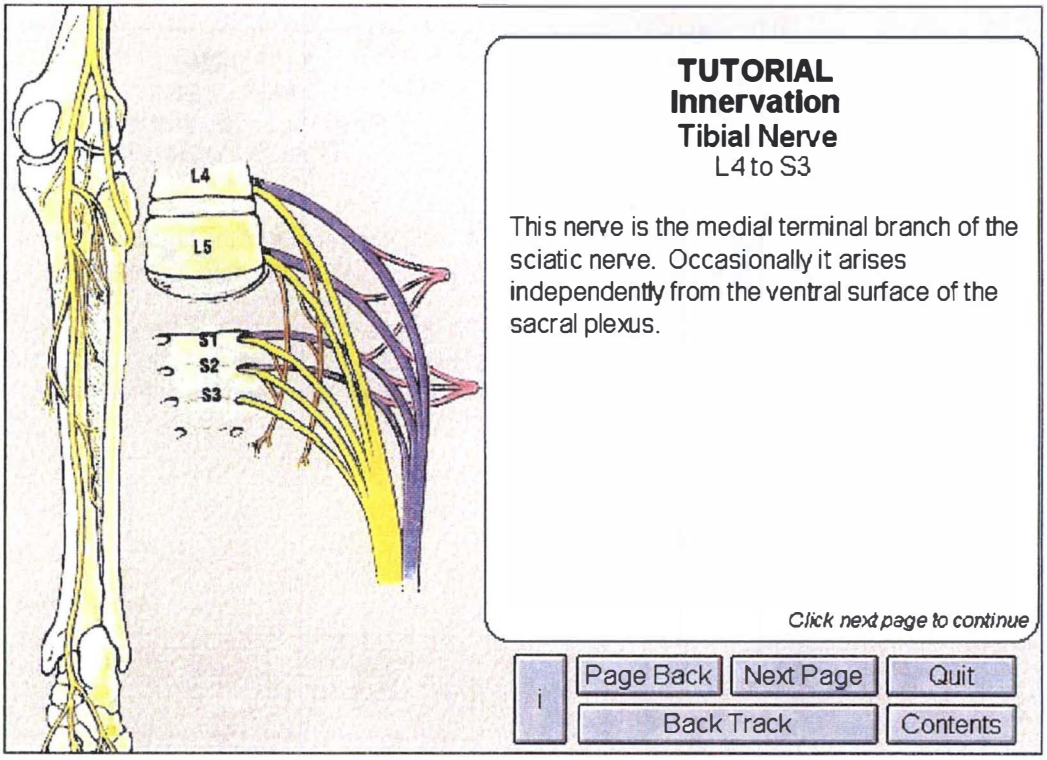
Page 32(b): Muscles – posterior compartment, deep level, tibialis posterior insertion



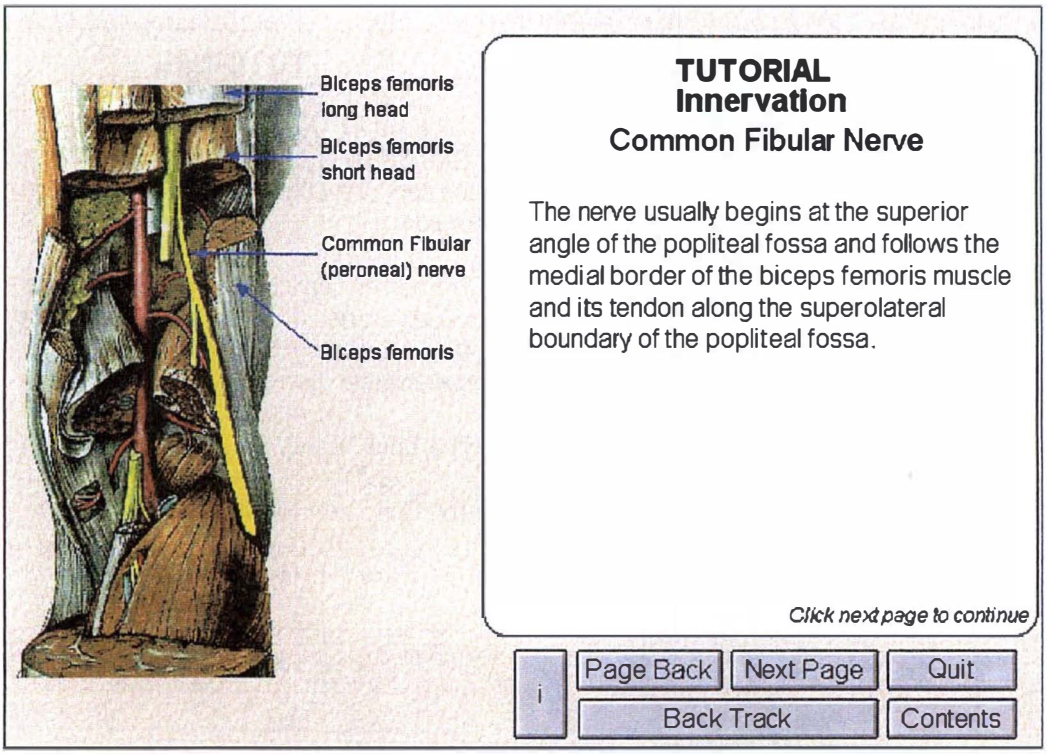
Page 33: Innervation



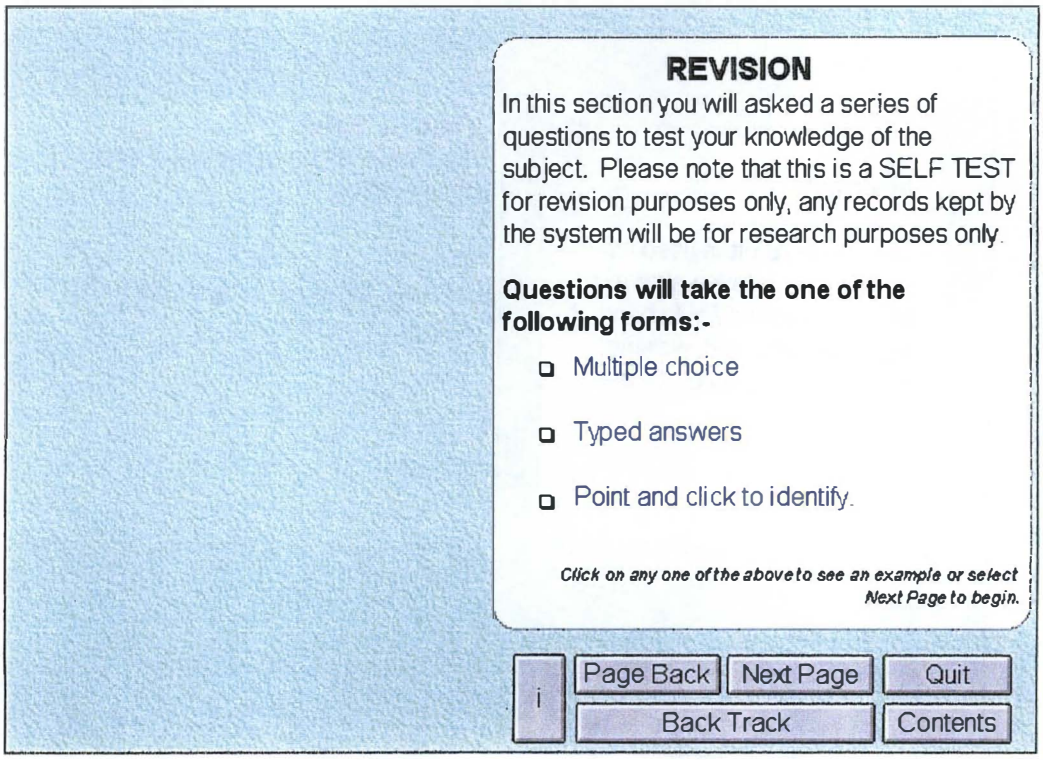
Page 34: Innervation – tibial nerve



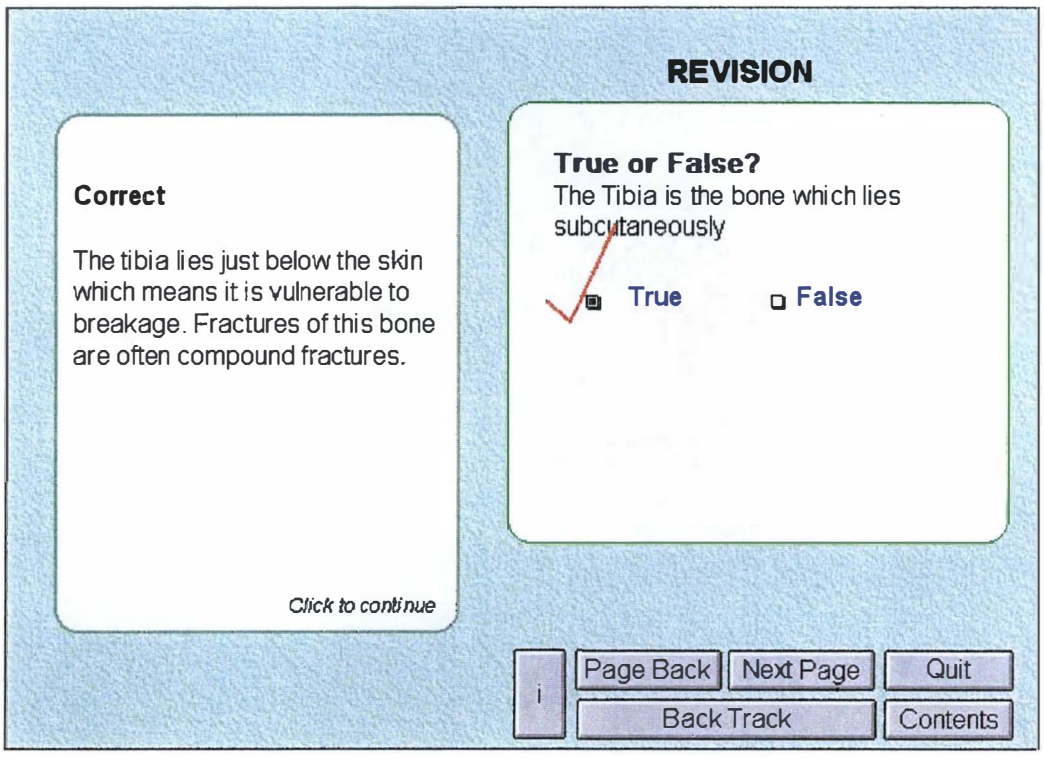
Page 35: Innervation – common fibular nerve



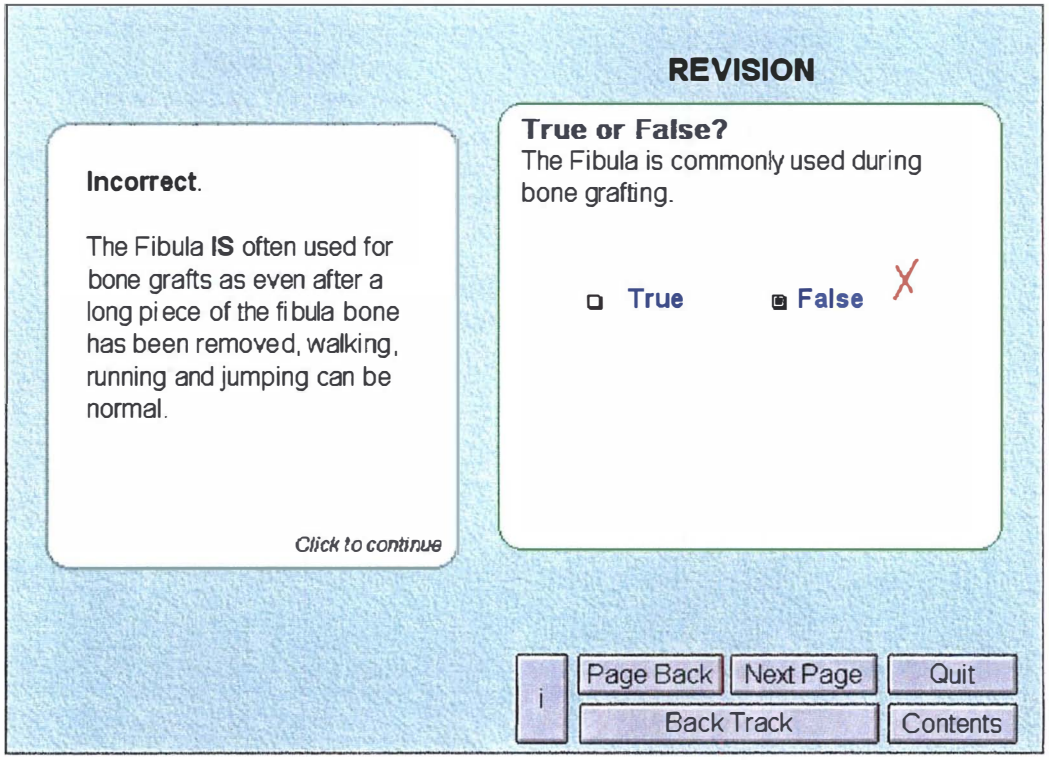
Page 36: Revision introduction displayed when using next page options



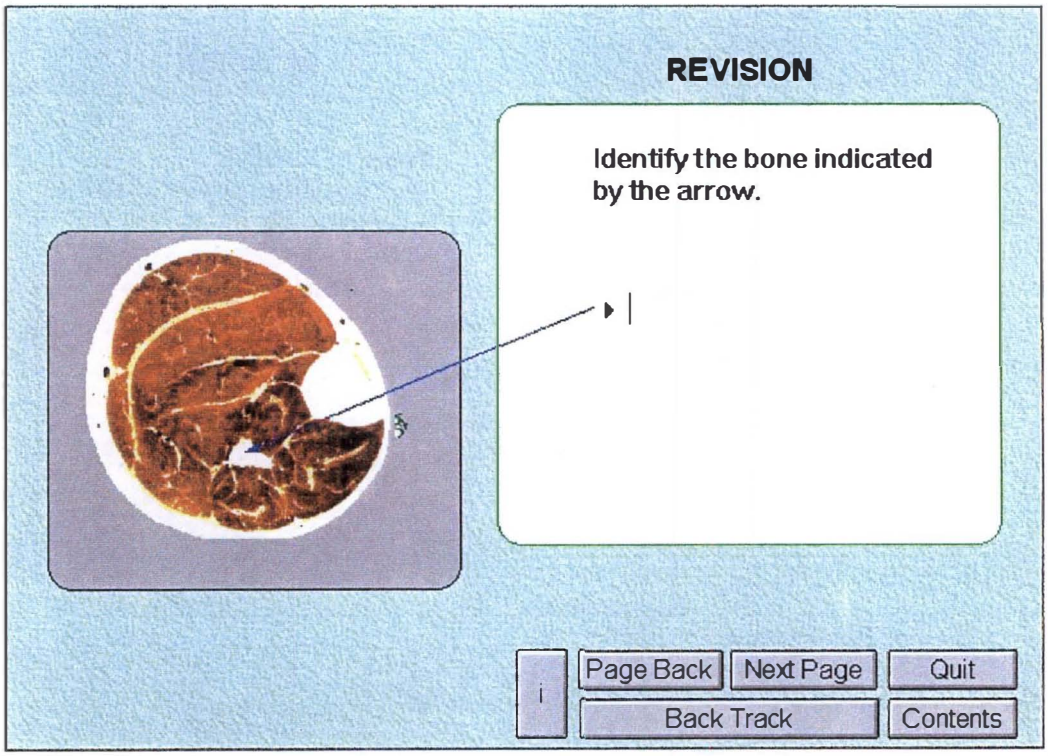
Page 37: Revision – example of tiba question with correct answer response



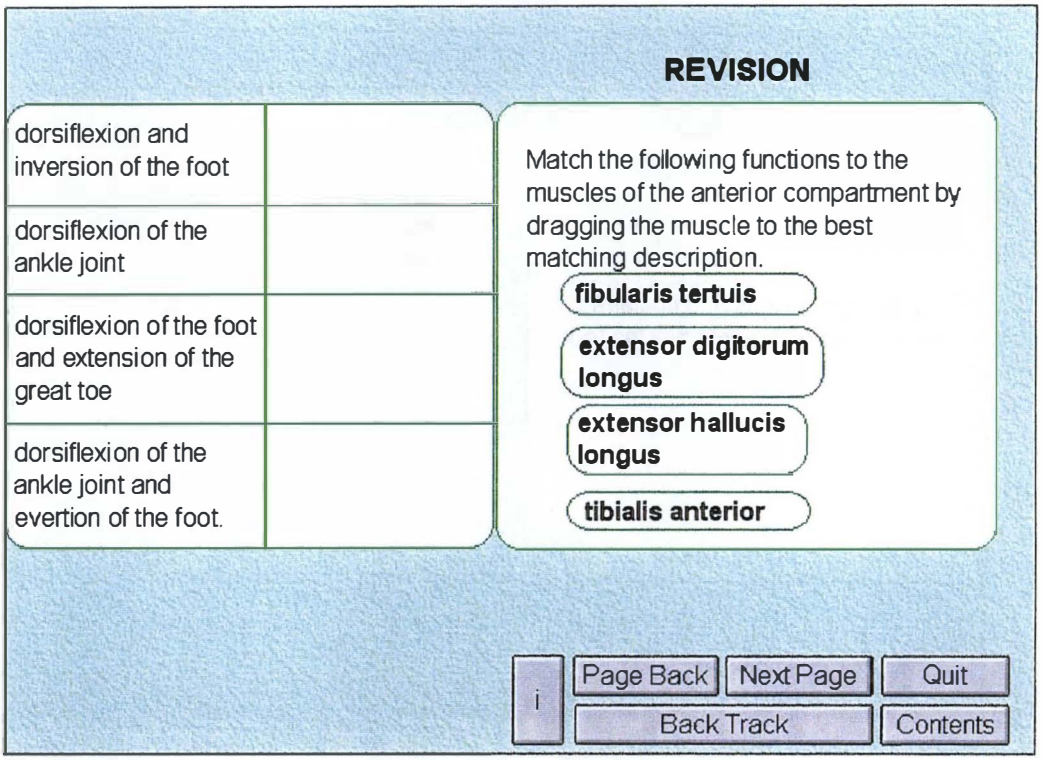
Page 38: Revision – example of fibula question with incorrect answer response



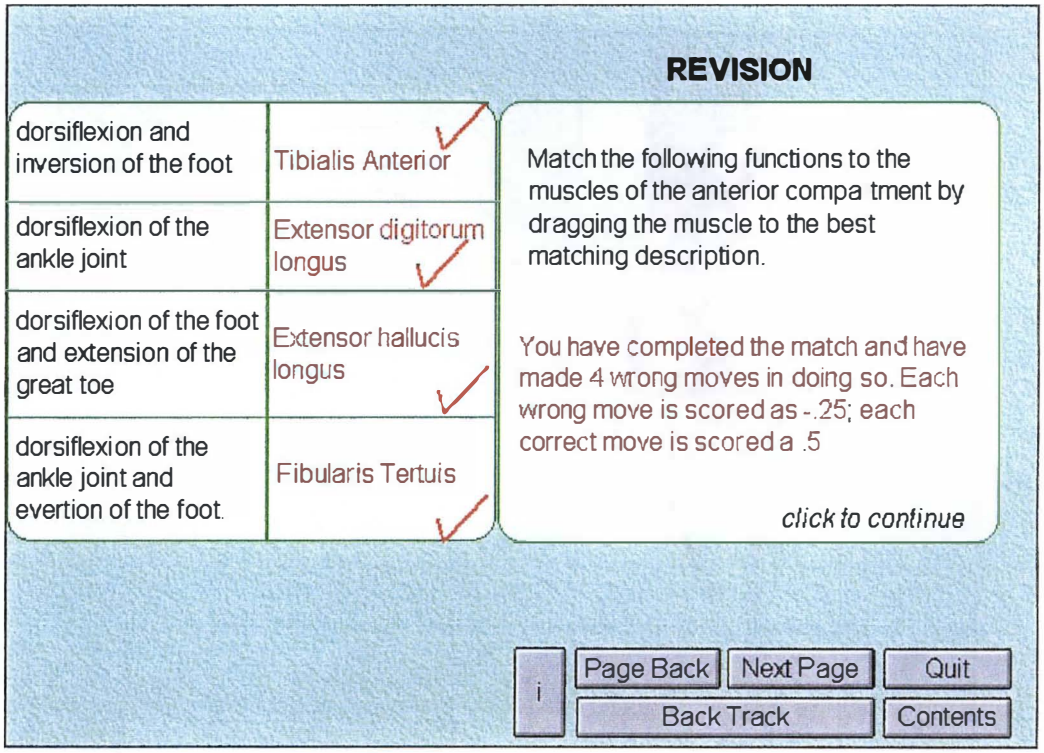
Page 39: Revision – randomly generated question from osteology combined



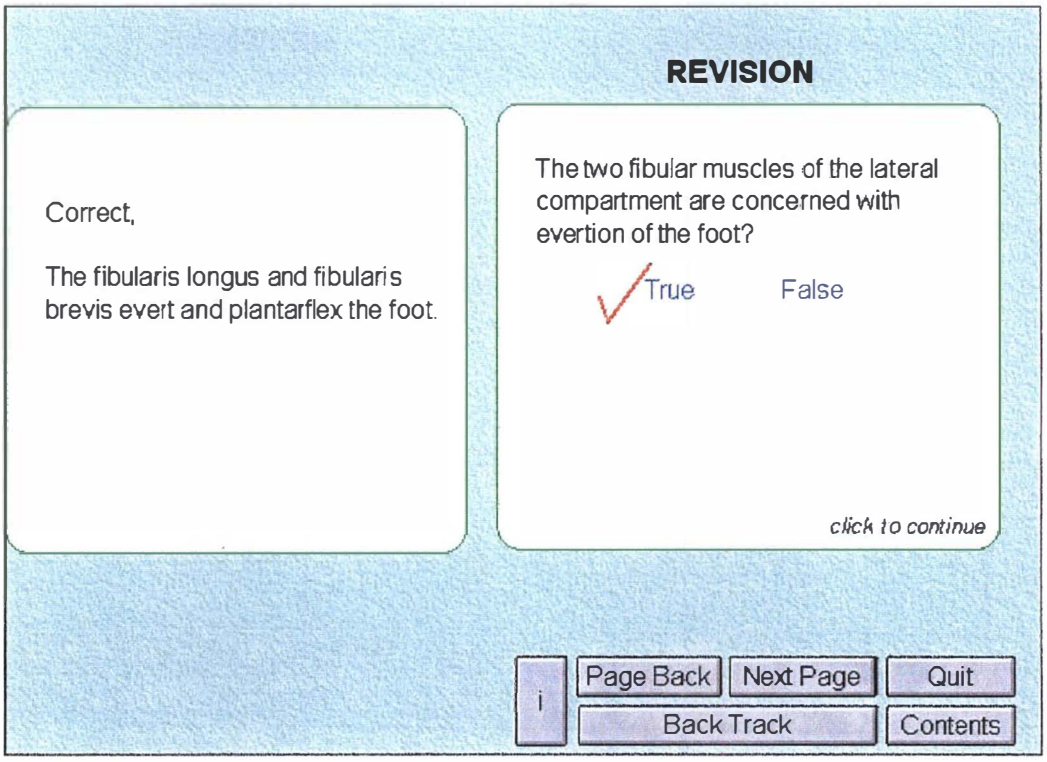
Page 40: Revision – example of randomly generated question from anterior compartment



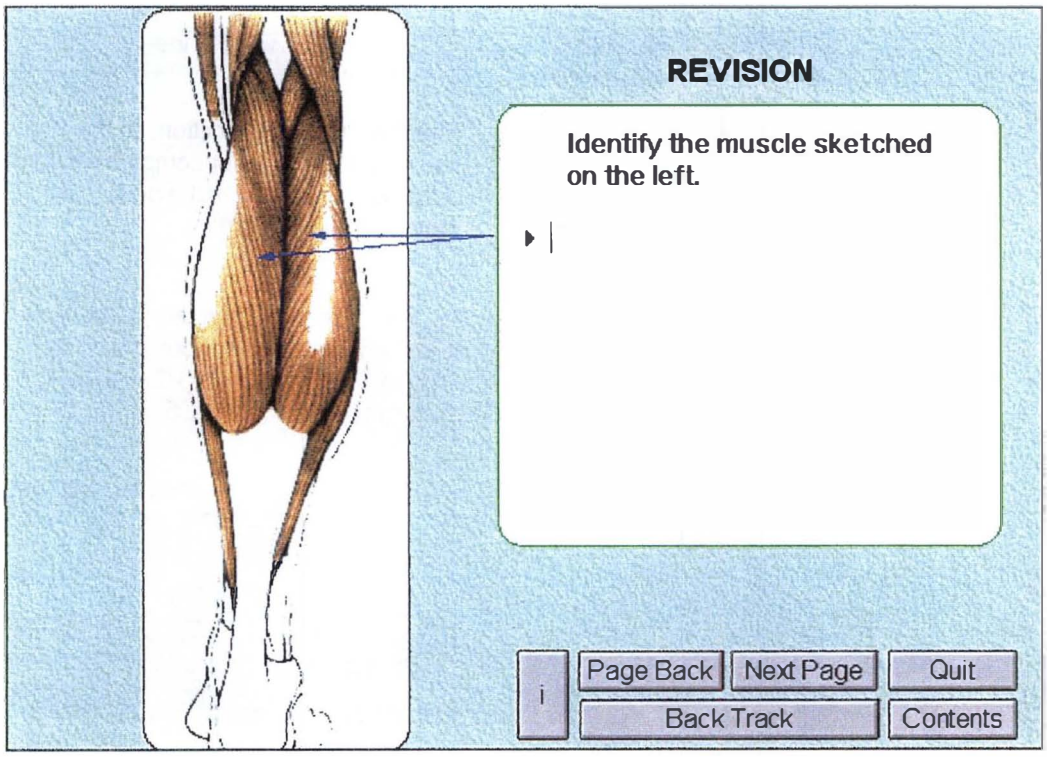
Page 40(b): Revision – example of completion of drag and drop question for anterior compartment (note several attempts were made to match the items).



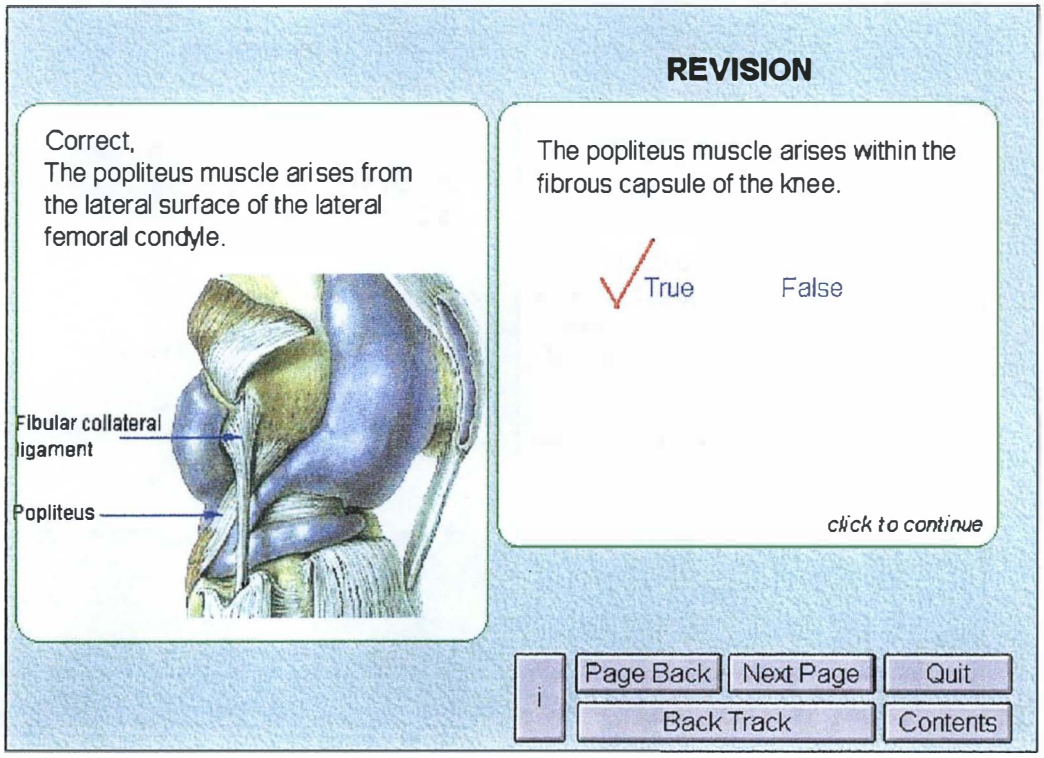
Page 41: Revision – example of randomly generated question from lateral compartment with correct response



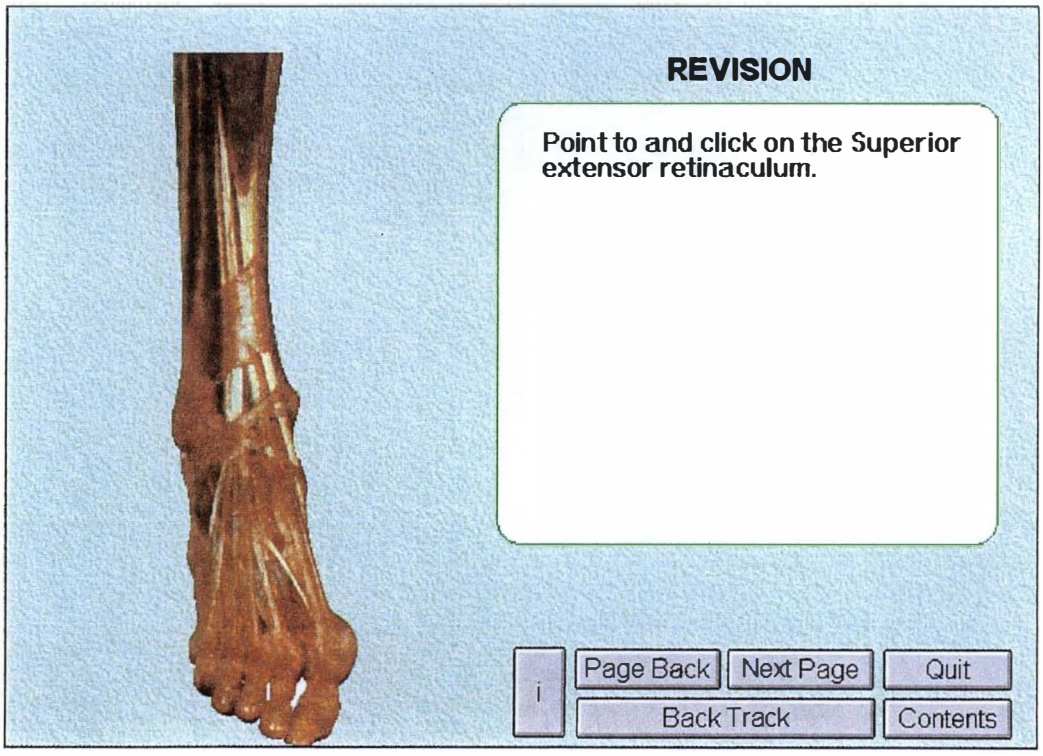
Page 42: Revision – example of randomly generated question from superficial posterior compartment



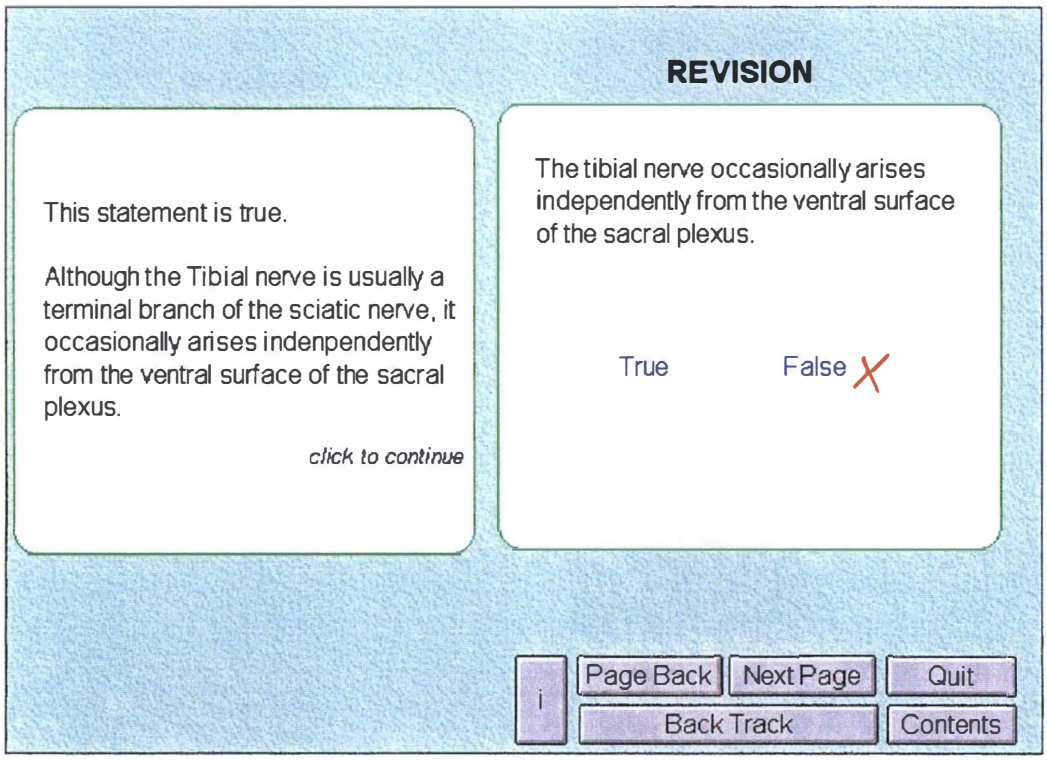
Page 43: Revision – example of randomly generated question from deep posterior compartment with response for correct seleIction.



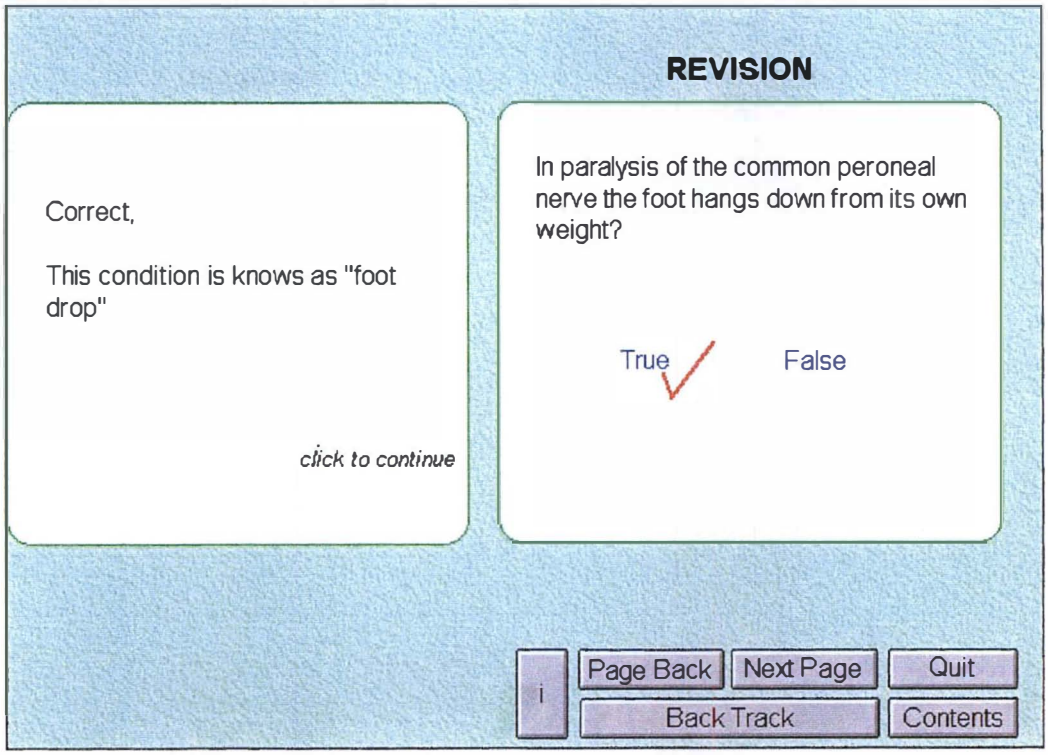
Page 44: Revision – example of randomly generated question for all leg muscles



Page 45: Revision – example of randomly generated question for tibial nerve



Page 46: Revision – example of randomly generated question for common fibular nerve



Page 47: Revision – example of randomly generated question for combined innervation

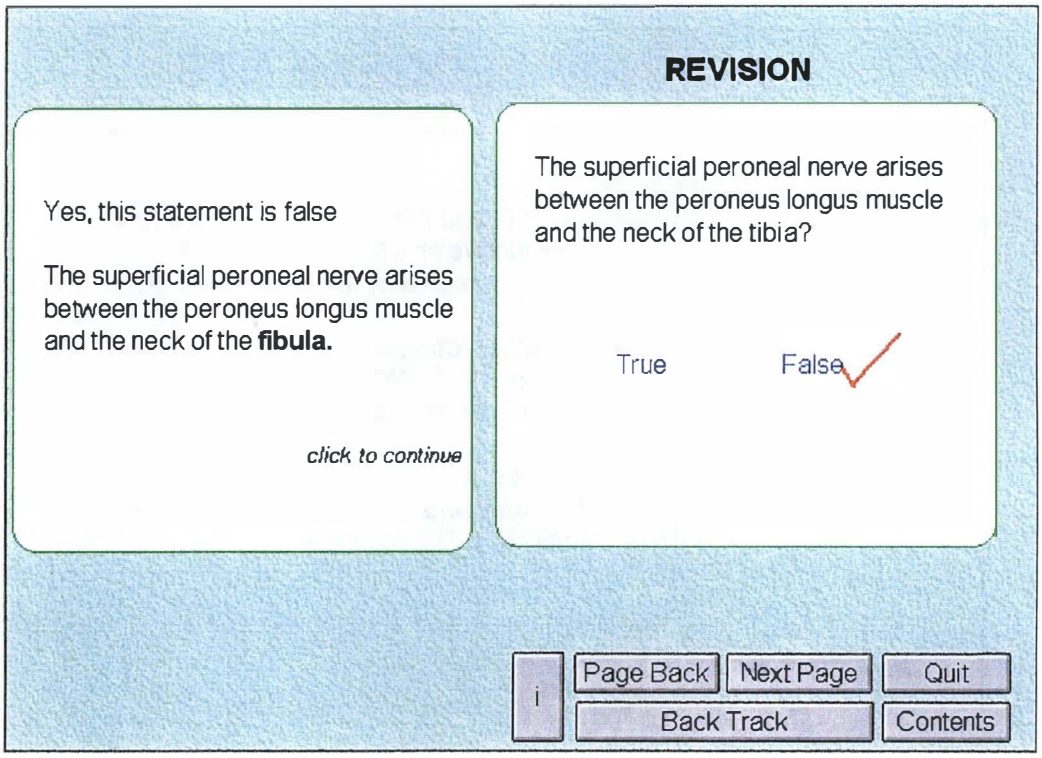
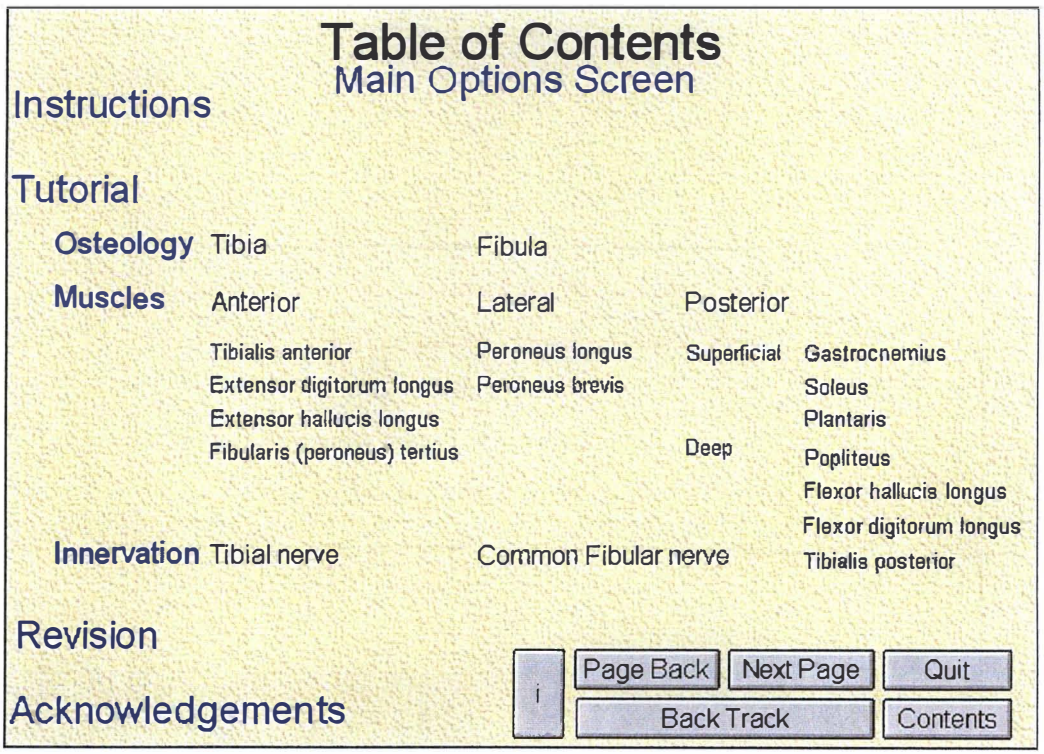
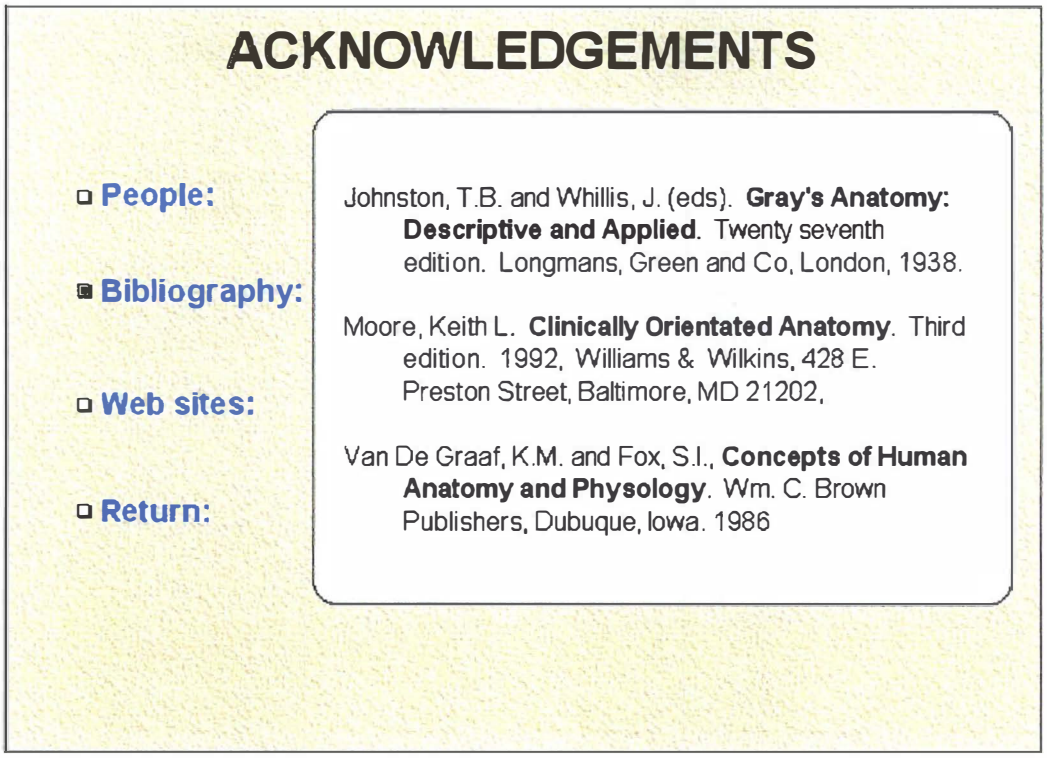


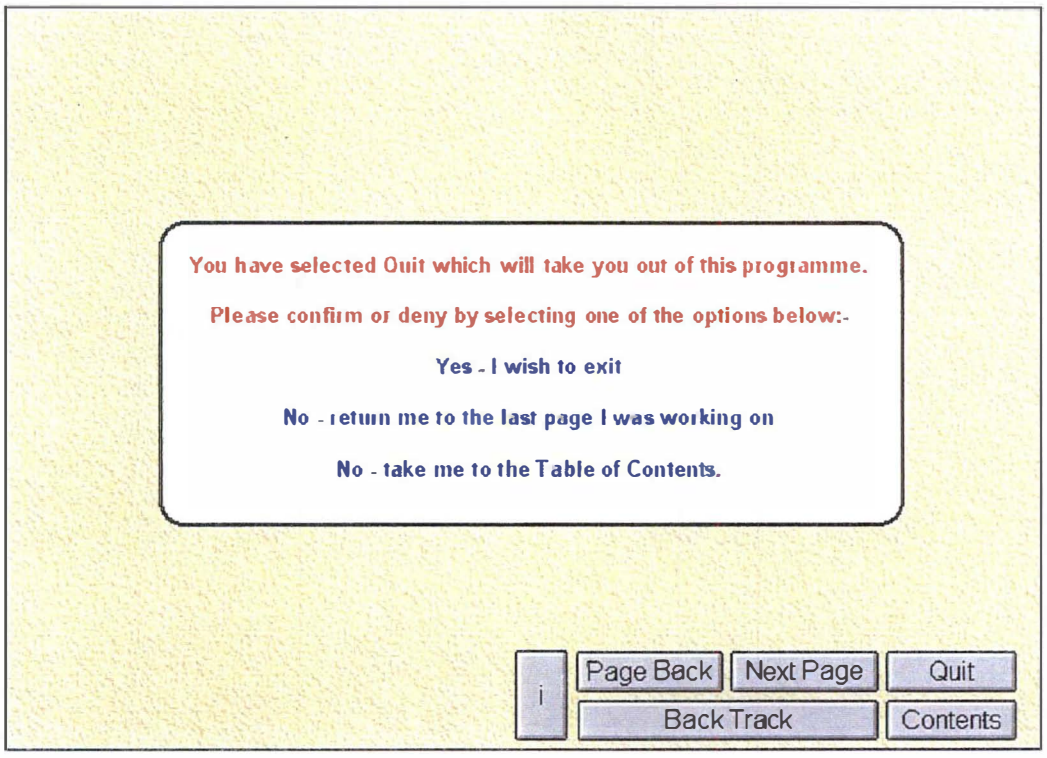
Table of contents



Acknowledgements



Exit screen



APPENDIX B

An example of a recorded text file showing student navigation and marks.

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,Student Number:,XXXXX
,FirstName:,XXXXX
,Initials:,
,Last Name:,XXXXX

,Day of the Week:,Thursday
,Day Number:,10
,Month:,June

,Start Time:,6:14:05 PM

,Enters Osteology Session Number:,1
,Enters Osteology begin time:,6:15:25 PM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Selects Fibula Revision:,no
,Navigation Method:,Next Page
,Navigation Method:,Quit
,Exits Osteology Session Number:,1
,Osteology exit time:,6:17:25 PM
,Length of current Osteology session measured in seconds:,120.1
,Session Time:,0:02

,**Session Number**:,2
,Student Number:,XXXXX
,FirstName:,XXXXX
,Initials:,
,Last Name:,XXXXX

,Day of the Week:,Thursday
,Day Number:,17
,Month:,June

,Start Time:,11:21:00 AM
,Navigation Method:,Contents
,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Contents
,Navigation Method:,Next Page

,Instructions Session Number:,1
,Instructions begin time:,11:22:18 AM
,Navigation Method:,Next Page
,Navigation Method:,Quit
,Exits Instructions Session Number:,1
,Instructions exit time:,11:23:04 AM
,Length of current Instructions time in Seconds:,112303

,Exit Quit option:,Exits
,Navigation Method:,Next Page

,Instructions Session Number:,2
,Instructions begin time:,11:23:14 AM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Exits Instructions Session Number:,2
,Instructions exit time:,11:23:23 AM
,Length of current Instructions time in Seconds:,112321

,Navigation Method:,Next Page
,Enters Osteology Session Number:,1
,Enters Osteology begin time:,11:23:26 AM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Exits Osteology Session Number:,1
,Osteology exit time:,11:23:49 AM
,Length of current Osteology session measured in seconds:,23.631

,Enters Muscle Session Number:,1
,Enters Muscle begin time:,11:23:50 AM
,Navigation Method:,Next Page
,Exits Muscle Session Number:,1
,Muscles exit time:,11:24:28 AM
,Length of current Muscles time in Seconds:,78

,Enters Anterior Session Number:,1
,Enters Anterior begin time:,11:24:28 AM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Exits Anterior Session Number:,1
,Anterior exit time:,11:27:07 AM
,Length of current Anterior Muscles time in Seconds:,279

,Enters Posterior Session Number:,1
,Posterior begin time:,11:27:07 AM
,Navigation Method:,Back Track
,Exits Posterior Session Number:,1

,Posterior exit time:,11:33:52 AM
,Length of current Posterior Muscles time in Seconds:,113351

,Enters Lateral Session Number:,1
,Enters Lateral begin time:,11:33:52 AM

,Revision Session Number:,1
,Revision begin time:,11:34:05 AM
,Exits Revision Session Number:,1
,Revision exit time:,11:35:05 AM
,Length of current Revision time in Seconds:,113504
,Score for this session:,.5
,total possible score for this session:,3
,percentage scored for this session:,16.66666666667

,Revision Session Number:,2
,Revision begin time:,11:35:11 AM
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,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Exits Revision Session Number:,2
,Revision exit time:,11:35:57 AM
,Length of current Revision time in Seconds:,113555
,Score for this session:,1
,total possible score for this session:,1
,percentage scored for this session:,100
,Exits Lateral Session Number:,1
,Lateral exit time:,11:35:58 AM
,Length of current Lateral Muscles time in Seconds:,113557

,Enters Common Fibula Innervation Session Number:,1
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,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Back Track
,Navigation Method:,Quit
,Exits fib Innervation Session Number:,1
,Fib Innervation exit time:,11:36:11 AM
,Length of current common fibular Innervation time in Seconds:,113610
,Exits Innervation Session Number:,0
,Innervation exit time:,11:36:11 AM
,Length of current Innervation time in Seconds:,113611
,Session Time:,0:14

,Session Number:,2 *note bug*[12] *- 3*
,Student Number:,XXXXX
,FirstName:,XXXXX

[12] There appears to be a bug in the recording of session numbers only identified when analysing data.

,Initials:,
,Last Name:,XXXXX

,Day of the Week:,Friday
,Day Number:,25
,Month:,June

,Start Time:,3:18:36 PM
,Navigation Method:,Next Page
,Instructions Session Number:,1
,Instructions begin time:,3:20:41 PM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Exits Instructions Session Number:,1
,Instructions exit time:,3:21:33 PM
,Length of current Instructions time in Seconds:,32132

,Enters Osteology Session Number:,1
,Enters Osteology begin time:,3:21:37 PM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Quit
,Exits Osteology Session Number:,1
,Osteology exit time:,3:33:10 PM
,Length of current Osteology session measured in seconds:,692.891
,Navigation Method:,Quit
,Exit Quit option:,Exits
,Navigation Method:,Quit
,Exit Quit option:,Exits
,Navigation Method:,Quit
,Exit Quit option:,Exits
,Navigation Method:,Quit
,Exit Quit option:,Exits
,Session Time:,0:14

,**Session Number**:,2 4
,Student Number:,XXXXX
,FirstName:,XXXXX
,Initials:,
,Last Name:,XXXXX

,Day of the Week:,Monday
,Day Number:,28
,Month:,June
,Start Time:,1:05:00 PM

,Navigation Method:,Next Page

,Navigation Method:,Next Page
,Instructions Session Number:,1
,Instructions begin time:,1:05:49 PM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Exits Instructions Session Number:,1
,Instructions exit time:,1:05:57 PM
,Length of current Instructions time in Seconds:,10556

,Navigation Method:,Next Page
,Instructions Session Number:,2
,Instructions begin time:,1:06:02 PM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page

,Exits Instructions Session Number:,2
,Instructions exit time:,1:06:08 PM
,Length of current Instructions time in Seconds:,10606

,Enters Osteology Session Number:,1
,Enters Osteology begin time:,1:06:12 PM
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Navigation Method:,Next Page
,Selects Fibula Revision:,no
,Navigation Method:,Quit
,Exits Osteology Session Number:,1
,Osteology exit time:,1:06:27 PM
,Length of current Osteology session measured in seconds:,15.135
,Session Time:,0:01
,Navigation Method:,Quit
,Exit Quit option:,Exits
,Session Time:,0:01

Researchers comment:
Concern that each session is initiated by paging through the instructions and moving onto oesteology. Suspect that this user was unable to use the Table of Contents

APPENDIX C

The questionnaire handed to students.

"THE LEG"
Questionnaire

I would be grateful if you would fill in the following so I can proceed with research and recommendation regarding the programme on the leg. As explained initially over and above an interest in whether the programme has had any benefit to you as students of anatomy, I am interested in the way people from different educational backgrounds use the programme. The following questions relate to those issues in particular and are not meant to be offensive in any way. **Your identities will be kept strictly confidential and responses will not affect your marks in anyway.**

Please answer the following questions in a way that you think best describes you. If you do not think the question is relevant or wish to refrain from answering it, you may do so, but it would help me if you let me know why.

Questions in the boxed area are optional.

Name: _____

Student Number: _____

1. **How would <u>you</u> describe your home cultural group:**

_____

_____

2. **What language/s do you speak at home?**

_____

_____

3. Which of the following best describes the last school you attended?

Historically advantaged private school	
Privately run cram college/school	
Historically religious-run "black" school	
Historically religious-run "white" school	
Historically religious-run "Indian" school	
Historically government-run English "white" school (Model C)	
Historically government-run Afrikaans "white" school (Model C)	
Historically government-run "black" school	
Historically government-run "Indian" school	
Other (please specify)	

4. Did you use the program "The Leg"?

Yes	
No	

If no please specify why not? (The rest is then not applicable)

_____

_____

_____

5. Did you use it ..

On your own	
With someone else	
Both of the above	

6. **How many times did you use it?**

Once	
Twice	
More than two times less than five	
More than five times	

7. **What did you find useful about the program?**

8. **What did you like about the program?**

9. **What did you <u>not</u> like about the program?**

10. Would you recommend further development of the program? e.g. extending it to other topics. Please make a brief comment.

Thank you for your time. Please feel free to use the rest of this page for any relevant comment you think may be useful to me. Enjoy your end of year break.

Kathy Murrell.

Other comments you may have: