Piloting a Web-based Science course for rural Northern Territory students

By

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To the best of my knowledge and belief, the work presented in this thesis is original, except as acknowledged in the text, and the material herein has not been submitted, in whole or part, for a degree at this or any other university.

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ABSTRACT

Potentially, the online environment offers many advantages over traditional methods used for the delivery of distance education. Increased communication and interactivity allow for the use of different and varied learning and teaching strategies. The challenge in developing online courses is to incorporate these advantages in an educationally sound and cost-effective manner.

The focus of this study was on the development and delivery of successful online courses for remote and rural distance education students in the Northern Territory. Accordingly, the task chosen for the study was first to develop an online module for Year 8 Science from a set of pre-existing printed materials and then to evaluate its subsequent delivery in Term 2, 2001. From this experience many issues that need to be considered in the development of online courses were raised and conclusions on the likelihood of developing a process or template for converting other modules were drawn. The study was a pilot project written up from the perspective of a participant observer who was both the online materials developer and a postgraduate student observing the processes and the issues at stake.

The findings of this study were disappointing. Due to the poor telecommunications infrastructure in the NT, CDs rather than the Internet had to be used to deliver the course. Without the use of Internet connections, communication tools such as email and discussion boards could not be used in the instructional design. This severely limited the teaching and learning strategies that could be used. The delivery of the module was beset by technical difficulties, as the students did not have the level of technical literacy required to complete the online module. On the economic side, the cost of developing the online module was significantly higher than that for the print based version and worse, the cost for developing subsequent similar modules was unlikely to be significantly less.
In conclusion, these results suggest that if the NTOEC is to realise the potential of the online module a very different approach to online development is needed and the technical literacy of their students needs to be improved.
CHAPTER ONE
INTRODUCTION

This was a pilot study investigating the possibilities of using the Web for Junior Secondary distance education students in the Northern Territory. Potentially, online courses offer many advantages over traditional methods used for the delivery of distance education and the challenge is to incorporate these advantages in an educationally sound and cost-effective manner. To investigate ways of achieving this, the task for the study was to develop an online module for Year 8 Science from a set of pre-existing printed materials. The task was commissioned by a distance education provider, the Northern Territory Open Education Centre (NTOEC), and undertaken by the author. This experience raised both generic issues and those more specific to the NTOEC that need to be considered in the development of successful online courses. From this evaluation the likelihood of developing a template or process for converting other similar print-based materials to an online format was then explored. The study was a pilot project written up from the perspective of a participant observer who was both the online materials developer and a postgraduate student observing the processes and the issues at stake.

This chapter introduces the background to the study, explains in detail the problem to be investigated and the approach taken to achieve this aim. In the first section 1.1 Background of the problem, distance education and the potential of the online environment to change it irrevocably are discussed. The next section 1.2 Statement of the problem introduces the problem this study addressed and the questions it attempted to answer before considering section 1.3 Significance of the study. Terms used in the study are then clarified in 1.4 Definition of the terms. The final section 1.5 Organisation of the study outlines the approach taken by the study and the layout of subsequent chapters.
1.1 Background of the problem

Distance education plays a vital role in the delivery of education to remote and rural students (HREOC 2000a). For many of these students it is the only access they have to education services without leaving home. This section introduces distance education, looks at why students enrol in distance education, how courses are delivered and considers some of the issues particular to distance education. The push for online courses in distance education and its possible benefits are then examined.

In Australia, all the States and the Northern Territory offer distance education through regional distance education centres. Distance education centres or schools are part of the standard school system and are the responsibility of the relevant State or Territory education department. Accordingly they follow the standard curriculum for their jurisdiction (HREOC 2000a and 2000c). Within the NT, the NTOEC has responsibility primarily for providing distance education to secondary students or Territorians traveling around Australia or temporarily living overseas. Initially opened as the Northern Territory Secondary Correspondence School, it has been operating for about twenty years. It is located in Darwin and is typical of many distance education centres (NTOEC 2000).

Around Australia, the student population undertaking distance education is diverse. Many distance education students live on isolated pastoral properties or in remote communities where the nearest school is too far away for them to attend every day. However there are other reasons for students to undertake distance education. Students may be physically unable to attend a school for a variety of reasons other than geographical isolation. Their families could be constantly moving, whether for work or a travelling holiday around Australia. Students may be confined to bed at home or in hospital. Some adults also enrol in distance education to complete their

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1 In addition, students living in South Australia who are entitled to enrolment at the Open Access College but for whom the required subject is not available from that school, are also entitled to enrol with the NTOEC.
secondary schooling. These include people requiring new skills for employment or others wishing to undertake a course with their children. Another group of distance education students attends school but wishes to extend the curriculum available to them. Small schools in particular may not have the resources or numbers to justify offering a range of subjects and in these circumstances students can take that subject by distance education. This reason often applies to senior secondary students (NTOEC 2000, OAC 2000).

As mentioned in the previous paragraph, while some adults do undertake distance education the majority of students are school-aged children. To simplify the following discussion all references to the distance education cohort will reflect the situation for the majority of participants, namely school-aged children.

Distance education is delivered using a range of methods including telephone, radio, printed materials, video, computer and, occasionally, interactive TV. However while recent advances in telecommunications technology such as telematics are used, the typical delivery mode still involves the distance education centre sending curriculum materials to each student by mail. Students complete their lessons under the supervision of a parent or supervisor and then return their assignments to the school by mail. These are marked by the teachers and returned. If students have any problems they have a contact teacher for help. The telephone is widely used to provide this support (HREOC 2000a, OAC 2000).

Full-time distance education requires the student to have a home tutor or supervisor, who is most often the student’s mother. The supervisor is responsible for helping the student organise his or her time and the necessary lesson materials as well providing motivation and assistance where possible. The younger the student, generally, the greater the support the supervisor needs to provide. This partnership between home and school and the contribution of supervisors and families in educating their children are important factors in successful distance education (HREOC 2000a).
Student isolation in distance education raises unique issues when compared to traditional education in a typical classroom. Instructional materials need to be designed that develop the skills and knowledge of the students without the benefit of regular, close contact. Activities that can be included are limited; for example, group activities are usually not possible and any necessary equipment or resources must be readily available to an isolated student. For students the resulting educational experience can lack variety. While course designers make every attempt to ensure the work is interesting, there is inevitably a "sameness" about the material (OTEN-DE 2000, SIDE 2000, OAC 2000).

Feedback to students also takes longer. Mail to remote areas can be slow with the turnaround time for mail in some areas taking up to a month. In these cases feedback on work is unavoidably slow and this can lead to an increased reluctance on the student's part to check mistakes or work through comments from the marker. This slow feedback needs to be compensated for in the design of the materials. A related problem is that when students enrol late there is a further delay while they wait for the material to be sent to them.

To combat this isolation, which can lead to a lack of motivation in some students, distance education centres actively try to foster contact with their students. Teachers make visits to students, students are encouraged to visit the school if in town, school and class newsletters are issued and residential schools or camps organised. Residential schools or camps involve students and teachers getting together in person for a number of days. These meetings not only provide educational support for the instructional materials but also allow for activities that cannot be completed by the student at home. Some examples include practical experiments that require specialised equipment or are dangerous to perform, excursions, group learning activities and access to facilities such as the library, laboratory equipment and computers (NTOEC 2000, OAC 2000, SIDE 2000, OTEN-DE 2000).

Fostering social contact between students as well as between students and teachers is also seen as an important aspect of these activities. Students in rural and remote areas
can have limited opportunities to mix with other children of their own age. Where radio is used or students have access to the Internet, the program can include assembly and after-school chat times where students can converse with each other in both formal and informal settings. Residential schools or camps can help to establish friendships and peer networks and, for younger children especially, this can be the primary purpose of the camp (HREOC 2000a and 2000b, NTOEC 2000, OAC 2000).

Despite these attempts, distance education is often a difficult way for students to study. These problems are highlighted by the following quotation from an address by Peter Toyne, former Shadow Minister for Education and Training in the NT Legislative Assembly and a parent of distance education students (HREOC 2000b, pp. 15-16):

I suppose I'm in a good position to talk about it because both my own children did secondary correspondence. It's a miserable way to do a secondary course. It's very mono-layered; it doesn't have any of the interaction between students and teacher and student that you'd normally find; it's very dilute, it's not a strong enough mechanism to actually carry a full secondary option.

Yet for some students it is the mechanism they use to complete a full secondary option.

Telecommunications can be used to reduce the distance aspect of distance education so that students are learning in an environment with more of the advantages that can be present in a classroom. Uses that can be made of this technology include audio teleconferencing, videoconferencing, electronic and voice mail, chat rooms, bulletin boards and online courses. In addition, these technologies can provide access to information services and support research and inquiry from any remote location that has a computer, modem and a telephone connection. For distance education this more immediate communication not only allows for social and work interactions but also importantly allows for timely feedback. The instructional approaches available to course developers also increase as these technologies allow not only for increased communication but also greater interactivity, the ready inclusion of multimedia and
multiple links through material. Collaboration, group projects, different representations of material, problem solving and less structured approaches can now be considered. This can lead to a more varied and better educational experience for the students (SIDE 2000, OAC 2000, OTEN-DE 2000).

Distance education centres, as mentioned earlier, are using some of these telecommunications systems. Alternative delivery systems involving the transmission of voice, data and images using a satellite, microwave or terrestrial mechanism are being trialled and used (SIDE 2000, OAC 2000, OTEN-DE 2000). One sophisticated use made of the technology is Telematics or the Electronic Classroom. Telematics uses telephone, computers and facsimile machines to allow a teacher to interact with typically five or six groups of students in different and often spread-out locations. The teachers and students see and can manipulate instantaneously the same graphic representations on their computer screens and at the same time interact verbally on the conference-style, open telephone line. This situation is very close to classroom face-to-face teaching. However, it obviously relies on students being able to congregate in a few locations, which is not feasible for many distance education students. One example of its use is to deliver senior secondary subjects to students at their local rural schools to allow them to complete their secondary schooling without having to live away from home (SIDE 2000, OTEN-DE 2000).

The use and relevance of online technologies in distance education is only likely to increase as the number of users of the Internet continues to increase rapidly and the technology of the Internet is continually improving in its functionality and sophistication. It appears this trend can only become more marked in the future. For example one estimate in April 1998 suggested that there were about 320 million Web pages and that in the next few years this figure was expected to grow by 1000% (O'Leary 2000, p. 29).

Political support for the use of these technologies is also apparent in recent releases of Government policies and national inquiry reports. For example, the Federal
Government in its policy statement *A Strategic Framework for the Information Economy – Identifying Priorities for Action* stated the following (NOIE 1999):

Online technologies, in themselves, will be an important tool in the cost effective provision of education and training. They offer the potential to transform the ways in which teaching and learning occur. For rural and remote Australia, online technologies offer a unique opportunity to address educational disadvantage stemming from the tyranny of distance. Not only do they facilitate communication between the student and learning institution; they also enhance interaction between the students themselves, allowing them to share their ideas and work on group projects.

Recent national inquiries into telecommunication infrastructure and remote and rural education have also recommended that support be given for the use of the technology in the education of isolated students. The *National Bandwidth Inquiry* (AIEAC 2000) identified providing adequate access to the Internet for regional, rural and remote Australians by 2005 as one of two bandwidth challenges for Australia. Its recommendations also include the need for governments to continue to develop online strategies across key areas including education (AIEAC 2000, Recommendation 19 p. 298). The Human Rights and Equal Opportunity Commission’s report *Education Access: National Inquiry into Rural and Remote Education* completed in April 2000, included in its list of recommendations (HREOC 2000d, p. 55, emphasis in the original):

**Recommendation 6.7:** Each education provider should review the availability and quality of videoconferencing and other interactive technologies for rural and remote students and staff with a view to providing additional funding and other support for curriculum and professional development initiatives which build in these technologies.

The inquiry also noted the “great potential for increasing the accessibility, quality and level of choice for rural and remote students” and noted some “very worthwhile initiatives had been developed” (HREOC 2000d, p. 54). As recently as September 2000, *Connecting Australia: Report of the Telecommunications Service Inquiry* recommended that “the government establish a fund to assist significant
communications projects by key users such as education” (DCITA 2000, Recommendation 8, p. 11).

While the description has so far been in general terms, these statements are all relevant to the NTOEC as it provides education to remote and rural students. Teachers at the NTOEC identified five reasons for converting courses online and these clearly correlate with the discussion above. The reasons given were (personal interview with T1, T2 and T3):

1. More effective educational outcomes: The online environment when compared to the traditional distance education environment offered a range of new features such as improved communication, which would allow a wider variety of teaching and learning approaches to be used in the design of the modules.

2. More immediate communication: Mail to remote areas can be slow and, as discussed above, student isolation and slow feedback can be problems. In some cases students can have completed a unit of work and its test before receiving any comments or corrections from their teachers. Late enrolments were also identified as a problem.

3. A more “exciting” and varied educational experience: Currently, the Year 8 Science course is a series of booklets consisting of activities, written work and the occasional video. While course designers make every attempt to ensure the work is interesting, there is inevitably a lack of variety. Each subject is simply a different booklet and a day’s work for a student is a lesson out of each of eight booklets. Student interest is especially important when there can be problems of supervision of students and schoolwork can be competing against more interesting activities such as mustering.

4. Strategic reasons: NTOEC felt that online education has great potential and will become an increasingly important teaching and learning approach for its courses. The NTOEC needs to investigate the issues and identify the options and possibilities.
5. The possibility of cost savings: For example, administrative and postage savings could be possible if courses were available on CD and/or online².

In summary, online education offers the potential to transform the delivery of distance education. As the Education Access: National Inquiry into Rural and Remote Education (HREOC 2000c, p. 50) reported:

Generally distance education in Australia is of a high quality with good outcomes for many isolated students. The failings are ... isolation from a diverse range of shared experiences ... Distance education is not suitable for all students and cannot be relied on to ensure effective educational access for every isolated student.

Online education could provide ways of overcoming both the isolation and may allow for effective educational access to be provided to a greater number of students.

1.2 Statement of the problem

The purpose of this study was to design from a set of pre-existing print-based materials a web-based course with a constructivist approach to teaching and learning. The study aimed to both maximise the use of the pre-existing print-based materials in the new module and to change the teaching learning approach from an instructivist viewpoint to a more constructivist viewpoint. A constructivist approach was chosen as it was seen as an effective teaching and learning approach, which would effectively harness the increased interactivity offered by the online environment.

The overriding problem investigated can be stated as follows:

If an online module is developed from a set of pre-existing printed materials is it likely to result in improved educational outcomes? What

² It could be argued that printing costs have been transferred from the NTOEC to the students. It should be stressed that any such savings were not seen as a driving motivation by the NTOEC but rather as an added bonus. At the start of the study, the possibility of transferring costs to the students had not been realised.
technical issues will need to be addressed? What is an appropriate instructional design? Will the resulting product be cost effective? Having created one online module, what are the implications for transforming other modules online? In other words, is the whole exercise worthwhile from an educational, administrative and technical point of view?

The module developed was a 5-week Science module for Year 8 students. It was developed over a six-month period in 1999/2000 and taken by the students in term 2, 2000. The focus of the investigation was on the development of the module from inception to evaluation and so each of these stages was explored: initial negotiations and agreement, requirements investigation, materials design, materials development and testing, implementation and evaluation. To explore the potential of the online module and the feasibility of developing a template or process for transforming other print-based modules, an analysis of the course development process was done. The author's experiences throughout the development process highlighted the educational, technical and administrative challenges involved. The educational challenges included ensuring that the learning environment design both supported the educational objectives of the module and was appropriate for the target group of young distance education students. The administrative challenges were to complete the commissioned task on time and within budget and so gauge the cost effectiveness of the approach. The technical challenges included keeping the interface simple and useful, ensuring the pages worked on a variety of platforms and machines and delivering the course to students in a trouble-free way. The specific questions the study addressed were:

1. **Given the situation of the NTOEC and its students, what technologies were the most appropriate to use in the delivery and development of the new module? Which desirable features of these technologies could be incorporated successfully in the design of the module?**

   As has already been discussed, the online environment had the potential to transform the way in which teaching and learning occurs for students living in rural and remote Australia. However, harnessing some of these potential features
requires a certain level of telecommunications infrastructure, equipment and technical authoring skills that may not be available to the NTOEC and its students.

2. **What limitations are placed on the instructional design if only those technologies identified in the response to the last question are used?** Given these limitations, what would be the distinguishing features of an effective instructional design? Once determined, can the design be implemented so that it is easy for the staff and students of the NTOEC to navigate?

Having identified the technical limitations in response to the last question, this question examines how the technology identified can be used for educationally successful learning and teaching. An instructional design that embodies an effective teaching and learning philosophy needs to be identified. Once such an instructional design is identified, its usability is an important factor in determining its acceptance by staff and students of the NTOEC. Online teaching and learning is only likely to be acceptable if its usability is high and students and staff experience few technical difficulties.

3. **As a result of using the new module, what were the students' and staff's levels of satisfaction with the learning and teaching and how did the educational outcomes of the students compare with using the print-based materials?**

The potential of this project to the NTOEC is the possibility of improved educational experiences for the students. As indicated earlier in this chapter, the online environment offers ways of decreasing the tyranny of distance and the isolation students may feel. This question examines the degree to which this potential was realised.
4. How did the money, time, skills and other resources needed to develop, run and maintain the new module compare to those required for the print-based course? Can the process, developed for one module, be readily reused for another module?

This question examines the economics of transforming modules online and examines the long-term viability of online education for the NTOEC.

1.3 Significance of the study

This study was needed, as it was the first time the NTOEC had developed Web-based course materials. To their knowledge it would also be the first time an online course had been developed for distance education secondary students in the Northern Territory. The specific module chosen was typical of many science units and of a sufficient size to raise pertinent issues in a realistic way without its size being overwhelming.

As discussed earlier, online education offers great potential to distance education and thus it is important that the issues concerning its implementation are investigated. The author believes that this study extends what is currently known in Australia by reporting on a possible implementation strategy to meet the particular circumstances of a local group. Its findings have particular relevance for the development of other online modules for remote and rural distance education students in the NT and throughout Australia.

1.4 Definitions of terms

The following definitions are provided to ensure uniformity and understanding of these terms throughout the study. The researcher developed all the definitions not accompanied by a citation.

**Bandwidth:** Bandwidth can be used in several different but related ways. For this study the amount of bandwidth between sender and recipient determines how much
data can be transmitted per unit of time. It is measured in bits per second (bps) or Kbps, Mbps and so on (AIEAC 2000, p. 6).

Document: "Document is any organised body of information, not just one on paper or even one suited for paper. Online documents can include animation, voice, music and other sounds and video" (Horton 1994, p. 2).

Flexible teaching and learning: “Flexible teaching seeks to provide educational programs in ways that meet the changing needs of learners. Programs are designed to cater for a more diverse range of learners, learning styles, needs and interests than are normally catered for through conventional study programs. ... Flexible teaching includes conventional teaching practices and learning modes as well as alternatives and options provided by various media including, but not exclusive to, the recent developments in communications and information technology” (UWA 2002).

Java: Java is a programming language for network programming which makes it very suitable for use on the Internet. It will work consistently on any platform. Java programs called applets can be used from within Web pages (Niemeyer and Peck 1998).

JavaScript: JavaScript is a programming language that can be used from within Netscape Navigator, Internet Explorer and other browsers that allow for executable content in Web pages. This means pages need no longer be static but instead can “interact with users, control the browser and dynamically create HTML content” (Flanagan 1998, p. 1).

Gbps, Mbps, Kbps and bps: These are short for gigabits, megabits, kilobits or bits per second respectively and refer to the rate of transfer of data through a communications channel. A bit is a unit of data and so the more bits per second, obviously, the quicker the transfer.

Internet: A global network connecting millions of computers all around the world.
Module: NTOEC courses are divided into modules, each of which consists of 20 by 50 minute lessons. Typically a module is completed over a five or six-week period.

Multimedia: The use of computers to present text, graphics, video, animation, and sound in an integrated way. Because of the storage demands of multimedia applications, the most effective media are CD-ROMs.

NTOEC: Northern Territory Open Education Centre

Online course: A Web-based course which is delivered over the Internet.

Online delivery: Pages or files which are sent to the user over the Internet. When used in relation to courses it refers specifically to the delivery mechanism and not to the teaching and learning approaches incorporated into the course.

Online page: A page is an HTML file that may contain many different elements such as text, graphics, JavaScript and video. An online document is typically made up of multiple online pages.

Remote and rural areas: The Human Rights and Equal Opportunity Commission Education Access: National Inquiry into Rural and Remote Education (HREOC 2000a, 2000b, 2000c and 2000d) distinguished between 'rural' and 'remote' using population as their criterion: towns with populations of less than 99,999 were clarified as rural, and those with populations of 5,000 or less as remote. Thus all of the Northern Territory is included within the Commission’s definition of rural and remote. The National Bandwidth Inquiry (AIEAC 2000) used remote and rural as areas defined as 'very remote', 'remote' or 'moderately accessible' by the Accessibility Remoteness Index of Australia (DHAC 1999). This encompassed areas that approximately 6 per cent of Australians live in. The two definitions do not totally coincide and thus there is some ambiguity with the term.

Topic: Within the online module similar units were grouped together into topics.
Unit: Within the online module a lesson or day's work was called a unit.

Web: A system of Internet servers that support specially formatted documents. The documents are formatted in a script called HTML (HyperText Markup Language) that supports links to other documents, as well as graphics, audio, and video files. This allows users to move between documents by simply clicking on hot spots. Not all Internet servers are part of the World Wide Web.

Web-based course: A course implemented using Web technologies, such as HTML and JavaScript and taken by students using a Web Browser. The course need not be taken online.

1.5 Organisation of the study

This chapter has presented the introduction, statement of the problem, research questions, significance of the study and definitions. Chapter 2 contains the review of the related literature and research. The methodology followed for this study is then explained in Chapter 3. Using this methodology, Chapter 4 details the development of the online module. The research questions are then addressed in the Chapter 5, The Findings. Finally, Chapter 6 contains conclusions drawn from the study and its findings, a discussion and a series of recommendations. The following paragraphs expand briefly on this.

The literature review in Chapter 2 concentrates on those techniques for transforming a print-based course into an educationally effective online course. The constructivist learning philosophy is investigated and approaches to building an online environment using these principles explored. Design issues behind successful navigation, site organisation and interaction are also addressed. The technological infrastructure of the Northern Territory and likely configurations of hardware and software to be used by prospective students of the NTOEC have been examined as these have implications for the course design. Finally the methodology used in the study,
participant observation, has been investigated and its advantages and limitations discussed.

Chapter 3 outlines the research methodology of this mainly participant observation study. Data was obtained using a variety of collection methods including personal reflections of the researcher, informal conversations and interviews with students and staff of the NTOEC, questionnaires, class rolls, academic results, curriculum documents and direct observation. Analysis methods, including an educational evaluation based on an approach detailed by Higginson (1990), was undertaken and known limitations of the study are detailed.

Chapter 4 outlines the development of the online module. The steps undertaken at all stages in the module development and the design of the resulting module are detailed. As this was a pilot study investigating the possibilities of using the online environment, throughout the study the process followed and any problems or successes encountered were documented. This provided information on the design, educational effectiveness and cost effectiveness of the module and accordingly formed an essential part of the findings.

The findings of the study are covered in Chapter 5. The data for the study comes from the description of the development process given in Chapter 4 and the results of a summative evaluation of the delivery of the online module. Using this data, the four research questions posed by this study are answered.

The final chapter, Chapter 6, discusses possible future directions for the NTOEC. The main lessons learnt from the development and delivery of the online module and its possible impact on the NTOEC are discussed. A series of recommendations for future online developments are also given.
CHAPTER TWO

A CRITICAL REVIEW OF THE RELATED LITERATURE

Chapter 2 provides an extensive review of the literature and research related to the development of online education for rural and remote distance education students in the NT. It has been divided into the following sections:

2.1 Telecommunications infrastructure available in remote and rural areas of the NT
2.2 Constructivist theory of learning
2.3 Transforming from a print to an online format
2.4 Implementing an instructional design
2.5 Technical considerations in implementing an instructional design
2.6 Issues in participant observation
2.7 Conclusion

Reviewing all the areas that online education encompasses was not feasible as this rapidly expanding field covers such a diverse range of topics and issues. Relevant topics range from educational issues such as learning theories, through to design issues including organisation, navigation and graphical layout, to technical issues such as JavaScript programming and the telecommunications infrastructure. When an online course is developed, all these topics are relevant. After all, a course without a sound educational basis, or one whose design cannot be implemented with the current technology, is unlikely to be an effective learning experience.

The areas chosen for review were seen as the most relevant for the NTOEC project. The telecommunications infrastructure available in the NT imposes restrictions on the design of any course, so this was investigated first. In light of these restrictions an appropriate learning philosophy incorporating a constructivist approach to teaching and learning was identified. Strategies for converting from a print-based course to an online course that reflected this learning philosophy were considered. Technical and
practical issues in implementing the course were then addressed. Finally, the methodology appropriate for participant-observation study was examined. From this review a strategy for implementing the online course was developed.

2.1 The telecommunications infrastructure available in remote and rural areas of the NT

The Internet and Web offer many exciting possibilities to a course designer. Interactive and dynamic courses that include multimedia can now be designed. Meaningful communication is possible via email, chat rooms, discussion boards and video conferencing. While none of these elements by themselves is an essential requirement of a successful course, they can help to achieve one. When used well they can form an integral part of instructionally sound and engaging courses.

Using these options obviously requires at the minimum a reliable Internet connection. The multimedia options need, in addition, reasonable bandwidth as well as appropriate machines and browser software. Consideration of bandwidth is necessary as these features often involve large files. This is a rapidly changing area and unfortunately the technical equipment of the students does not always keep up. Ensuring accessibility to students is obviously an essential requirement; a brilliant course that few students can use is of very limited value. Ideally, a course should be available to students with the widest possible range of equipment and Internet connections and consequently many of the options discussed above may not always be feasible. Thus, part of any course development should involve a survey of the equipment and telecommunications infrastructure likely to be available to the students.

Before considering the infrastructure available, the likely access of students to hardware and software needs to be considered. After all, presupposing Internet access is the assumption that the student has access to a computer in the first place. During the 1999-2000 period the Human Rights and Equal Opportunity Commission held a
**National Inquiry into Remote and Rural Education** (HREOC 2000a, 2000b, 2000c and 2000d) and as part of its inquiry it investigated distance education and the telecommunications infrastructure. HREOC (2000c) reports on the high cost to individual families wishing to equip themselves with a computer, modem, printer and individual software licenses. It goes on to recommend an allowance of “$1,500 per household per year for computer hardware, software and maintenance and access to the Internet” (HREOC 2000c, Recommendation 7.6, p. 50). Currently, however, some students will not have the use of a computer, whether due to the cost being prohibitive or simply their families having other priorities. In these cases, access to a computer-based course is obviously not an option and other arrangements will be necessary.

Proportionally, Australians are among the biggest users of the Internet in the world with the estimated number of Internet users in Australia at over seven million (Nielsen Media Research 2000, AIEAC 2000). Within the NT, the Australian Bureau of Statistics (1999) shows that the NT’s proportion of households with home Internet access is among the highest in Australia. Twenty-nine per cent of households in the NT had home Internet access in 1999 and, after the ACT, this was the largest in Australia. This is also up from the 1998 figure of 16 per cent for the NT and this was the biggest increase for any State or Territory.

These State and Territory wide figures form only part of the story. The Australian Bureau of Statistics (1999) notes that the uptake of Internet services was not consistent across the areas. Households in metropolitan areas had a greater uptake than non-metropolitan areas. The use of the Internet in these non-metropolitan areas has been the subject of a number of recent reports (e.g. Devlin 2000a; Klesch and Madden 1999; Craske, Murdoch, Besse, Heywood and Nunn 1999; HREOC 2000b and 2000c; AIEAC 2000). These reports have highlighted a number of problems.

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1 Distance education providers for secondary education in Australia are obliged to ensure that all their students have access to the courses and cannot require specific equipment such as computers or video machines. Thus in these instances an alternative course, most likely print-based, would need to be provided.
relating to provision, quality and access to telecommunication services in remote and rural areas.

Internet access is especially difficult for students in remote areas. HREOC (2000c) found that in some of the more isolated areas, students have no access at all to the Internet. ASTIC in their submission to the inquiry quote the NT government as believing "the basic services that are available in many [remote] areas of the NT have insufficient capability or capacity to attach any computing network device, consequently can provide audible service only" (HREOC 2000c, pp. 97-98, clarification in original). The National Farmers Federation submission to the same inquiry stated that nationwide "only 14% of farms and 8% of country households have Internet access" (HREOC 2000c, p. 45).

Where students do have access, the National Bandwidth Inquiry (AIEAC 2000) reported a lack of sufficient bandwidth capacity in remote and rural areas. By comparison, the majority of users in urban areas can achieve “reasonable” data rates. Craske et al. (1999, p. 1768) see data transfer rates of 33600 bps as the “minimum acceptable rate” but report that “[m]ost remote areas would be happy to achieve speeds above 9600 [bps]”. At the public hearing held in Darwin for the HREOC inquiry, it was acknowledged by Peter Toyne when discussing the advantages of online learning for the NT, that “In terms of the actual bandwidth that you need, in many cases that doesn’t exist at the moment” (HREOC 2000b, p. 16).

It should be noted that as a condition of its licence Telstra was required by the end of 1998 to provide 96 per cent of the population with access to an ISDN service, which would provide for 64 Kbps data transfer rates. After communications with Telstra, Devlin (2000a) reported that Telstra believed that access options for remote and rural users were probably better than most people realised. However, it should be remembered that the majority of the four per cent who cannot access ISDN are probably located in rural and remote areas. There are certainly enough reported examples and evidence (e.g. Devlin 2000a, Klesch and Madden 1999, Craske et al.)
1999, HREOC 2000b and 2000c, AIEAC 2000) to suggest that, for whatever reason, many students in remote and rural areas do have problems with access.

For those with access, the reliability and quality of connections are also problematical. Line noise is a major problem. While the correct choice of modem can help (Devlin 2000a, Craske et al. 1999) in some areas tested, Craske et al. (1999) found noise was so bad no modem could have provided adequate connection speeds. Numerous examples exist of communities and users being unable to connect to the Internet for periods of time (Devlin 2000a, Klesch and Madden 1999, HREOC 2000b and 2000c). For example, Bandias (as cited in Devlin 2000a, p. 9) writes that 31 per cent of schools with Internet connections in the NT rural area have cited poor quality lines as a constant problem.

Adding to these problems can be the relatively high prices paid for data transfer services in remote and rural areas (AIEAC 2000, HREOC 2000c). This is largely due to a lack of Internet points of presence in rural areas, which requires rural students to pay STD call rates to connect to their Internet Service Provider (ISP). Compounding this is the slow speeds experienced by many rural students, who must stay connected to the Internet for longer periods of time to access the same information as their city counterparts. Within the NT, Devlin (2000a) reports that STD rates will frequently apply to those users outside the Darwin region and can soon become prohibitive. He notes “there is little point having Internet access if it is too costly for the end-user to take advantage of it” (Devlin 2000a, p. 8).

People with the skills and expertise to support and maintain the equipment are also scarce (HREOC 2000a, 2000c and 2000d). When phone lines go down or computers malfunction, often the local community does not have the people or businesses with the skills to fix it. The options are then usually to send the equipment away or wait for the relevant technical service provider to visit. Both can lead to long delays and usually result in higher prices.
The level of access to the Internet also varies considerably across rural and remote areas. For example, Hoy (as cited in Devlin 2000a, p. 4) reported the example of El Questro, an international resort in Western Australia which has a one million dollar optic fibre link to it while the Kimberley Aboriginal Medical Services Council based 110 km away in Kununurra has only very basic telecommunications infrastructure for servicing six townships and 150 indigenous communities. While this is an extreme example it does highlight the differences that exist.

Just recently, in October 2000, the Connecting Australia: Report of the Telecommunications Service Inquiry was released. Its conclusions are in agreement with the findings of the earlier studies mentioned above. While reporting that Australians “generally have access to a range of high quality, basic and advanced telecommunications services” (DCITA 2000, p. 5), it recognised that problems existed in rural and remote Australia. The report went on to state (DCITA 2000, p. 5):

[A] significant proportion of those who live and work in rural and remote Australia have concerns regarding key aspects of services which, at this stage, are not adequate. Their concerns relate primarily to

- the timely installation, repair and reliability of basic telephone services,

...  

- reliable access to the Internet and data speeds generally.

Within the NT, the experiences of Internet users accord with the national picture for remote and rural users. The situation is clearly illustrated by Batchelor Institute’s experiences with using the Internet in the delivery of an online course across ten communities in rural regions of the NT (Klesch and Madden 1999). Numerous examples of poor or unavailable connections, difficulties experienced with email and trouble with getting online support are listed. Outlying communities found that the cost of ringing the central server in Bachelor soon became prohibitive. The NTOEC has also experienced similar difficulties with emailing some students. For example a teacher from the NTOEC found with one student the link was so bad that it was only
possible to send text messages; attachments of graphics were simply not possible (personal interview with T3). Across the border in outback Queensland, Willie, Ng See Pu and Allan (1999) report frustrations experienced by users with slow connections that effectively restricted the content which users could access.

The current outlook for the provision of online courses for remote and isolated users in the NT does not look promising although in the medium term the NT Department of Education’s Learning and Technology in Schools (LATIS) Project should make a difference (DEET 2001). Devlin (2000a) recommends several possible strategies for online course designers. These include offering text-only options as well as multimedia access and only selectively using multimedia so as to produce “lean” pages. His alternative suggestion is to use CDs for the bandwidth-intensive materials and the Web for “communicative purposes such as debating issues relevant to the course to provide better educational experiences and outcomes” (Devlin 2000a, p. 11). Using CDs has been a popular strategy. Klesch and Madsen (1999) note that Bachelor Institute found that the standard of links between the college in Bachelor and the outlying community study centres were not of a sufficient standard to be used for the provision of course materials. Instead, the Institute decided to distribute course materials on a CD, which was then posted to students. Willie, Ng See Pu and Allan (1999) in Queensland used CDs for bandwidth-intensive videos and reported that Internet video delivery was not as successful as a hybrid delivery approach that placed the video on CD with dynamic links to the Web site for updates. The Open Access College in South Australia also took this approach, placing course materials on a CD and using the Internet for communication purposes (OAC 2000).

For some rural and isolated students in the NT there appears to be little option but to use CDs. Internet links are non-existent in some areas, unreliable and slow in others and usually expensive for the student. This lack of services in remote and rural areas is well recognised by the government, which has shown some commitment to

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2 This is further discussed under 2.5.3 Plugins available later in this chapter.
improving it. This may well help with future provision of services but currently, as Devlin (2000a, p. 8) writes, “fundamental problems with provision remain”. While CDs may lose some of the interactive aspects of using the Internet, CDs do have some advantages. Bandwidth is no longer a major concern and so developers have more freedom to include multimedia. Students too are saved the costs of downloads. Where possible, using a CD in conjunction with the Web has obvious appeal and can add another dimension to a course. Care, however, is needed to ensure that prospective students will have adequate access.

2.2 Constructivist theory of learning

Having an adequate telecommunications structure is one thing; using it successfully for teaching and learning is another. Traditional teaching involves much more than just the transmission of knowledge, and similarly teaching on the Web is much more than presenting pages of hypermedia. Just as with traditional teaching, it is important to have a sound pedagogical basis for online learning. The danger can be that as education providers become involved with the new technologies their focus is on the apparent visible changes rather than ensuring that the materials incorporate effective instructional methods (Benyon, Stone and Woodroffe 1997; Greening 1998; Alexander 1995). Bednar, Cunningham, Duffy and Perry (as cited in Tam 2000) write:

Instructional design and development must be based upon some theory of learning and/or cognition; effective design is possible only if the developer has developed reflexive awareness of the theoretical basis underlying the design.

3 Given the lack of an adequate telecommunications framework in the NT, the decision to provide a web-based course may seem surprising. However it was felt that the technological framework would improve substantially over time and thus there was a need to examine the feasibility and potential of using online technologies to provide better educational experiences and outcomes for the NTOEC students.
Even though the online environment is new, there have been no fundamental changes in the basic human learning processes and thus accredited teaching methodologies are still relevant (Gilliver, Randall and Ming 1999). The online environment can support alternative delivery styles, whether these are, for example, instructivist or constructivist. The choice is the course designers', who can adapt the environment to their preferred style (Kennedy and McNaught 1997, Gilliver et al. 1999). Gilliver et al. (1999, p. 446) believe that there is danger of “elevating technology to an undeserved status of dictating style and content”. Instead they would argue that "technology provides nothing more than a framework and delivery infrastructure to enable educators to be as imaginative, creative and flexible as they wish."

Thus, determining the pedagogical basis of a course should be the first step for any course designer. In recent years the basis for instructional design has moved towards a constructivist perspective of learning to explain how knowledge and understanding are developed (Harper, Squires and McDougall 2000; Reeves 1998; Albion and Gibson 1998; Jonassen 1996; Laurillard 1993). For constructivists “[r]eality (or at least what we know and understand of reality) resides in the mind of each knower, who interprets the external world according to his or her own experiences, beliefs, and knowledge” (Jonassen 1996, p. 12). This is radically different from the instructivist view, which sees knowledge and truth as existing outside the learner. “Learners are told about the world and are expected to replicate its content and structure in their thinking” (Jonassen 1991, p. 6). Thus the role of education in the instructivist view is to transmit to a learner a chosen set of skills and knowledge that helps the student learn about the real world (Tam 2000).

Constructivists view learning very differently from instructivists. Learning is concerned with the process of how learners construct and come to know knowledge

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4 Clearly there are other learning approaches that could equally have been chosen as the pedagogical basis for an online course. However, constructivism is a well-established and respected educational theory and was chosen for use in this study.
as well as the results of the constructive process. Reeves (1998) describes this process in this way:

How students construct knowledge depends upon what they already know, their previous experiences, how they have organised these experiences into knowledge structures such as schema and mental models, and the beliefs they use to interpret the objects and events they encounter in the world.

Reality is different for each individual, as it is their unique interpretation of their own experiences. Teachers cannot simply map their interpretations and representations of knowledge onto students, as their experiences and interpretations are not shared (Reeves 1998, Jonassen 1996). Instead, students must build or construct their own interpretations. These individual interpretations depend upon the content, context, experiences and goals of the learner and so what is learned will depend on how it is learned. A variety of different experiences are unlikely to lead to the same understanding (Savery and Duffy 1995).

In this process, learning is active, as “information may be imposed, but understanding cannot be, for it must come from within” (Tam 2000). The emphasis here is on students as active participants, as “knowledge builders”, not simply passive receivers and reproducers of information. Knowledge is constructed through the activity of the learner in trying to articulate their own personal understandings of new concepts and ideas. Meaningful learning demands that the information is internalised and located in a student’s pre-existing knowledge representation. Learners need opportunities to reflect on the new material, discuss their tentative understandings with others, actively search for more information to throw light on areas of interest or difficulty and build conceptual connections to their existing knowledge base (Laurillard 1993). Old ideas and concepts may need to be restructured (Spiro, Feltovich, Jacobsen and Coulson 1991). Learners who actively build their own knowledge representations of the world have more ownership of these representations, which are therefore less likely to degenerate over time (Jonassen 1996).
As well as learners being actively engaged in interpreting the external world, they need to also reflect on their interpretation. Jonassen (1996) distinguishes between experiential and reflective thinking. Experiential thinking evolves from a learner’s experience and is reflexive while reflective thinking is deliberate. In reflective thinking learners think about what they know, how they know it, what they need to know and where they can find it. McInerney and McInerney (1998) describe this as learners needing knowledge about how to monitor their cognitive resources (metacognition) and how to learn (metalearning). If learners are to be self directed, a key principle of constructivism, then they also need to acquire the skills, strategies and resources to perform learning tasks effectively.

While learners construct their own knowledge representations, “all views, or all constructions, are not equally viable” (Savery and Duffy 1995, p. 33). Learners must be able to justify their position and its viability (Tam 2000). This often happens when learners interact with others and so test their understanding and examine the understanding of others. Through this social negotiation of meaning learners can come to a shared understanding (Savery and Duffy 1995). This accords more with Vygotsky's social constructivist theory (or cultural-historical theory) which emphasises the social and cultural interaction of the learner with others in cognitive development (Rice and Wilson 1999) rather than Piaget's personal constructivist theory where learners undertake a much more solitary exploration of their environment (McInerney and McInerney 1998).

In the learning environment there is always some stimulus or goal for learning, regardless or not whether the teacher makes it apparent. In Piaget's terms it is the new experience that cannot be explained by the current scheme and so requires accommodation (McInerney and McInerney 1998). Savery and Duffy (1995, p. 31) call it the learner’s “puzzlement” and state “it is a primary factor in determining what the learner attends to, what prior experience the learner brings to bear in constructing an understanding, and, basically, what understanding is eventually constructed.”
Thus constructivists see meaningful learning determined by the "complex interplay among learners' existing knowledge, the social context, and the problem to be solved" (Tam 2000). Tam believes that two characteristics are central to descriptions that have been given of constructivist instruction. The first is a problem, which is authentic, meaningful and realistically complex. Good problems should interest students enough, allow them to take ownership of their learning, provide the context for all learning and stimulate the exploration and reflection necessary for knowledge construction (SIU 1999, SDSU 1996, Tam 2000, IMSA 1998). The second characteristic is collaboration with others, often peers, to develop solutions. The dialogue that occurs allows learners to test and refine the validity of their understanding in an ongoing process (Savery and Duffy 1995, Jonassen 1996, Laurillard 1993).

In this environment the role of the teacher is as a guide or facilitator in creating a collaborative problem-solving environment in which students actively construct knowledge (IMSA 1998, SIU 1999, SDSU 1996). This obviously requires regular and meaningful communication between teachers and students, and students and students. Unfortunately, as discussed earlier, the telecommunications infrastructure within the NT is insufficient to provide for regular communication with and between remote and rural students. There can also be the added feature that in distance education students often work at their own pace and start at different times. In these circumstances organising a group of communicating students to collaborate on work is difficult and thus collaboration, one of the two central characteristics of constructivist environments as identified by Tam (2000), is missing.

Attempts have been made to circumvent the need for groups. Albion and Gibson (1998) in their distance education course incorporated a feedback mechanism through which students gained access to a collection of sample responses after students had completed a task. They anticipated that exposure to a collection of varying responses in this way would have effects similar to interactions among a group of learners with differing interpretations of a problem. No results of this approach were reported. The
findings of Oliver and Omari (1999) would appear to question the effectiveness of this approach. In their study, they used online collaborative groups to develop solutions to problems before a face-to-face tutorial. Their evaluation found that students responded very positively to the online learning environment, but rated the face-to-face discussions and the input of the teacher as the most valuable part of teaching and learning. These findings would tend to suggest that constructivist environments rely heavily on adequate communication between all participants at all stages and not simply at the end.

Even if all elements of the constructivist learning approach cannot be implemented into a particular course design, inclusion of those elements which can be implemented is still worthwhile and can add value to the course (workshop with Dr Penny Little on 22 October 2000). Accordingly, this review concentrates on those elements that can be implemented in an environment which only allows limited online communication and how these elements can best be incorporated into an existing instructivist style. This may mean making compromises such as the one proposed by Albion and Gibson (1999).

2.3 Transforming from a print to an online format

Having established the theory of learning that seems most appropriate for an online course, an instructional design that incorporates these principles is needed. The emphasis as stated above is on including constructivist elements into a course in an environment which only allows for limited communication. A further restriction on this review is that it also assumes that a print-based version of the course with an instructivist approach already exists and the instructional design of the online course must look to maximise the reuse of the existing course material.

Accordingly, this section starts by looking at the literature on the differences between the online and print environments and establishes the need to create courses specifically for the online environment. Various development strategies for creating
online courses are then examined. Finally, design considerations in organising resources and providing sufficient scaffolding for students within online courses are addressed.

### 2.3.1 Designing specifically for the online environment

The simplest way to create an online course might appear to be to take a successful print-based course and convert the format of the material from that of the word processor to HTML. While this would obviously be the quickest method, it is also very unlikely to be successful. The online and print environments are two very different media. In the words of Barrett (1988, p. xv):

Another aspect of the re-definition of writing and writer dictated by online documentation systems is the assault on a central concept of Western culture— the book itself: a linear narrative moving in time, occupying real space, with a beginning, middle and end.

Print is linear and comes with many conventions for structure (e.g. chapters, sections etc.) and navigation (e.g. page numbers, table of contents, index) that have been developed over time. Readers and writers have many similar expectations. This is not true with the online environment (Fleming 1998, Barrett 1988, Horton 1994, Brockman 1990).

The online environment is not linear. Via hyperlinks many different paths can be taken through the document. Writers of online pages usually do not know which path users followed to arrive at their page and what information they have already read. There is no notion of the “standard path” that exists in a book, which is designed to be read in order from the first to the last page. Thus book authors can assume this knowledge and refer to information from earlier chapters. Web designers do not have this luxury.

Fleming (1998, p. 1) goes further and argues that Web users perceive the Web “as a space to move around in, an environment we can change, a place where we can get things done.” She supports this by looking at the language used to describe the Web:
dead ends, paths, shortcuts, alternative paths, who's visited?, where did they go? Users of the Web demand, “freedom of movement, clearly marked paths, personalized service, quick delivery, immediate answers” (Fleming 1998, p. 2). These are considerations a person designing a space such as a library or department store rather than a book might worry about.

Considering the inherent differences between the media, Ruebens' findings (as cited in Horton 1994, p. 17), that online documents created by dumping print-based materials online work poorly compared to the original paper versions, are not surprising. Similarly, Alexander’s (1995) examination of the failed uses of educational technology found that simply presenting old learning experiences in this new environment almost always leads to failure. Nielsen (1997a) makes the analogy that “movies are not made by filming a play and putting the camera in the best seat of the theatre”. Similarly, taking a print-based course and putting it online unchanged does not make for a successful online experience. Materials need to be specifically designed and written for the online environment.

These new designs need to be educationally driven solutions that support the educational goals of the learner rather than technology-driven solutions (Ellis, Torokfalvy and Carswell 1998; Benyon, Stone, and Woodroffe 1997; Albion and Gibson 1998, Greening 1998; Jamieson 1999; Jones, Stewart and Power 1999). Good or improved use of the technology will not necessarily improve or create effective teaching and learning environments (Alexander 1995, Jamieson 1999). Factors other than the role of the technology are crucial and a more pedagogically oriented understanding of teaching and learning with online technologies is needed (Ellis et al. 1998, Benyon et al. 1997, Jamieson 1999). While much of the research on successful teaching in classrooms and for distance education will obviously apply to online teaching, it is, as discussed above, a different environment. Coppola, Rana and Bieber (1997), for example, note that while online materials can solve some fundamental problems with traditional pedagogical techniques, new problems can be created by the online technology. Instructional methods for the online environment are more
likely to be successful if they are either designed specifically for the environment or are adaptations of successful instructional methods used in the classroom. Courses need to be designed with the delivery medium in mind.

While the online environment provides for a new range of options and opportunities, it should be stressed that the media and technologies themselves do not have unique instructional effects. Variations found in learning outcomes when different technologies are used can be explained by differences in instructional design, novelty effects, or other factors (Reeves 1998 and 1999a). Clark (1994a and 1994b) describes technology merely as the vehicle that delivers instructional methods. It is the instructional methods, the teaching tasks and student activities that account for learning. Further, the delivery medium does not define the instructional approach (de Verneil and Berge 2000). Some educational objectives, however, are more easily achieved using some technologies rather than others. For example, viewing a video of an experiment can be more powerful and meaningful than reading about the same experiment (Reeves 1998 and 1999a).

The online environment is not the panacea to solve instructional design challenges. It allows for the implementation of instructional methods in new ways. However, the determining factor for any course is its instructional design and for a course to be effective in the online context it is essential that its instructional design is conceived with reference to the characteristics of the online environment.

2.3.2 Developing an online course

As discussed earlier, the constructivist and the objectivist approaches to learning are quite different, and similarly their approaches to instructional design and course development also differ (Tam 2000, de Verneil and Berge 2000). Objectivists describe learning outcomes in terms of exhibited behaviors, and the development and design process typically starts with the learning objectives (de Verneil and Berge 2000). Conversely, constructivists describe the learning as the process as well as the final product and the objectives often emerge during the design and development
work (Tam 2000). Constructivist and objectivist approaches to learning also tend to place different requirements on the curriculum. Constructivism takes a more integrated or holistic approach to learning and thus the spiral curriculum, rather than the more traditional linear curriculum, can often be more appropriate (interview with Penny Little on 22 October 2000). A spiral curriculum is one where concepts are represented at higher levels of abstraction as learning develops (McInerney and McInerney 1998).

Accordingly, before course development starts, it is necessary to first establish the learning philosophy to be followed and then a suitable development model can be chosen. Choice of a development model should also consider the mode of delivery (e.g. traditional classroom, distance education) used for the course (Bell and Lefoe 1998). This review has concentrated on issues concerned with converting pre-existing print materials with an objectivist approach to an online course with some constructivist elements. Thus, investigation of more traditional approaches to online course development, rather than a pure constructivist design approach, was seen as most appropriate.

Various different models have been proposed for course development. This review examines three outlined in Benyon, Stone, and Woodroffe (1997), Ellis, Torokfalvy and Carswell (1998) and Bell and Lefoe (1998). Benyon et al. (1997) describe a six-step development strategy: courseware specification, instructional design, multimedia design, integration, implementation and evaluation. Courseware specification identifies the objectives of the course. Instructional design is concerned with the pedagogical approach taken and developing educational strategies or learning activities (e.g. notes, practical exercises, videos etc.) to achieve the established objectives. Constraining the course design are the usual factors such as time, money and the nature of the student population. In addition, for online courses the delivery technology and authoring software will also impose limitations. The third step, multimedia development, is concerned with the selection, design and production of the components of the course. Integration combines these elements together and aims
both to achieve a consistent look and feel, and to ensure the course is easy to use and navigate. Implementation ensures the course works on one or more platforms. Finally, evaluation looks at the outcomes of the course as well as its presentation, design, content and usability against certain criteria.

Ellis et al. (1998) approach the first four steps – courseware specification, instructional design, multimedia design and integration – slightly differently. They suggest starting the development process by first breaking the content into topics and then detailed knowledge items. From this process the learning objectives will be generated. Bloom’s Taxonomy of Educational Objectives (1956) can help in creating effective objectives. The emphasis here is to move away from a linear sequence. After the objectives are defined, as with the previous model, the learning activities are then identified. The activities chosen should be the best to achieve the learning objective and specific technologies should not be considered. Unlike the first model, this model delays considerations of which technologies to use until after the integration of topics has been determined.

In Bell and Lefoe's (1998) model, the first four steps are approached very differently and in a more integrative fashion. In their model, student profiles and needs, along with the learning outcomes, drive the design. Learning outcomes are developed in the context of the student population and some examples of students’ needs include the requirement for flexible access or the student’s level of assumed prior knowledge. The four other curriculum elements in this model are teaching and learning methods, media decisions, assessment and evaluation. These elements are seen as interacting with one another as the design of one element will influence and possibly change the design decisions of other elements. Media decisions are seen as a major curriculum element that significantly influences other elements. For example, an identified students’ need was for 24-hour access, which influenced the choice of asynchronous rather than synchronous communication, that in turn affected both the choice of learning and teaching events and assessment items.
The role of media in this last approach is in contrast with the first two models that saw media decisions occurring after the educational strategies for a particular learning outcome had been identified. Ellis et al. (1998) believe that technology should not be addressed until after the course framework has been determined. "It enables academics to develop detailed domain learning objectives by applying appropriate educational implementation methods, and then matching technology for the effective support of these objectives" (Ellis et al. 1998, p. 212). Technologically driven solutions can be less appropriate for the learner (Petre, Carswell, Price and Thomas 1998). In contrast, Bell and Lefoe (1998) believe that the media has to be considered throughout the design process. The Benyon et al. (1997) model is between these two positions in that while they propose a linear progression through specified developmental steps, they note that the delivery technology and authorware will place limitations on the design and so imply the need to consider it throughout the design process.

In practice all three models offer insights. Bell and Lefoe (1998) provide an integrative approach to development which explicitly acknowledges the influence of technology. All three models see learning objectives as the driving force behind the approaches and stress the need for educationally driven approaches as opposed to technologically driven solutions. In addition, Benyon et al.'s (1997) model lists the processes and elements that need to be considered. Ellis et al.'s (1998) approach to topic development is consistent with the approach taken by many Web developers (e.g. Horton 1994, Brockman 1990, Rosenfeld and Morville 1998, Fleming 1998). It is also more akin to some constructivist instructional designs that start by examining the learning domain (e.g. McMamus 1996). Thus, there would appear to be merit for course designers to take elements from each of the development approaches and so develop an appropriate strategy for their own particular course.
2.3.3 Organising information and scaffolding

During the instructional design, issues in designing courses for the online environment as opposed to print need to be considered. This subsection looks at some of the issues in developing topics and organising information.

Organising information or topics is different in online and print-based environments. Reference earlier was made to the non-linear nature of the online environment and the fact, that unlike printed materials, there is a lack of conventions on how material should be structured. Rather than the image of linear progression through a series of pages, online documents are more like a series of separate cards that can be accessed in any order the reader finds them (Horton 1994). There can be lots of beginnings and endings and the middle is whatever comes in between. The non-linear nature of the online environment is one of its strengths (Eklund 1995), but it can also lead to conceptual and navigational confusion if not handled appropriately (Tergan and Lechner 2000).

This complex structure can in one sense be seen to mirror the structure of knowledge. Knowledge, too, is complex and ill structured and each discipline structures knowledge differently. By allowing for flexible and nonlinear links between pages of information, the online environment can model the conceptual interconnectedness that is core to the notion of knowledge (Alexander 1995, Eklund 1995, Doherty 1998). Different perspectives of the same or similar information, multiple representations, conceptualisations and perspectives on an issue can be given.

Providing both multiple paths and perspectives can support higher levels of cognition (Ramsden 1992) and be used to create constructivist learning environments\(^5\) (e.g. Spiro, Feltovich, Jacobsen and Coulson 1991; Kennedy, Eizenberg and Kennedy

\(^5\) The Web also provides access to a rich array of resources and these have often been used to provide both resources and alternative views (e.g. Brown 1997, Oliver and Omari 1999). However, as this review is concentrating on those cases where students have limited access to the Internet, this area was not investigated further.
In their study, using Cognitive Flexibility Theory, Spiro et al. (1991) argue that, for learning in domains involving "ill-structured" problems, it is essential for knowledge to be represented from different conceptual and case perspectives. This requirement "corresponds nicely to well known properties of hypertext systems, which facilitate flexible restructuring of instructional presentation sequences, multiple data codings, and multiple linkages among content elements". Further, Spiro et al. (1991) believe that the reason why many instructional approaches fail is because they represent complex subject matter in an unrealistically simplified and structured manner.

This need for authentic, ill-structured learning tasks, which have not been over simplified, is central to constructivism. For example, Laurillard (1993) questions teaching a scientific formula to students by showing them numerous examples and using the formula in different situations. She goes on to write (Laurillard 1993, p. 18):

The problem arises from the scope of "authentic", the degree of embeddedness in the social and physical world. We have to help students not just to perform the procedure, but also to stand back from that and see why it is necessary, where it fits and does not fit, distinguish situations where it is needed from those where it is not, i.e. carry out the authentic activities of the subject expert.

Reeves (1999b) argues that academic tasks, which remove the context from the task, as opposed to primarily authentic tasks, dominate the school curriculum. Further, the "Web offers teachers and students unique opportunities to focus on authentic tasks" (Reeves 1999b, p. 6). It should be stressed that an authentic task is not only one presented in a realistic context, but also one that requires cognitive skills consistent with the environment the learner is being prepared for (Savery and Duffy 1995). Thus, in the scientific formula example given earlier, learners would need to be

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6 When making this statement, Reeves was also presumably including using the Web to provide access to resources. Even if access to Web access is limited, resources on a CD could be used to mimic this.
required to engage in scientific discourse and problem solving and not to simply plug
the numbers into the formula as dictated to them by the teacher.

The way in which knowledge and skills are initially learnt also affect the degree to
which these abilities can be used in other contexts. Authentic, ill-structured learning
tasks can help learners avoid glib oversimplifications and also help learners to
transfer knowledge to new situations (SDSU 1996). Authentic tasks can also help the
learner to develop task ownership (Reeves 1997 and 1999b, Savery and Duffy 1995,
Spector 2000). Thus authentic tasks which learners have ownership over should be
emphasised (Reeves 1997 and 1999b).

Care is needed when multiple links are provided in online materials as they can cause
users to jump around a lot, and to be skimming and scanning rather than deeply
engaging with the material. This is not consistent with encouraging students to
engage in meaningful learning. Albion and Gibson (1998, p. 42) write:

IMM [Interactive Multimedia] designs [can] incorporate a variety of
access mechanisms leading to a rich array of content ... in an
instructional setting such designs may work against deep learning by
encouraging users to skim and sample from the content, even
unwittingly missing critical components. If learners are to be
encouraged to deep learning through engagement with the material
then designs that promote this behavior will be needed.

If materials are not designed well, this surface learning can actually be encouraged
(Laurillard 1993). Most learners will have limited knowledge of the domain being
studied and are unlikely to have a coherent conceptual model of the domain. Without
this conceptual model, it is hard for learners to structure their learning in an effective
manner (Horton 1994). Learners may never discover the key principles or concepts.
Important resources may be missed or even if they are found their importance may
not be recognised (Petre, Carswell, Price and Thomas 1998). Small and Grabowski
(as cited in Horton 1994, p. 387) found that, without guidance, users would select
familiar topics and tended to learn less than those users who followed an order
specified by the author.
Thus, in conjunction, the materials and the teacher need to provide scaffolding to ensure learners stay on track. Laurillard (1993) describes this as a basic design principle; the need to think what learners are required to do for their part and how the materials can be designed to support them in achieving their aims. This is consistent with the constructivist philosophy that, as noted earlier, does not see any solution as adequate. Instead, the critical element is that the students are supported in becoming effective practitioners in the particular domain (Savery and Duffy 1995, IMSA 1998, SIU 1999, SDSU 1996). The role of the teacher is as a facilitator or guide rather than as the provider of knowledge.

This notion of a teacher's role accords with Vygotsky's idea of scaffolded instruction and the zone of proximal development. The zone of proximal development is defined as the distance between the actual development age of a learner, i.e. what the learner can achieve independently, and the level she/he can reach in solving problems with assistance (Cole and Wertsch 2000). A teacher's role is to determine where a learner is in their development and to place learning within the zone (McInerney and McInerney 1998). If the task is in the zone the learner will need assistance in completing it and thus this assistance or scaffolded instruction needs to be provided by the teacher. The scaffolding needs to “involve helping learners to learn strategies they can apply when faced by new problems, not just answers to particular questions” (Devlin 2000b, p.2). This accords well with the constructivists' viewpoint, which stresses the need for learners to reflect on the learning process as well as the content learned (Savery and Duffy 1995, Reeves 1999b, Kennedy et al. 1997). As the learner learns how to perform the task, the learning scaffold can be progressively dismantled.

Some scaffolding can be provided by the organisation of the materials. Structuring the material into manageable topics and providing concept maps and graphic organisers can help learners both to see relationships between concepts and provide direction on how to use the materials (Reushle, Dorman, Evans, Kirkwood, McDonald and Worden 1999). Providing scaffolding in this form and providing multi-linked representations of the material can be in conflict (Ellis et al. 1999). On
one hand the designer wishes to provide multiple links to represent fully the conceptual interconnectedness of the material. As discussed earlier, this has been identified as an essential component of constructivist courses (Spiro et al. 1991). On the other hand as the number of links, increases the ability of the learners to use the materials to achieve their aims and find their way around the site decreases (Ellis et al. 1999, Rosenfeld and Morville 1998). The challenge in designing a site is how to use the power of links to provide a meaningful and expressive representation of the material without overwhelming the user (Reushle et al. 1999; Misanchuk, Schwier and Boling 2000).

Deciding on a particular representation to use may not be simple. As discussed earlier, knowledge is ill structured and complex and consequently materials can be organised in a variety of ways (Rosenfeld and Morville 1998). Concepts have ties to many other concepts and the manner different people view the materials will be based on their particular context, knowledge and experience (Horton 1994). Relationships formed between different parts of the material will to some degree be subjective and choosing an appropriate organisation is in part deciding which of these relationships to organise on. Thus any organisation chosen for the materials will be subjective. What is important is that the structure of the material should be meaningful and apparent to the users (Nielsen 1997a, Fleming 1998).

The organisation of the materials needs to support the learning goals of the learner. Shapiro (2000) found that when learners have no prior knowledge, the interactive overview (also called a concept map or graphic organiser) detailing the organisation of the material strongly influences the learners' internal representations and overshadows any learning goal. Where learners have some prior knowledge of the area, the effect of the organisation is less. This leads her to recommend that it may be unwise for novice learners to use online or hypermedia systems if their goals are not clearly supported by the organisation incorporated into the pages. For example, if novice learners are required to learn about animal families the pages should be organised by animal families and not for example by ecosystems. However, she does
also note that for students with some prior knowledge, "giving the students a new perspective on information with which they have at least some familiarity may stimulate greater depth and flexibility in their knowledge base" (Shapiro 2000, p. 76). This may be analogous to the multiple perspectives provided by Spiro et al. (1991).

The organisation of materials affects the way they are interpreted and understood (Shedroff 1994). Different organisations of the same set of data can express different attributes and messages. Shedroff (1994) gives the example of the Vietnam War Memorial in Washington DC to show how one particular organisation of the data can provide an intense emotional reaction that may not be present in other organisations:

The names of all of the US military personnel who died in the Vietnam War are inscribed on the surfaces of two long, black granite walls. The walls start out short (around twelve inches) and grow to more than nine feet in the center where the two meet. They are constructed in this way for a special reason. All of the names are arranged by time (date of death), from the first who died during the "police action," to the mounting death toll at the height of the war, trickling off as the US pulled out of the area. The names thus chart the pattern of US involvement in Vietnam and the personal stories of the real people involved and most affected. ...

An alphabetical organization would have completely depersonalized the monument and devastated its emotional power, so would most other organizations. Imagine if the names were organized by category (e.g. pilots listed here, infantry listed there) or on a continuum based on rank or for that matter height (e.g. the tallest men at one end, the shortest at another). What is the key to this emotional experience is that those who died are found among those whom they died with. Without this organization, in fact, there is no longer meaning to the wall growing and tapering down in height. Any other organization would have created a different memorial entirely and, most likely, one without the power and emotion created in the existing one.

While the organisation plays a significant role in the experience created, visitors are unlikely to be aware of its information structure. Shedroff (1994) goes on to argue that this is true of any project, however the power of the organisation should not be underestimated.
In summary, the organisation of materials is critical to the design of the course. The particular organisation chosen for a course will be a significant factor in determining the learning experiences created for students as well as the effectiveness and usability of the course.

2.4 Implementing an instructional design

Identifying the pedagogical basis for a course and the implications it has for the instructional design is only the first step. Implementing the design so that it reflects the elements identified as important is the next challenge. While print-based designs can provide many useful insights, there are substantial differences between the issues facing designers of online course materials compared to those confronting designers of print-based materials. Three of these main differences can be summarised as follows:

- Organisation is approached differently in the two media and thus implementing a chosen method of organisation will also be different.
- Layout and writing styles need to be changed, as readers approach online and printed pages very differently.
- Navigation and interaction take on totally different meanings for online courses.

In the language of Fleming (1998), the appearance of the space and the movement through the space need to be defined. The qualities and the characteristics of successful navigation need to be recognised.

The following subsections discuss from a practical viewpoint how these issues could be addressed.

2.4.1 Implementing a method of organising material online

Deciding on one or more organisations or representations of the course material is only the first step. Organising involves breaking up the material into pages or nodes. Typically, a node is a distinct topic that includes enough information so that it can stand by itself (Horton 1994, Brockman 1990, Benyon et al. 1997). The method of organisation chosen will strongly influence the choice of topics but "dividing a
subject into discreet topics is as much art as science and requires compromise and judgment" (Horton 1994, p. 109). With small topics students can access details quickly without having to page through lots of material and designers can combine topics in more ways. Conversely, with larger topics the design is simplified and navigation among topics easier (Benyon et al. 1997, Horton 1994).

Benyon et al. (1997) used a strategy that placed each distinct piece of information (e.g. description of a concept, a two-line answer) in a separate topic. They found problems with this approach, as important contextual information was lost for the small topics. Tufte (1997, pp. 146, 148) too, concurs with this and stresses the need to avoid "sequentially stacking up little bits of data to be unveiled gradually" in "tiny irritating steps". Conversely, chunking too much information into a topic can lead to a very sequential display and this negates one of the advantages of the online environment, which is its non-linear nature (Horton 1994).

Even once a course structure has been decided upon, implementing it may not be straightforward. Benyon et al.'s (1997, p. 209) experience with breaking material up into topics lead them to warn that:

It is only once the conceptual course structure is realized in an implementation that the usability issues become apparent, and the Web lags behind other hypermedia systems in many respects. Shneiderman (1997, this issue) comments that Web design is still at the "Model T" stage of development. In our context, we would argue that educational hypermedia is the model T; the Web has some way to go before it reaches this stage.

This would appear to support Bell and Lefoe's (1998) position on instructional design, that media elements should be an important consideration in the course design.

2.4.2 Qualities of well-written online pages

Once a structure for the material has been established the content itself needs to be written. Access issues, organisation and navigation all exist to get the content to the user. If the content does not meet the needs of a significant number of the targeted
users, the site will never succeed regardless of its graphics or design (Fleming 1998, Horton 1994).

As has been constantly stated, the online environment is very different from the print environment. The way online pages are read is different from print pages. Gillespie (2000) looks at the difference between the two:

When reading any page at a normal reading distance, there is a certain field of view that the eye can cope with – that is governed by small movements of the eye - enough to scan a line of text and be aware of that line's relationship to its surroundings. If you have to move your head, you are changing the field of view completely and the brain has to try to relate the new field of view to the previous one.

With a newspaper page, there will be considerably more head movement required than with a paperback book. For Web pages, it depends very much on the browser size on the screen. Scroll bars allow the field of view to be changed but one of the most common mistakes on Web pages is to allow the text to flow to the browser width. This is word-processor thinking, not design, and is much too wide for a comfortable horizontal field of view on even a small monitor.

The recommended width for a line on screen is eight to ten words (Gillespie 2000). A two-column display can be used to keep the lines to an easily readable length (Misanchuk, Schwier and Boling 2000).

Other differences between written and online pages also exist. The physical act of scrolling takes considerably more effort than the eye or head movement needed to scroll down a printed page (Gillespie 2000). Compact vertical design that reduces scrolling is recommended (Shneiderman 1997, Misanchuk et al. 2000). Compact design is also needed, as the amount of information that can be displayed on a typical computer screen is much less than what can be displayed on a page of text. Computer screens have a typographic density (characters per unit area) of 3 to 50 times less than text (Tufte 1997). Compounding this lack of space can be the inefficient use made of it. The display, should as far as possible, be devoted to substantive information and
not logos, navigation, other tools and white space (Misanchuk et al. 2000, Tufte 1997). Tufte (1997) advocates using quantitative measures to provide an assessment of what percentage of the interface is devoted to content and non-content. “Applied thoughtfully, these measures may help to restrain the imperialism of operating systems and of interface metaphors – and thereby enhance the richness of content displayed” (Tufte 1997, p. 150).

Several practical examples can be given of how to use space well and avoid scrolling. Over-elaborate icons, logos, borders or other such visual effects included simply to provide “decorative spice” should be avoided. Simple text may not only save valuable space but can be more appropriate (Tufte 1997). White space, too, needs to be used carefully. While white space can help with a page’s organisation, too much or wasted white space simply lengthens a page without adding any benefit to the user. An example of inappropriate use is the excessive use of horizontal rules or blank lines to separate items on a page (Shneiderman 1997). Another is having a single column of links on the left-hand side, which leaves the right-hand side of the screen empty. In this instance a multiple column display would probably make better use of the screen space and so increase the usability for users (Shneiderman 1997).

Writing for the Web is also different from writing for print. This can partly be explained when the purpose for many Web sites is considered. Most Web sites exist in a competitive environment where users have choices about which Web sites they use. For Web designers not only is it important to attract visitors to their site, but it is more important that they stay on the site and continue to return to the site. Users will only do this if the site meets their aims; if it is slow or difficult to use users will move onto another site offering the same services that matches their needs. Writing needs to support users in achieving their aim of finding information as quickly as possible (Fleming 1998, Nielsen 1995, Morkes and Nielsen 1997).

Studies of how users read on the Web have found that users do not actually read, but rather tend to scan the text on the pages (Morkes and Nielsen 1997, Tilta 2000,
Niederst 1998). This has lead to writing guidelines to support this behavior. Some of the more important of these are:

- Writing should be short and concise as possible without detracting from the meaning of the content. This helps users to find information quickly.

- Chunking the content into small, relatively standalone topics helps with usability. Long scrolling pages should be avoided.

- Language used should be simple and informal as it is quicker to read and understand. This includes not using marketing speak and unnecessary jargon. However it is important that the content is not compromised or over-simplified.

- Text should have a clear visual structure that is easy to scan. Headings, short text passages and bulleted lists are all tools that can help with this.

This list is not exhaustive but it does highlight the style of writing that is currently favoured by Web site creators (Tilta 2000, Fleming 1998, Morkes and Nielsen 1997). To increase the readability, Misanchuk et al. (2000) recommend using a large point size and black text on a white background.

These writing guidelines are not entirely appropriate for online courses. By selecting a course, students have shown a degree of commitment. They are no longer casual users who by chance have stumbled on the site while surfing and need to be immediately attracted to the site and encouraged to stay and explore. Instead they have signed on for a period of time and are after more than snippets of information. Presumably they are prepared not to simply scan pages but instead engage meaningfully with the content. The aim for the online course is to provide an experience that will encourage the student to complete the course and learn the content. This is opposed to many Web sites, which need to provide information, services or products quickly to busy users. One compromise is that used by Misanchuk et al. (2000, p.244). They decided for their Hypermedia Book, even though they were “producing a serious, research-driven treatment of the topic”, that “direct, simple and conversational language where possible” was more appropriate and in keeping with “what people have learned to expect from the Web”.

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While the differences between Web and print pages have been highlighted here, there are also many similarities. Many of the rules and recommendations for writing and layout that have developed over time will obviously apply to the online environment. However, the online environment does have its own characteristics and these need to be considered.

2.4.3 The qualities of successful navigation

An essential requirement for any successful online course is an appropriate interface design which allows trouble-free and easy access to the materials. Pretty graphics and clean code by themselves are not enough to guarantee a successful interface. The interface must also be easily navigable otherwise, regardless of the quality of the content, the site is likely to be an unusable failure (Fleming 1998). Sue Damais of Microsoft states (as quoted by Dillon 2000), “The improvement in performance gained through usable interface design are 3 or 4 times larger than those gained through designing a better search algorithm”. Good navigation design also allows for students’ cognitive efforts to be directed solely at mastering the course content and not to be sidetracked on trying to find particular pages or working out where in hyperspace they are currently positioned (Tergan and Lechner 2000).

Earlier, Fleming’s (1998) notion of users perceiving the Web as a space to move around was discussed. Central to moving around in a space is knowing where you are, where you can go, how you can get there and how you can return to previous locations. Users need support that provides a strong sense of structure and place (Nielsen 1996a; Kirsanov 1996; Rosenfeld and Morville 1998; Muehlbauer 1997; Marlatt 1997; Misanchuk, Schwier and Boling 2000). With good navigation, users move around without a deliberate effort while, conversely, with bad navigation, users are constantly aware of their movement and the problems it raises. Successful navigation should be an intuitive process that hides the complexity of a site from the user. This does not mean the site cannot be “information rich”, but rather through good design and construction the site appears simple and approachable (Fleming 1998).
Fleming (1998) has identified ten qualities of successful navigation, which she believes apply to all Web sites. These qualities and how they relate in particular to an educational course are:

1. Navigation should be easily learnt: The importance of sites being easy to learn has been recognised by many as an important design issue (e.g. Brockman 1990, Rosenfeld and Morville 1998, Horton 1994). Users should expend their energies on the content of the site and not on how to access it. With respect to an educational course, students may at first be apprehensive about using an online module and the easier it is to learn how to navigate, the greater their confidence will become. This is important when it is considered that the online module is competing against print-based courses. If the initial learning curve is too difficult, students may well switch back traditional print mode of study.

2. Navigation should be consistent: The tools and methods used for navigation should be the same throughout a site and this includes keeping the appearance and the position of these tools constant on a page. In this way users need only learn the navigation once and it helps to make their movement around the site become intuitive (Reushle et al. 1999, Brown 1997, Kirsanov 1997, Gillespie 2000).

3. Navigation should provide feedback: This includes creating controls that are responsive and provide information about location to users. Rollovers, for example, alert users to active components of the page and can provide extra information and guidance to users (Kirsanov 1997, Gillespie 2000). Making the structure of a site apparent is also important and where possible every page should contain some indication of its place in the overall organisation (Misanchuk et al. 2000). Techniques to do this include using a grayed-out or second version of a navigational image to let users know they are currently on that page. Another devices is to include a topic or category title on content pages that identify which section a page belongs to (Shubin and Meehan 1997, Gillespie 2000).
4. Navigation should appear in context: Navigational tools should always be available when needed. Users should not have to use guesswork or rely on browser features such as the back button to move around (Brockman 1990, Horton 1994, Marlatt 1997). This is particularly important for new and intermittent users.

5. Navigation should offer alternatives: In 2.3.3 Organising information and scaffolding the importance of accommodating different personal preferences was raised. Alternatives are also needed to ensure accessibility. Accessibility requires making sure that not only users with disabilities\(^7\) have access but also those without the latest browser and/or plugins. As discussed in the next section, 2.5 Technical considerations in implementing an instructional design, differences exist between browser versions and platforms and these can cause pages to be displayed totally differently. For example colours, font sizes and form layout appear differently on Macs and PCs and care is needed to ensure that pages render successfully in all environments.

6. Navigation should require an economy of action and time: For users, navigation is simply a means to an end. At successful sites users can move around quickly and painlessly (Misanchuk et al. 2000). Navigational shortcuts including site maps, indexes and toolbars can help to provide this quick access. Frequent users of a site can easily become frustrated if quick access is not provided. For larger and more complex sites these tools are essential (Marlatt 1997). Most information resources can be scanned linearly from start to finish but their size often dictates the need for shortcuts to relevant information.

Site maps and indexes have a dual role in that they not only provide access to the pages but can also be viewed to help understand the topic (Tergan and Lechner

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\(^7\) Access for those users with disabilities was not investigated further because there were no students with a disability involved in the pilot study.

7. Navigation should provide clear visual messages: The visual appearance of navigation options provides cues for users. Features such as size, colour, shape and position all help users judge and use items. For example large items are more important than small items, buttons or underlined text are links, red is danger and grayed out content means it is not currently available. In the Web environment where so few conventions exist, following these cultural understandings takes on increased importance. As noted before, the print environment comes with many established conventions such as page numbers, chapters and table of contents and thus navigation is easy for users. The Web does not have this history of shared understandings and users are dependent on the messages being provided by the designer of a site (Gillespie 2000). Kirsanov (1997) gives the example of a site\(^8\) that used different size buttons because the descriptions for individual buttons were different lengths. This could easily confuse users into believing that the larger buttons represent more important links than the smaller buttons do. Small details such as this can have a significant impact on the success of a site.

Visual clues can also help to clarify the structure of a site. Kirsanov (1997) suggests using separate navigation bars for tools and topics. Here tools refer to aids such as email, search facilities and help while topics are the different categories the information on the site has been divided into. Another advantage of this division is that the topic bar will allow users to form a view about the structure of the information. For this view to be accurate the various topics should be of equal importance.

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\(^8\) The site was that of Sun Microsystems, but it has since been redesigned.
8. Navigation should offer clear labels: Labels, whether for text links or icons, need to be unambiguous, clear and concise. They should be in the terminology of the users and not the organisation (Gillespie 2000, Tufte 1997). Icons without labels can be confusing. For example, does a question mark icon refer to help, frequently asked questions, a search facility or a way to submit questions?

9. Navigation should be appropriate to the site’s purpose: Navigation should reinforce a site’s purpose and every decision no matter how simple or mundane should also support that purpose (Shedroff 1994). What is appropriate for a shopping site’s navigation may not be appropriate for a learning site. For example, at an educational site the site map can be designed to help highlight the conceptual structure of the knowledge as well as providing access.

10. Navigation should support a user’s goals and behaviours: An important issue in Web design is consideration of a user’s goals rather than just those of the owner of the site (Nielsen 1997a, Rosenfeld and Morville 1998, Tufte 1997). These goals are often not in agreement. For example, educators have long been aware that, unless a task is assessable, some students are unlikely to value it. This is not to suggest that all tasks should be assessable, but to highlight that educators have long realised the importance of considering a student’s goals and behaviours. Smith, Newman and Parks (1997) cite numerous studies that stress the need for the information to be structured in such a way that it supports users’ goals.

Shneiderman (1997) also stresses the role that identifying the users' tasks plays in guiding designers in shaping successful Web sites. For example, interfaces for children need to be designed to ensure that the interface is clutter free as the users are young and unlikely to have patience with complicated structures. On a practical note for all sites Kirsanov (1997) reports that studies have shown that the number of choices on most Web pages should not be more than seven (though he personally believes in some circumstances eight to ten may be acceptable). Tufte (1997, p. 146) would appear not to be in total agreement with this as he presents a
screen with over 40 choices as an example of good design. He particularly stresses the need not to break up the content into small chunks of information but rather to let the information become the interface.

As should be apparent from this discussion, navigation design is a creative process. As Misanchuk et al. (2000, p. 250) write, "Interface design is a complex problem, tied closely to the content and context of a product, and without the comfort of cut and dried solutions".

2.5 Technical considerations in implementing an instructional design

Having written the content of their course and designed the navigation and framework, developers then need to consider how pages will be rendered on the screen. A difficulty that applies to Web designers around the world is that pages are at the mercy of the software and hardware configuration of individual users. Pages can look totally different in different configurations. A page that looks good on one user's machine can look terrible on another's and not even render successfully on a third's (Niederst 1998, Goodman 1998, Gillespie 2000, Heinle 1997, Flanagan 1998, Bradenbaugh 1999). These differences can be due to a number of reasons that include:

- Functionality of the browser: Browsers come in different brands (e.g. Netscape Navigator, Microsoft Internet Explorer) and versions, and the functionality available varies significantly between them (Goodman 1998, Heinle 1997, Flanagan 1998).

- Platform display differences: Differences, in addition to colour and text discussed below, exist between different platforms such as Macs and PCs (Goodman 1998).

- Plugins available: Users will not always have the relevant plugin software installed on their machines (Basiel, Jones and Dudman 1999, Gillespie 2000, Niederst 1998).
• Available screen space: Monitors come in different sizes and with different resolutions and this significantly affects the amount of information that can be displayed on a Web page (Gillespie 2000, Niederst 1998).

• Display of colour: The number of colours available and their brightness also varies between individual monitors (Bancroft 1997, Gillespie 2000, Niederst 1998).

• Display of text: The fonts available vary between individual computers. The size of text when displayed on a screen is also not constant (Gillespie 2000, Shafer 1998a and 1998b, Niederst 1998).

2.5.1 Functionality of the browser

One of the biggest headaches for designers is overcoming problems caused by inconsistencies between various versions of browsers. Different browsers vary in the functionality they offer and in the way they offer that functionality. A page that worked well in one version of a browser may not work in another (Bradenbaugh 1999, Flanagan 1997, Goodman 1998). This section starts by looking at the browsers most commonly in use and the features individual browsers offer. From this, strategies for designing pages can then be developed.

Almost all personal computer users have either Netscape Navigator or Microsoft’s Internet Explorer (IE) as their browser. Nua Internet Surveys (2000) in June 2000 reported that WebSideStory’s StatMarket put Internet Explorer’s share of the browser market at approximately 86% and Netscape Navigator’s share at 14%. Other browsers such as Opera had less than 0.02% of the market. TheCounter.com (2000b) reported similar figures with IE having 84% of the market and Netscape Navigator 14%. The discrepancy between these survey results is only to be expected, as accurate figures
on browser usage are difficult to determine. The market is rapidly changing\(^9\) and methods of collecting statistics are difficult to organise.\(^{10}\)

While the browser users choose may be limited to two major brands, Web technologies are rapidly evolving and over the last few years, both Microsoft and Netscape have released numerous different versions of their respective browsers. This has resulted in a myriad of browsers being used on the Internet. For example, Nielsen (1997b) found that in December 1996, 37 versions of Netscape, 12 versions of Internet Explorer and 19 other browsers visited his site www.useit.com. In April 1999, Nielsen (1999b) found that the proliferation of browsers had not abated. Faulkner and Chen (2000) write that there are some 200 variations of the Netscape browser alone in use on the Internet.

Later versions obviously support greater functionality and allow for the creation of more dynamic pages. Despite this, many users do not use the latest browsers even though browsers are freeware and relatively easy to download over the Internet (Niederst 1998, Goodman 1998, Benyon \textit{et al.} 1997). StatMarket (1999) found in November 1999 that 5\% of browsers being used were version 3 browsers and 56\% were version 4 browsers. Nielsen (1999b) estimates that version 3 browsers will be in use until at least 2001 and version 4 until 2003. The delay in the uptake of new technology is explained in part by bugs and inconsistencies in advanced browser features and reliability problems that have made users wary of upgrading quickly (Winer 1999, Nielsen 1999b).

As the user uptake of the new technology is slow, sites will need to continue to support old browser versions for a considerable time (Nielsen 1999b). Most

\(^9\) In the same article Nua Internet Surveys (2000) reported that in February 1999, IE's share was approximately 64\% and Navigator's share 33\%. In July 1998 BrowserWatch (1998) had Navigator's share at 52\% and IE at 36\%.

\(^{10}\) StatMarket for their November 1999 survey claimed to obtain their figures by checking the browsers used by over 28 million visitors to 83,000 independent web sites and theCounter.com obtained their figures from over 260 million hits.
commercial sites have little option if they wish to ensure that their pages are universally accessible to users. If users are required to have a certain level browser to access a site successfully, they are just as likely to search for a competing site, which does not require a browser upgrade. Educational sites probably have more leeway. Students, by choosing to enrol in a course, are showing some commitment to the course and requiring them to upgrade their browser is consistent with that commitment. For example, the Northern Territory University (2000) in its Web policy states "The University is required to provide accessible information to people with various levels of technology. ... Web sites must be designed to be functional on the following specifications: Netscape 4, Internet Explorer 4". It should be noted that this includes the entire university site and not only their online courses.

Insisting on version 4 browsers does involve a trade-off. On the downside, it limits the browsers that will be able to view the page successfully. On the upside, it allows for greater possibilities in page development, as Dynamic HTML (DHTML) features are available only in browsers version 4 and above. These features, as the name suggests, aim to make pages more dynamic. One solution to ensuring pages are available to the largest possible audience is to create separate pages for pre version 4 and post version 4 browsers. This will also substantially increase the development and maintenance costs of the pages (Niederst 1998, Goodman 1998, Fleming 1998, Boles and Siciliano 2000).

DHTML offers much new functionality but unfortunately no one single standard covers all these changes. Rather, there is an amalgamation of standards from several different bodies with each body responsible for one part of the new technology. Further complicating the issue is that releases of IE and Navigator occur at different times from each other and the standards. Pressure of market forces dictated the release of browser versions in some cases well before the standards were released and so not surprisingly their implementation in some areas of the standards are incomplete and differ considerably from one another (Goodman 1998, Boles and Siciliano 2000, Steinman 1998).
Standards relevant to DHTML include those covering HTML 4.0, Cascading Style Sheets, Document Object Model and JavaScript. HTML 4.0 substantially increased the number of tags available in HTML (Boles and Siciliano 2000, Piperoglou 2000). One of its aims was to distance the formatting of pages from the content\(^\text{11}\). Other aims include improving access for people with a disability and increasing support for other languages (Olsen 2000, Piperoglou 2000). Navigator 4 was released well before the scope of the standard was finalised and consequently its support for the standard is limited. On the other hand IE 4 was released later and has thus implemented much more of the standard (Goodman 1998, Piperoglou 2000).

Cascading style sheets (CSS) are one of the more exciting improvements in version 4 browsers. Goodman (1998, p.6) defines a style sheet as a “definition of how content should be rendered on the page”. Style sheets perform the same role as their counterparts in desktop publishing and word-processing packages, namely, separating the content of the page from the formatting of the page. The deployment of fine-tuned formatting and the positioning of page elements are simplified. An element or group of elements can be precisely positioned, hidden or shown from view, and moved around the page without disturbing other page content (Lie and Bos 1999). Both Netscape 4 and Internet Explorer 4 have similar implementations of most of the Cascading Style Sheets Level 1 (CSS1) recommendations, which covers the less dynamic aspects of style sheets and allows for style rules to be applied to HTML elements (Goodman 1998). Unfortunately, the positioning elements recommended by the Cascading Style Sheets-Positioning Workgroup (CSS-P) are implemented quite differently in the two browsers. While techniques to handle both variations exist, the page design is complicated considerably (Bradenbaugh 1999, Gould 1999).

Style is important. Shedroff (1994 p.14) has written, "All style has meaning, whether it is implied, accidental, or deliberate. Choosing the appropriate attributes and

\(^{11}\) For example tags for making text bold or red are deprecated as this is formatting information and belongs to a separate standardization effort related to content style (Lie and Bos 1999).
implementing them consistently is imperative to the development of a cohesive experience." Style sheets are an invaluable tool in helping to provide both this consistency and an appropriate effect. Many sites have a team of developers and style sheets help to ensure standards are maintained across the site. Maintenance is easier as global changes to pages are simple to make.

The last two standards covering Document Object Model (DOM) and JavaScript allow for scripting in pages. Put simply, DOM defines what parts of a page are scriptable objects while JavaScript provides the programming constructs needed to manipulate the objects. Internet Explorer and Netscape have almost identical implementations of JavaScript but, unfortunately, their respective DOMs are fundamentally different. Scripts need to take these differences into account if pages are to work in both browsers. This will complicate the code needed (Flanagan 1998, Bradenbaugh 1999, Goodman 1998, Heinle 1997, Gould 1999, Boles and Siciliano 2000, Steinman 1998).

The power of stand-alone multimedia applications can now be replicated on the Web through many types of plugins. However, as will be discussed in 2.5.3 Plugins Available, most plugins require specialist software and downloading plugin applications can be a slow, time consuming process. Basiel et al. (1999) propose client-side JavaScript as a fast, reliable alternative. The basic specification for viewing these examples is a Java-capable browser (e.g. version 4 and above) that is set to view graphics/animated gifs. Jones and Jo (1999) use JavaScript to add effective teaching and learning strategies to their pages.

As can be seen from the brief discussion of DHTML it offers great potential to Web pages but also great challenges. Goodman (1998, p. 12) advises "understanding and using the common-denominator functionality among the various pieces of DHTML". This coupled with scripting techniques to handle differences between the two browsers can lead to pages accessible from both (Boles and Siciliano 2000, Steinman 1998, Bradenbaugh 1999, Goodman 1998). It should be stressed that DHTML is only
available in version 4 plus browsers. Earlier versions still abound and to quote Goodman (1998, p. 13) further:

The imperative to upgrade rarely trickles down to all the users of yesterday's browsers. If you are designing Web applications for public consumption, coming up with a strategy for handling the ever-growing variety of browser versions should be a top priority.

These issues concerning differences between Internet Explorer and Netscape Navigator and their respective versions are among the most difficult for Web designers. In some cases a page will work successfully in an earlier version browser and in a later version browser but not in an intermediate version. Thus, even if designers follow Goodman's advice and use "the common-denominator functionality" it is still necessary to extensively test pages in as many different browser versions as possible (Boles and Siciliano 2000, Goodman 1998, Niederst 1998). With Internet Explorer clearly being the most popular browser, pragmatic considerations would suggest directing most effort at its versions.

2.5.2 Platform used

In the previous section the differences between various types and versions of browsers were discussed. Differences also exist between browsers developed for different operating systems such as Mac OS or Windows. Browsers are tailored to the individual operating systems. For example the HTML code for adding a button to a form is the same for both Mac OS and Windows but the button will be rendered very differently in both operating systems. This is deliberate, as browser makers have appropriately observed the traditions of the user interface look and feel for each operating system. Unfortunately for Web designers, it can create problems. For example, a form whose elements align correctly in a Windows operating systems may

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12 While there are clearly some risks in applying worldwide data to a local area such as the NT these were used as unfortunately the researcher could not find any similar statistics for the NT area.
look totally unacceptable when rendered in a Mac OS (Goodman 1998, Niederst 1998). Again, all designers can do is test their pages on both operating systems.

Another potential pitfall for designers is that the same browser brand and version may not behave identically across operating systems (Boles and Siciliano 2000). While Netscape 4 behaves consistently across different operating systems the same cannot be said for Internet Explorer 4. Microsoft itself acknowledges that some features will only work on Win32 operating systems (Windows 95, 98, 2000 or Windows NT) and other features, which should work on non-Win32 systems, do not (Goodman 1998). For example, style sheets and option buttons in forms do not always translate well to the Macintosh version of IE 4 (Shiran and Shiran 2000).

Web designers would obviously wish to direct their efforts to the most common operating system(s). Nua Internet Surveys (2000) reported in June 2000 that 93.63 percent of Internet users worldwide use a Windows OS product, 2.53 per cent of users use Macintosh products and about 3.5 per cent use another OS. Unless a developer has local statistics that suggest otherwise, these statistics would strongly support developing pages for PCs.13

2.5.3 Plugins available

Plugins extend the capabilities of a Web browser by providing extra features and enabling the display of proprietary file formats. Popular plugins include Flash and ShockWave from MacroMedia, QuickTime from Apple and Real Audio from Real.com. Some increased-functionality plugins can offer digital video, videoconferencing, digital audio and sophisticated animations. Plugins are available free over the Internet and the onus is on individual users to download them. Many plugins require users to have the right browser software, a suitable machine and a

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13 As stated in the previous footnote there is a risk in applying worldwide user data to a small site such as in this study. Apple has targeted the education market and thus among school children it is likely that the dominance of Microsoft is not so complete. Unfortunately as discussed in 4.1.2.3 Technical requirements obtaining statistics from the local context was not possible.
reasonable connection to the Internet to run successfully. When these conditions are met, they can be useful and enjoyable additions to a page (Niederst 1998, Gillespie 2000).

Gillespie (2000) advises:

The decision to introduce browser specific or plugin dependent elements into your Web pages should not be taken lightly. You should have a clear objective and target audience in mind. It is a shame if you lose readers because you have included some frivolous 'eye candy' that requires a plugin that they don't have and are not prepared to download it.

Numerous examples of problems with plugins have been reported. Basiel, Jones and Dudman’s (1999) experience with developing online educational material led them to recommend that "multimedia tools requiring special plugins" should not be used. Similarly, Willie et al.’s (1999, p. 156) experience with video clips was "The network bandwidth and currently available technology causes the download time to be lengthy, often exceeding a user’s patience". They attribute this finding solely to technical issues, as they found definite user interest in videos. Eastman (1999) provides another example of reported difficulties with using plugins.

One solution is not to use plugins for the central messages of the page. In this way the page will work for all users. If users can successfully access the plugin it is an added bonus. It should also be noted that producing files using plugin formats is skilled work. Time and costs involved can be substantial (Niederst 1998, Fleming 1997).

**2.5.4 Available screen space**

Monitors can show different amounts of information on the screen, which affect the way pages render on the screen. While monitors come in many sizes (e.g. 13", 14", 17", 19", 20", 21") the important measurement is the resolution or the number of pixels available on the screen. The higher the resolution, the more pixels that are available and thus the greater the information that can be displayed on the monitor.
Resolutions come in a range of standard values that differ between Macs and PCs (Bancroft 1997). A few of the more common settings are 640x480, 800x600, 1024x768 (Mac), 1024x870 (PC) and 1600x1200. Not surprisingly, the larger the monitor usually the greater its resolution.

Resolution determines the number of pixels in the screen space but not their individual size. Many monitors can be set to more than one resolution. For example if both a 21” and 14” monitor are set to the same resolution the pixels on the 21” monitor will be significantly larger than those on a 14” monitor. Thus on a 21” monitor set to 640x480 all the page elements (e.g. graphics, text etc) appear much bigger than on a 14” monitor set to the same resolution (Niederst 1998).

Resolution is not the only factor in determining the amount of available screen space for a Web page. A monitor’s resolution determines the total screen space available, but the actual space available to the Web page will be less as both the operating system and browser use some of the space to display their menu bar, title bar address bar and scroll bar. The exact amount taken varies according to the operating system and browser used. An individual user’s preference settings also play a part. Users can choose to have only some of the navigation options showing or may even choose to vary the size of their window (Gillespie 2000, Niederst 1998). Most Web designers design pages whose actual dimensions are considerably less than the monitor’s resolution (Bancroft 1997, Gillespie 2000, Niederst 1998). For example, the Web Policy for the Northern Territory University (2000) assumes for 640x480 resolutions the viewable area to be 600x300 pixels and for 800x600 resolutions 760x420 pixels.

As the number of pixels varies from user to user, the amount of information that can be displayed on a screen cannot be determined exactly. Page design strategies need to take this into account. Two such strategies used are flexible pages that resize and adapt to the various window sizes or fixed pages that are designed to a particular size. Flexible pages are more attuned to the philosophy of the Web and accept the reality
that pages will be displayed on a variety of monitors. The downside is that text lines can become very long and difficult to read and users will have varying experiences of the page, as the results are much more unpredictable. With fixed design, pages have a fixed width regardless of the monitor size or resolution and this largely solves the shortcomings experienced with flexible design. The pages will look the same regardless of the monitor used and the text lines will not become too long to read. Problems, however, do occur when the width of the page is larger than the width of the monitor. The user will need to horizontally scroll to view the whole page and this is universally condemned as it reduces usability. Fixed design is also very much against the general philosophy of the Web. Pages do not need to be simply designed according to either fixed or flexible design and many pages combine elements of both (Shafer 1998a, Niederst 1998).

If fixed page design is to be used, a page size needs to be chosen. Ideally it should be matched to the most common monitor resolution so as to suit the greatest number of people. PCs now sell with a standard monitor of 17" up from the 14" monitors of a few years ago. 17" monitors can handle resolutions of 600x800 as opposed to the 640x480 resolution used by 14" monitors. In mid-1998, Niederst (1998, p. 22) claims that many monitors in use "particularly by schools, households, or other institutions without the budget to upgrade" are still 640x480. Further while 17" monitors can be set to higher resolutions they are often set to 640x480 and many owners are unaware they can increase the resolution. She goes on further and states that the majority of Web designers advise a safety-first approach and design for 640x480 displays. This ensures that users should not need to scroll horizontally and helps to keep text lines at comfortable lengths for reading.

Obviously this advice will need to be continually reviewed and updated. By mid-1999, when this project was being undertaken 17" monitors had become more common. However 640x480 resolutions were still in use as reported by

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14 This was discussed further in the section 2.4.3 Qualities of well-written online pages
theCounter.com (1999) with 56 per cent of users visiting their site in November using monitors set to a resolution of 640x480. This figure is more likely to be an underestimation rather than an overestimation as theCounter.com site is dedicated to browser information and thus their users are interested in technology and presumably more likely to upgrade than the average user. This would suggest that for educational sites, whose users are likely to include some of the last to upgrade, designing for 640x480 resolutions would definitely be advisable.

This situation is rapidly changing. By September 2000, theCounter.com was finding only 8 per cent of its users used 640x480 resolutions (theCounter.com 2000a). In the local region by September 2000, the Northern Territory University (2000) Web policy required Web pages be designed to be functional only on monitors with resolutions of 800x600. Even while acknowledging that the 800x600 resolution had become the accepted minimum to design for, this policy still required navigational aids to be within the viewable area of 600 x 300 pixels. Thus even at the end of 2000, this policy still saw a need to still consider the old 600x480 resolution when designing Web pages in the Northern Territory.

2.5.5 Display of colour

Another difference between monitors is in how they display colours. The number of colours and the brightness of those colours vary significantly between individual monitors. The number of colours for example can range from 24-bit colour, which can show approximately 17 million colours, 16-bit colour, which can show approximately 65,000 colours, and 8-bit colour, which can show 256 colours (Niederst 1998). Colours from the 24-bit or 16-bit colour ranges shown on an 8-bit colour monitor will dither or appear speckled. To avoid this problem there is a palette of 216 colours, which appear in both the PC and Mac palettes, that will not dither on either PC or Mac 8-bit colour monitors (Bancroft 1997, Gillespie 2000, Niederst 1998). This palette is commonly known as the Web palette and by using only it for all
page elements will guarantee that colours do not dither on either Mac or PC displays\textsuperscript{15}.

Unfortunately, the number of colours available is not the only difference between monitors. Monitors also vary in the brightness of the display known as the gamma value. Typically, PC monitors are much darker (gamma value of 2.5) than Macs (gamma value of 1.8) so graphics which on Macs appear with deep and rich colours can look black on PCs and vice versa graphics created on PCs that display well can looked washed out on Macs. One strategy for overcoming this difference is to design graphics on a monitor whose gamma value has been set to 2.2. While graphics designed on such a monitor will appear slightly lighter in Macs and slightly darker in PCs they should look acceptable in both environments (Bancroft 1997, Niederst 1998, Gillespie 2000).

\subsection*{2.5.6 Display of text}

One of the uncertainties for Web designers is that they do not have control over the display of text on a Web page (Shafer 1998b, Gillespie 2000, Niederst 1998). All browsers use two fonts at least: a proportional font and a fixed-width font to display pages. The designer can specify additional fonts but these two fonts will always be available. The proportional font is used for the majority of text in a Web page and the fixed-width font for type within certain tags such as \texttt{<pre>}, \texttt{<tt>} and \texttt{<code>}. The difficulty for designers is that they do not know which fonts are being used or what size they are. Users can set both the fonts to use and the size of the fonts through methods as simple as setting browser preferences. Even if the majority of users choose not to do this, the default font settings vary across browsers and platforms (Niederst 1998, Gillespie 2000).

\textsuperscript{15}This may not be strictly true as Niederst (1998, p 29) notes "A phenomenon occurs on 16-bit displays colours that may cause the colours in your web pages to shift and dither. This includes colours that are 'web-safe' on 8-bit displays." She goes on to give examples of when this occurs and possible solutions for avoiding the problem but offers no explanation for why it happens.
Using style sheets or the `<font face>` tag\textsuperscript{16} allows designers to specify fonts and sizes. While this helps, it does not guarantee users will see pages the way designers wish. Browsers also can only display fonts that are installed on a user's machine and if a font specified is not installed the default font will be used in its place (Shafer 1998b). Unfortunately Macs and PCs have their own set of standard fonts and it is difficult to specify any one font that will be universally found (Niederst 1998, Gillespie 2000). At least a designer needs to specify a list of fonts to use. Users can still specify their own style sheet and so override the settings of the designer (Lie and Bos 1999).\textsuperscript{17}

This uncertainty is a design feature of HTML, which is a content markup language and not a desktop publishing environment. Users are supposed to be able to tailor their own environment to suit their individual preferences (Shafer 1998b). Many, such as Hendrickson (1999 p. 1083), advise as follows “Don't use HTML to create a page that cannot be reconfigured by the users to meet their needs. Use it to create pages that are proportionally structured so users are able to change font size and color.”

Font or type size also varies between Macs and PCs. Font sizes appear much larger on PC screens than on Mac screens. Gillespie (2000) notes that on monitors with resolution 640x480 a 9-point PC font is physically the same size as a 12-point Mac font when measured on the screen. Text that is easily and clearly legible on a PC may be hard to read on a Mac (Shafer 1998b). Care needs to be taken if it is to be ensured pages are legible in both platforms.

\textsuperscript{16} This tag has been deprecated in HTML 4.0 and thus its use is not recommended.
\textsuperscript{17} Both Netscape Navigator and Internet Explorer support technologies for embedding fonts in a web page. The font travels with the page and so it not necessary for users to have the font installed on their browser. Unfortunately the competing browsers have different technologies, which limits its usefulness (Niederst 1998).
2.5.7 Recommendations

Differences in users' software and hardware configurations are a major concern for developers. The pressure for lowest-common-denominator design is often outweighed by desire to assume larger displays, use more detailed and more numerous graphics and employ newer browser features. A balanced approach is needed and the following recommendations drawn from the literature constitute one such approach:

- Use fixed width pages designed for a viewable area of 600x300. This will help to ensure pages are easily usable regardless of monitors users have.\(^{18}\)
- Design graphics on a monitor with a gamma setting between the default for Macs and PCs (i.e. 2.2). This should ensure it looks reasonable on both platforms.
- Text should be at least 12 point so as to be readable on a Mac as well as a PC. Specifying fonts needs to be done with care as not only do Macs and PCs typically have different fonts loaded but also user preferences can overwrite any settings.
- Requiring a level 4 browser so that DHTML features can be included on pages is reasonable for an online course. Significant differences in DHTML implementations exist between Netscape Navigator and Internet Explorer. A strategy for dealing with these differences is using first the common features between the implementations and then using JavaScript to deal with some of the other differences.
- Plugins need to be used selectively, as not all users are prepared or able to download the necessary plugin. One strategy is not to use plugins for the main message but as extra for those able to access them.

Once pages have been developed it is essential to test them on as many different platforms and in as many different browser versions as possible (Bancroft 1997, Goodman 1998, Niederst 1998, Flanagan 1998, Boles and Siciliano 2000). Significant

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\(^{18}\) Note this recommendation was made for the end of 1999. As noted earlier this may no longer be appropriate.
differences exist between both versions and platforms. Testing should be directed at the most common platforms and browsers and worldwide that is Internet Explorer and PCs. However, figures are not readily available for the NT and care needs to be taken with using worldwide figures locally. If developers have specific information for their local users, pages should be developed that work best in that environment.

2.6 Issues in participant observation

Having looked at the literature pertaining to the developmental, educational and technical issues involved in developing and designing an online course in the Northern Territory, an appropriate methodology to be used in this study needed to be identified. The methodology chosen as most appropriate for this study was participant observation. This section briefly reviews the literature on participant observation and analyses its major advantages and limitations.

Providing a simple definition for the participant observer method is difficult as it is not really a single method but rather an amalgamation of methods and techniques (McCall and Simmons 1969; Zelditch 1969; Miles and Huberman 1994; Dean, Eichhorn and Dean 1969). McCall and Simmons (1969, p. 3, emphasis in original), for example, write:

\[\text{[P]articipant observer is most sensibly regarded, operationally, as the blend of methods and techniques that is characteristically employed in studies of social situations or complex social organizations of all sorts. ... That is, we shall view participant observer not as a single \textit{method} but as a type of research enterprise, a style of combining several methods toward a particular end.}\]

The blend of techniques used in participant observation (McCall and Simmons 1969, p. 1) involves some amount of genuinely social interaction in the field with the subjects, some direct observation of relevant events, some formal and a great deal of informal interviewing, some systematic counting,
Not surprisingly, given this description of participant observer method, the distinction between participant observer and other qualitative methods is not clear-cut. McCall and Simmons (1969, p. 1) themselves note, that some researchers would prefer to call their description field work and use the term 'participant observer' for "techniques in which the scientist virtually performs the role of a genuine member and counts as very critical data his resulting subjective experiences, which provide leads for interviewing his fellow participants". Smith (as cited in Miles and Huberman 1994, p. 1) sees the terms 'participant observer', 'ethnography', 'field methods', 'qualitative inquiry', 'case study', 'naturalistic methods' and 'responsive evaluation' as having become practically synonymous.

The use of qualitative methods, such as the participant observer method, has increased substantially in recent years (Miles and Huberman 1994). While researchers may wish to be as rigorous as possible, quantitative methods are not always applicable or appropriate (Dean et al. 1969). Qualitative data allows for the chronological flow of events to be maintained, consequences of particular events recorded, case histories of an individual, an organisation or community detailed, and pilot inquiries into new problem areas where the purpose is the production of hypotheses rather than the verification of them (Dean et al. 1969, Miles and Huberman 1994). While participant observation can offer strong potential for testing hypotheses and seeing whether specific predictions hold up (Miles and Huberman 1994), it is more commonly an empirical application and modification of a particular theory (McCall and Simmons 1969).

Prior to fieldwork, participant observer research design often does not have a fixed shape or conceptual design. The conceptual framework and research questions may emerge as the study progresses (Strauss, Schatzman, Bucher, Ehrlich and Sabshin 1969; Miles and Huberman 1994). Research can be frequently redirected on the basis of data gathered from the field. As hypotheses emerge, data collection can be directed
towards finding supporting evidence and clarification (Dean et al. 1969, Zelditch 1969, Strauss et al. 1969). To achieve this, informants are often not treated uniformly but instead are interviewed about the things they can illuminate most. Statistical treatment of the collected data is not usually a major concern. Instead, researchers aim "to make the most of the individual peculiarities of the situation" they find themselves in (Dean et al. 1969, p 20). An advantage of this constant reformulation of the research problem is that the effect of inaccurate prejudgments can be limited and misleading and meaningless questions prevented (Dean et al. 1969, Strauss et al. 1969). As researchers better understand a situation they can constantly modify their analysis to suit the situation and reflect it appropriately. Unlike with more structured methods, researchers are freer to move between the data collection and analysis stages (Dean et al. 1969, Miles and Huberman 1994).

The relationships researchers establish with informants are very important if data is to be successfully elicited from informants. Information relating to private or confidential matters is unlikely to be shared with researchers unless the informants trust the researchers. By easing themselves into the situation slowly, researchers can hopefully build trust with informants and hopefully avoid blundering into delicate situations (Dean et al. 1969). If effective relationships can be built, the possibility for understanding latent, underlying, or non-obvious issues is strong. The data is collected in close proximity to a situation and so is embedded in its context as opposed to say a survey that has been conducted over the phone or by mail. The resulting data should be both rich and holistic (Miles and Huberman 1994). In these circumstances the impressions of the researcher can be more reliable for classifying data than rigid indexes on a survey and the researcher may be able to impute motives more validly than with other methods. Difficult-to-quantify variables may be less distorted by unstructured observation and interviewing than by inaccurate attempts to operationalise them for use in a survey (Dean et al. 1969).
While the participant observer offers many advantages and is well suited to some studies, there are issues which limit the approach. Miles and Huberman (1994, p. 2) write:

> These issues include the labor-intensiveness (and extensiveness over months or years) of data collection, frequent data overload, the distinct possibility of researcher bias, the time demands of processing and coding data, the adequacy of sampling when only a few cases can be managed, the generalizability of findings, the credibility and quality of conclusions, and their utility in the world of policy and action.

The reliability and validity of such qualitative findings can be seriously doubted (Miles and Huberman 1994, McCall and Simmons 1969). The likelihood of bias by researchers is a major limitation. The research problem is constantly being reformulated and reviewed as data is collected, and so there is a danger that a researcher will guide the inquiry in accordance with incorrect impressions or misunderstandings gained from informants. These may direct the researcher away from data that points in another direction (Dean et al. 1969). Determining the representativeness of the findings and data collected is equally problematic as only part of the population is sampled (Zelditch 1969, Dean et al. 1969). The personality and characteristics of an individual researcher will also influence not only the type and strength of relationships he or she forms but also his or her interpretation of the data supplied (Schwartz and Schwartz 1969, Dean et al. 1969). The researcher too is part of the context being observed and so both modifies and influences this context (Riecken 1969).

Methods of analysis are not well formulated and there are no clear conventions that the researcher can use (Miles and Huberman 1994, McCall and Simmons 1969). Miles writes (as cited in Miles and Huberman 1994, p. 2, emphasis in original):

> [T]he analyst faced with a bank of qualitative data has very few guidelines for protection against self-delusion, let alone the presentation of unreliable or invalid conclusions to scientific or policy-making audiences. How can we be sure that an “earthy,” “undeniable,” “serendipitous” finding is not, in fact, wrong?
While these analysis problems are being addressed more seriously and methods for qualitative analysis are advancing, these concerns still loom large. Where possible, researchers should use explicit, systematic methods to draw and test conclusions. These methods need to be "credible, dependable, and replicable in qualitative terms" (Miles and Huberman 1994, p. 2).

Another issue that each individual study needs to address is the degree of flexibility that should be present in his or her research design. The greater the flexibility the more researchers can be receptive to local idiosyncrasies and reformulate the problem as they go. Conversely, with greater flexibility collection of data is less selective and everything can look important at the outset while the researcher is waiting for the key constructs or regularities to emerge from the field. Researchers may become overwhelmed with data and not have the necessary time or resources available to sort it in a meaningful way. With multiple-case research the lack of a common framework and instrumentation will also make comparability across cases problematical. Designs with restricted flexibility face the opposite problems. While their data collection and analysis is likely to be more economical, comparable and possibly generalisable, they are less sensitive to the local idiosyncrasies and may involve bending data out of contextual shape to answer cross-case questions. Researchers need to determine the design most suited to their situation and resources (Miles and Huberman 1994).

In conclusion, Zelditch (1969, p. 19) notes that, "the objective of participant observation studies ... dictates the use of several techniques, each of which is especially suited to obtain particular types of information". The researcher needs to give the facts of the situation every chance to guide his or her interpretation of the situation. However his or her findings and conclusions must be justifiable and convincing to others. In Miles and Huberman's (1994) words the use of "credible, dependable and replicable" methods in "qualitative terms" will help enormously with this process.
2.7 Conclusion

This chapter has reviewed the major issues that need to be considered when online courses are developed. These included examining the telecommunications infrastructure in the NT, pedagogy, instructional design, navigation and technical issues in developing Web pages. The emphasis of the review was on transforming an existing print-based course online. The final section of the review considered the methodology for a participant observation study. The next chapter will explain how the methodology was used in this particular study.
CHAPTER THREE

DESIGN OF THE STUDY

The last chapter reviewed the major issues that should be considered when Web-based courses are developed. Given the number of factors and issues that require consideration, the need for a pilot study becomes apparent.

This chapter details the design of that study and gives the justification for the methods and procedures used. The chapter has been divided into six sections:

3.1 Methodological approach
3.2 Locale of the study
3.3 Data collection methods
3.4 Collecting the data
3.5 Data analysis
3.6 Limitations

As a point of notation the module created during this pilot study will be described as Web-based rather than online. The module used web technologies in its creation but due to the poor telecommunications infrastructure was delivered using CDs rather than the Internet. This decision and its implications are covered in later chapters.

3.1 Methodological approach

Given the mixed nature of this study, which covered both technical and educational issues, a flexible research methodology that coped with the somewhat unusual nature of the study was needed. A combination of both qualitative and quantitative measures was felt to be more likely to give an accurate and informative description. For these reasons the methodologies chosen as most appropriate for the design of this study were participant observation and educational evaluation.
3.1.1 Participant observation approach

Dean, Eichhorn and Dean (1969, p. 20) list "pilot inquiries into new problem areas where the purpose is the production of hypotheses rather than the verification of them" as among the "most frequent uses of observation and interviewing". This study falls clearly into this category, as its purpose was to investigate how courses could be converted online successfully and whether it would be possible to develop a template or method for converting other courses online.

As discussed in 2.6 Issues in participant observation, the participant observation methodology allows for a flexible research design. With this study the aim was the "production" rather than "testing" of hypotheses and so the ability to redirect the research as data was gathered was important. For example, it was inappropriate to finalise the design of the evaluation of the Web-based module before its format and appearance were determined. As the study progressed and the issues were better understood, the evaluation was modified to fit the situation.

A participant observer approach was also appropriate, as the purpose of this study was to understand the underlying issues and idiosyncrasies particular to one site (Dean et al. 1969), i.e. the NTOEC's situation. Statistical treatment of data was not required as this was a qualitative study. This methodology also allows for the collecting of data that is rich and in context and so helps the researcher in correctly understanding and analysing the experiences and achievements of students and staff involved in the study (Miles and Huberman 1994).

Qualitative approaches can also allow for the greater involvement of the subjects in the study. They can become involved in the design of the study, identifying the process and assigning value to the endeavour (Popkewitz 1984). Members of the NTOEC initiated the study and actively contributed to the shape of the study. This was especially true in the early stages of the study.
The role of the researcher as a participant observer can vary considerably. Gold (1969) provides a description of four possible social roles for a fieldworker: complete participant, participant-as-observer, observer-as-participant, complete observer. In the case of a complete participant the true identity and purpose of the researcher is not known to the informants. The participant-as-observer is similar to the complete participant but, significantly, the informants are aware there is a field relationship. The observer-as-participant role is used in studies involving one-visit interviews. Finally, in the complete observer role the researcher has no social interactions with the informants.

During this study the researcher's role changed as the study progressed and did not always fit neatly into Gold's description. At the start the researcher was the developer and designer of the module. In this role, the researcher was the instigator of change. The researcher's necessarily subjective experiences were critical data. In terms of Gold's description, the researcher began in the role of a participant-as-observer. When the course was run and the various informants interviewed, the researcher's role started to become that of an observer-as-participant. The researcher's role was dynamic and in a way reflected the change in the study itself as it moved from a development to an evaluation.

Disadvantages associated with adopting a qualitative approach, such as participant observation, include the difficulties in trying to ensure reliability and validity. These problems and the way they were addressed will be detailed in 3.3 Data collection methods.

In sum, this study was well suited to the participant observation methodology. It provided both the flexibility needed in the research design and could accommodate the use of several different techniques for obtaining information. However, to make the results justifiable and convincing to others it is necessary to use credible and dependable methods that are clearly explained. The following sections in this chapter will elaborate on these methods.
3.1.2 Educational evaluation

The design of an evaluation study in education can take many possible approaches such as "qualitative or quantitative, survey or experimental, goal-based or goal-free, process or product-oriented and/or portrayal or measurement" (Devlin 1989, p. 38). Many excellent methodologies based on one or some of these approaches have been developed. The methodology chosen for any particular evaluation will depend heavily on the subject and purpose of that particular study.

For this study, a goal-based evaluation based on the objectives model with both qualitative and quantitative aspects was seen as most useful. Among the many methods proposed, the most useful approach found was that by Higginson (1990) for evaluating externally assisted projects in education.

Higginson's (1990) instrument stresses the need for the system analysis to consider a project in its totality. So, while each of the project components needs to be assessed in sequence, the interdependence of all the components must also be considered. The project's place in the larger community is also an issue. Thus the performance of a project in relation to the goals of the larger society as well as its own goals needs to be evaluated.

The design of the evaluation is centred on the project objectives that are either developmental or immediate objectives. The developmental objectives state what the project expects to accomplish "as a contribution to a large sectoral development effort requiring a substantially longer time to achieve the expected results" (Higginson 1990, p. 38, emphasis in original). In comparison, the immediate objectives state what the pilot project expected "to accomplish by itself (that is only with its own resources) and within the time frame allowed for the implementation of its activities" (Higginson 1990, p. 38, emphasis in original).

To measure a project's success in achieving the objectives, performance indicators are used. Performance indicators can be either qualitative or quantitative. Good indicators
are readily accessible and so can be measured, are problem specific and so relate to a project objective, are unequivocal and so not open to multiple interpretations and finally they are hard to manipulate and so cannot be subjectively interpreted (Tognolini 1991). Indicators should also measure degrees of achievement. For example, an all-or-nothing indicator such as "the school opened" needs to be avoided.

Once the objectives and indicators have been established the notions of internal efficiency and external productivity can be used to evaluate the project's success. Internal efficiency refers to the degree of correspondence between the project's immediate objectives (what it wanted to produce) and its output (what it did produce). External effectiveness or productivity looks at the extent to which "there [is] a cause and effect relationship between what the project produced in the way of outputs and the resolution of given development problem which we presume to be the project's real objectives" (Higginson 1990, p. 5).

Internal efficiency is much easier to assess than external effectiveness. In any consideration of external effectiveness it has to be remembered that the impact of the project is generally not felt immediately. In general, the broader the objective, the longer it can take for the impact to be felt. Another difficulty is that no project works in isolation and there will usually be influences outside the project scope that cannot be controlled. Thus, detecting a clear cause and effect for any observed changes can be difficult. Given these difficulties in obtaining direct measures of impact, utilisation is often used as a proxy indicator. The assumption here is that if an output is utilised then there is a "reasonable" chance that a project has achieved its desired impact.

Assessing the impact of a project also requires that long-term results and unforeseen results also be considered. Long-term results are not always what were expected. For example, a project aimed at training can be a failure at the time it was first evaluated but years later it may start to have an effect. Unforeseen results can occur when a project is used in a way not initially envisaged. The change may be good and could lead to a change in the objectives for the project. However, these changes need to be
carefully assessed to ensure the project still solves the initial problem and that the solution is the most efficient available.

In all evaluations, bias is an issue that needs to be considered. The choice of which information to collect during an evaluation is not random but rather is driven by specific questions. These questions define the scope of the evaluation and will reflect the point of view of those who established the evaluation's design. Issues of bias in data collections that were raised in the previous section on participant observation are also largely applicable to evaluation.

The problem with confounding variables has already been raised. No project works in isolation from its environment. While an evaluator will always try and be aware of extraneous factors, often the assumption that any observed changes are due to the project has to be made.

3.2 The locale of the study

Before looking at the how and why the data was collected, the environment or context of the study is described. The site, informants and researcher are introduced and the reasons for their selection explained.

3.2.1 The site

As mentioned in the introduction, the Northern Territory Open Education Centre (NTOEC) is located in Darwin and has responsibility for providing secondary-level distance education to students in the NT. It is one of many secondary schools operated by the Northern Territory Department of Education and was established twenty years ago as the NT Secondary Correspondence School. The NTOEC's
experiences and modes of operation are similar to other distance education centres. On its Web site (NTOEC 2000) the NTOEC defines its role as,

[T]o provide secondary education for students unable to attend other schools, and to extend the curriculum available to students attending other schools. Students may enrol as full-time or part-time students and may be school-age students or students beyond compulsory school age.

Currently, course materials are predominantly sent out by mail and students mail back their work after completing each unit of work. Teachers then mark the work and mail their corrections back. Students have a supervisor who is usually one of their parents. It is the supervisor's role to ensure students keep up with the work. Completion of the required work can be a problem.

Each student normally undertakes a number of subjects. In Year 8 one of these is Science and it is organised into eight five-week modules. Students are only required to complete the first six of the modules and the last two are extension work for the quicker students. This organisation is typical of many NTOEC subjects. The task for this study was to take the third of these five-week modules, Matter, and to transform it into an online module.

Prior to this study, the NTOEC had not written or run any online courses. During 1999, a Web site for the organisation was created. So far, however, it has been used more as an information source rather than actively supporting the delivery of their courses.

The choice of NTOEC as the site for this study was necessary as it is the only institution in the NT providing secondary school distance education. Stenhouse (1988) notes that many case studies are opportunistically set up and this was clearly

1 See 1.1 Background to the problem for further information.
the case for this study. There were in addition other advantages:

- The supportive approach taken by the NTOEC to the project: Before the start of the study, the NTOEC staff were already keen to investigate developing Web-based courses. As discussed in 1.1 Background to the Study, educational, strategic, administrative and economic reasons for doing this had already been identified. A small amount of funding\(^2\) was also available. Some of the teachers involved with the study were also friends and acquaintances of the researcher. Accordingly, the staff at the NTOEC were open and receptive to the researcher and this limited the time needed at the start of the project to become accepted. Frequent access to the participants was also made easier and allowed for appropriate follow up and confirmation of detail.

- NTOEC was a “fairly typical” distance education centre: As was demonstrated in 1.1 Background to the Study, the NTOEC shared many features in common with other distance education centres around Australia. While there was no certainty, it was hoped that any findings from this study would be of value to other similarly situated organisations.

The choice of subject was made by the NTOEC. The Science staff were enthusiastic about the study. Year 8 is the first year taught at the NTOEC and the age group was seen as appropriate. There were no external pressures such as exams and it was felt the students were at an age where they were likely to be enthusiastic about using the technology.

The particular module chosen for Web-based development was the third in a series of modules undertaken by Year 8 Science students. It was a basic chemistry unit called

\(^{2}\) The amount of funding was $2000 and as will become apparent in the next chapter, while obviously useful, it was a drop in the ocean.
The choice was dictated by mainly pragmatic considerations. The first two modules were not considered suitable. The first module is the students' first experience with the NTOEC, and it was felt desirable that students had a chance to settle into distance education study and that any teething problems were resolved before students attempted the Web-based module. The second module has a very high practical component and was not seen as typical of the modules or particularly suitable for Web-based development. Matter, the third module, fitted into the timing scheme for both the author and the NTOEC. It was hoped students would complete it, before coming in to Darwin for a week's residential course. This would help with the evaluation.  

3.2.2 The informants

The informants in this study involved some of the staff of the NTOEC, students in year 8 Science and the researcher.

3.2.2.1 Staff at the NTOEC

The staff at the NTOEC who participated in this study included the Head of the Science department, two senior science teachers, the writer of the print materials the Web-based module was based on, another science module writer, the two teachers responsible for delivering the module to the students, a visual designer and the senior teacher of information technology. All the staff involved were experienced teachers and some had considerable experience with distance education. However, with the exception of the senior teacher of information technology and to a lesser extent the visual designer, the staff's experience of technology was as users. For all of the staff involved, their only experience of using the online environment for teaching was email and indicating useful sites on the Web to their students.

3 As discussed in 5.3.3 Time taken and completion rates for the module this did not eventuate.
From the initial stages of development through to the creation of the Web-based module, the Head of Science, a senior science teacher and writer of the print materials were primarily involved. Two of these had or were currently teaching the module to be transformed. Once the module was being trialed another senior science teacher, another writer and the visual designer also became involved. The senior teacher of information technology was primarily involved at the distribution and running of the module though he was contacted at the very early stages of the project. When the Web-based course was running the two teachers responsible for delivering the course and looking after the students were the main informants. The researcher had little control over when and which members of staff were involved in the study.

A coding system of T1, T2 etc. was used to identify the teachers.

3.2.2.2 Students of Year 8 Science

The number of students in the lower secondary years at the NTOEC is not large. The average size of a class is between about 10 to 20 students. However, within these groups the students’ backgrounds, past school experiences and abilities are often quite different. The student groups are also constantly changing with students joining and leaving NTOEC. The length of time students study with NTOEC also varies greatly. A few may do all their schooling through NTOEC but for most their time with NTOEC is much more limited. It can be as short as a term or even weeks if a student’s circumstances change suddenly.

The students who participated in this study were those completing the Year 8 Science course. They were divided into two classes taught by different teachers. The number of students who completed Matter and so were involved in this study is given in the Table 3.1.
### Table 3.1 Student numbers

<table>
<thead>
<tr>
<th></th>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>12</td>
</tr>
<tr>
<td>Class 2</td>
<td>8</td>
</tr>
</tbody>
</table>

Number of students who completed the print or Web-based version of *Matter*

The actual number of students who were enrolled at some stage in each class is larger. However, as these students did not attempt the *Matter* module in either format, they were not included in the study.

The students' physical locations were diverse. Seven were located in or close to centres such as Darwin, Alice Springs or Katherine. Eleven were spread to all comers of the Territory in locations such as Papunya, Borroloola and Roper Bar. Out of these eleven, three of the students lived at one location. The last two were travelling with their families.

#### 3.2.3 The researcher

As has been discussed earlier, one of the limitations of the participant observation methodology is researcher bias. Not only does the researcher bring his or her own personality and subjective viewpoint to the study but as part of the context being observed the researcher will both modify and influence the context as well (Miles and Huberman 1994, Dean *et al.* 1969). This is particularly true for this study, where the researcher was actively involved in instigating the change. Accordingly, it is pertinent to give a brief description of the researcher and the role she undertook in the study.

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4 In almost all cases, these students enrolled but never sent any work in.
The researcher was both the Web-based materials developer and a postgraduate student observing the processes and the issues at stake. As such, she participated in all stages of the Web-based module development. In consultation with the teachers at the NTOEC she determined the requirements for the module and then was responsible for its design, implementation and evaluation. Throughout the study, she was in regular contact with the staff and students of the NTOEC and thus was in a good position to observe and record the development and use of the module.

The researcher’s qualifications and experience were in favour of using such an approach. Her qualifications include an honours degree in Information Technology and she has over five years commercial experience in the Information Technology field. Her commercial experience had involved the development of software packages from initial requirements to the implementation stage. On the education side she has taught for five years in secondary schools. While this teaching experience had not included the use of online courses, it had involved the use of the Web and other technologies in the delivery of her courses.

3.3 Data collection methods

Having described the context of the study, this section details the methods used to collect the data. The next section will identify the data collected and detail the data collection procedures used.

In order to explore fully the research questions for this study, it was considered important to collect both factual information about the events, problems and issues that occurred and also the researcher’s and informants’ accounts of their experiences. A diverse range of methods was needed to gather these different types of information about the Web-based module at all stages of its development and delivery. Accordingly, the following data collection methods were chosen as appropriate for this study: reflection of the process, field notes taken of meetings and conversations
with informants, interviews, questionnaires, direct observation and written documents.

It should be noted that the study could not use techniques such as server logs or online questionnaires. To overcome the problems with the telecommunications infrastructure used by the students\(^5\), the module was distributed on a CD. Technical issues\(^6\) prevent Web pages stored on a CD or on a local machine readily writing to a file. Thus user logs giving detailed quantitative data on file accesses and pathways of use were not possible. As will be elaborated in greater detail, this infrastructure and students' level of technical skills made online data collection methods inappropriate.

The choice of data collection methods was made in order to increase the reliability and validity of the study. As was identified in the literature review, a major disadvantage of qualitative methods such as participant observation is that, due to the necessarily subjective nature of the methods, the reliability and validity of any findings are open to question\(^7\). Reliability of research "concerns the replicability and consistency of the methods, conditions, and results", while validity "deals with the accurate interpretability of the results (internal validity) and the generalizability of the results (external validity)" (Wiersma 2000, pp. 8 and 9). Reliability is a necessary characteristic for validity and essentially the two together establish the credibility of a study (Wiersma 2000).

For this study, external validity and reliability would be difficult to establish given the small size of the study and the individual nature of the module, site and informants. Internal validity and reliability were, however, important to consider. Internal validity is the degree to which the study reflects a clear, representative picture of a situation (Miles and Huberman, 1994). Internal reliability requires ensuring that the

\(^5\) See 2.1 Telecommunications infrastructure available in remote and rural areas of the NT for more details.

\(^6\) See section 4.2 Hardware and Software selection for further details.

\(^7\) While reliability and validity are usually easier for the quantitative researcher, Dobbert (1982) maintains that absolute validity and reliability cannot be obtained in any science.
observations made are not unduly biased by the nature and characteristics of the observer, instrument or informant or by the constraints of time and place. Reliable observations are those any similarly situated observer would make (Miles and Huberman, 1994).

When designing this study an attempt to achieve the most internally valid and reliable data possible was made. Consequently, triangulation or the collection of data from a range of sources to give several frames of reference or perspectives was seen as important. As McCall (1969, p. 130) writes,

The key to data quality control in participant observation is, thus, the thorough use of multiple indicants of any particular fact and an insistence on a very high degree of consonance among these indicants, tracking down and accounting for any contrary indicants.

Frequent contact with informants and the site over a period of time can also help support validity claims (Miles and Huberman 1994). The researcher’s links with different members of staff at the NTOEC extended over a period of approximately 18 months though the level of contact varied considerably depending on the stage of the project. For example, during the creation and testing phase contact was up to several times a week. Conversely, at other times such as in the early stages of investigation or school holidays there were periods of four weeks where there was no contact. The researcher’s contact with students was over a much shorter period of time.

The findings of this research were also compared to other research findings and discussed with the staff at the NTOEC. This peer examination and corroboration of findings by informants and other researchers in similar settings can help support validity claims (McCall and Simmons 1969, McCall 1969, Miles and Huberman 1994, Wiersma 2000).

Other measures taken to decrease the risks to internal validity and reliability are detailed below as each individual data collection method is described.
3.3.1 Reflection on the process involved

The researcher was the developer of the Web-based module and hence her own experiences and reflections on the development were chief sources of data on the issues and processes involved in the creation of the Web-based module. These reflections tended to be factual in nature and recorded the events, problems and decisions that occurred. While some bias will inevitably occur, the factual and descriptive nature of the data help to limit its effect.

In many ways it was the decisions themselves taken by the researcher as the developer of the module that were much more likely to be subjective than the researcher's reporting of them. As with any development, there were several different options that could have been undertaken and the process of choosing one of these options is a matter of judgment and therefore subjective. Following good developmental practices these decisions were taken with the active involvement of the stakeholders, in this case the NTOEC, and with reference to sound information technology and educational principles.

3.3.2 Field notes taken of meetings and conversations

During the project, the researcher had various meetings, telephone conversations and exchanges of email with the informants. Notes were taken during both the meetings and telephone calls. Requesting informants to confirm observations and interpretations can decrease the risks to internal validity (Miles and Huberman 1994). Notes of some meetings with NTOEC staff were shown to the participants for confirmation. With the telephone calls, the researcher repeated back some information to informants. It was felt that requesting confirmation of all notes would have strained the researcher's relationship with the informants and so this technique was used only judiciously. As noted earlier, some of these relationships were over a period of 18 months and this helped to limit misunderstandings.
3.3.3 Interviews

Interviews were used as they allowed for greater flexibility than a structured questionnaire. The interviews were organised to allow the informants to discuss the things they thought were important, rather than the researcher alone determining everything that should be discussed. Becker and Geer (1969, p. 323) write:

[T]he interviewer explores many facets of his interviewee's concerns, treating subjects as they come up in conversation, pursuing interesting leads, allowing his imagination and ingenuity full rein as he tries to develop new hypotheses and test them in the course of the interview.

The researcher had a set of open-ended questions that were used if the voluntary information offered by the informants was limited or not closely related to the study.

The interviews allowed for the researcher to elaborate on the purpose of the study or explore any questions that were not clearly understood by the informants. Given the age of the students, this was an advantage. For instance, changing the question around, rewording it or generally elaborating on it when an informant did not understand, made it possible to explore issues in greater depth.

The aim had been to tape record all the interviews to ensure complete accuracy and so further enhance credibility. Unfortunately, an accident to the tape recorder at the start of one set of interviews meant this did not always happen.

3.3.4 Questionnaires

An advantage of using questionnaires is that they are very economical (Wiersma 2000). This study used two questionnaires that are listed in Appendix A. One was used to determine the equipment students were using, the level of access they had to equipment and their level of technical ability. The items asked were factual in nature. Care was taken to avoid technical language or jargon as far as possible. The second was designed for students to complete after they had finished the Web-based module. The aim of the questionnaire was to provide the researcher with some initial feedback.
that could be explored in greater depth in an interview situation. The questionnaires were developed by the researcher and given to staff members at the NTOEC for comment. Where appropriate, their feedback was incorporated into the final design.

3.3.5 Direct observation

Direct observation of the student and staff using the module was also used. This allowed for the collection of data on how the module was used and the way the informants interacted with it. Telephone conversations with informants when problems in using the module arose also provided some insight into its usage.

A disadvantage with this approach is that researchers can fall into the trap of finding exactly what they set out to find. There are often massive amounts of material available to the researcher and selecting the most significant material can be subjective and arbitrary (McCall and Simmons 1969).

To limit, as far as possible, the bias in the data, the researcher tried to cross-check her data as much as possible. When the students were observed using the module, teachers from the NTOEC were also present. This allowed the researcher to check her observations with other observers. Over the telephone, the researcher addressed some of the problems students or teachers had and these discussions tended to be technical or factual and so less prone to bias.

3.3.6 Documents

The print-based modules, NT Science curriculum documents and documents relating the print module to the NT curriculum were important sources of information in the development of the Web-based module. Class rolls, student details and achievement were also collected.
3.4 Collecting the data

This section describes how the methods detailed above were used to collect the data. The focus of the investigation was on the development of the module from inception to evaluation and so each of these stages was explored: initial negotiations and agreement, requirements investigation, materials design, materials development and testing, implementation and evaluation.

It should be stressed that this was a pilot study investigating the possibilities of using the Web for Junior Secondary distance education students in the Northern Territory. Throughout the project, the process followed and any problems or successes were documented. This was an essential part of the evaluation. The final evaluation investigated students', teachers' and the author's lasting impressions and experiences of the module.

3.4.1 The development methodology used

Before looking at the collection methods used throughout the development of the Web-based module, a development methodology needed to be established. The approach to course development and instructional design taken in this study combined elements of the three models proposed by Benyon, Stone, and Woodroffe (1997), Ellis, Torokfalvy and Carswell (1998) and Bell and Lefoe (1998). Details of these models were discussed in 2.3.2 Developing an online course.

The design and development of the Web-based module started with determining the strategy for developing the module. Information on the requirements and the resources available to develop the module was gathered. This corresponds to the first step in Benyon et al.'s (1997) model of courseware specification. This information was then used to define the framework for the module. Ellis et al.'s (1998) process of breaking the content into topics was followed here. The navigation for the module was then designed and the navigation tools, site maps, templates and the front-page developed.
Attention then turned to the instructional design and the development and design of the materials. Bell and Lefoe's (1998) more integrative approach was found informative here. In this model, the learning outcomes and student profiles drive the design and the other four elements in the model teaching and learning methods, media decisions, assessment and evaluation are seen as interacting with and influencing the design of each other. In this study's course development there was an additional element of the print materials to consider. Using this approach, a prototype for the units or individual lessons was developed. The individual pages were then written.

Having developed the module, the last stages were those suggested in Benyon et al.'s (1997) model of testing and evaluation. In any Information Technology project testing is never really over. There is always one more test that could be run or a new combination of factors that needs to be tried out. For Web pages this is particularly true due to the significant differences that occur between different user configurations of software and hardware. There is almost certainly a new browser release, a current browser version or platform that the pages have not been tried in. Some of these were discussed in 2.5 Technical considerations in implementing an instructional design. For this project testing stopped when, with the few exceptions mentioned, the pages worked successfully in ten different browsers tried on both PC and Mac platforms.

The final steps were the delivery and evaluation of the module. The course was distributed to the students with some preliminary explanation. The section 3.4.4 Delivery and evaluation of the Web-based module explains this process in more detail.

3.4.2 Developing the strategy: Initial negotiations, requirements investigation and designing the framework

Through a mutual friend, the researcher and the NTOEC were put in contact in mid-1999. The NTOEC was keen to put a module online and the researcher was looking for a project in this area. During the first couple of meetings the purpose of the study was clarified and the scope for the project set. The agreement was informal and the
scope necessarily included a degree of flexibility, as the area was new to both the NTOEC and the researcher. Throughout this first stage the staff involved were the Head of Science, a Senior Science teacher and the writer of the print materials (who also taught Year 8 Science).

Once the study had been agreed on, a requirements analysis was undertaken. The data collected included:

- **The pedagogical requirements**
  The learning strategies for the module and the requirements of the NT curriculum were gathered from course documents, curriculum documents relating to the module and the informants mentioned above. Research into constructivist learning environments was also needed.

- **The practical requirements**
  These included the operational, administrative and course considerations of the NTOEC and information on these was gathered from the NTOEC.

- **The technical requirements**
  These included the telecommunications infrastructure, equipment and computer literacy skills of both the students and the teachers. Teachers of Year 8 Science and the Information Technology teacher provided most of the information. While this was likely to be accurate for staff, determining the students' level of technical knowledge this way was more problematical. Year 8 is the first year students enrol with NTOEC and the intake for 2000 was not known in 1999 when this investigation started. The 1999 enrollment could have been surveyed to determine the likely level of skills of the 2000 intake. However, as time was limited and the NTOEC teachers felt confident of predicting the computer literacy skills of the students, no survey was done. When students were surveyed these estimates
proved reasonably accurate. Recent reports reviewed in 2.1 Telecommunications infrastructure available in remote and rural areas of the NT were also important reference data. It was also determined at this point that students who did not have access to a suitable computer would undertake the print-based module.

One of the important requirements of developing either an educational or a software package is to identify the intended audience (McKilim 1990, McInerney and McInerney1998, Horton 1994). While not specifically mentioned above, this data was gathered across all three categories.

Once the requirements were known, an overall framework or strategy for the Web-based module was developed. The researcher's reflection and recording of the design issues and processes involved at this stage was a chief source of data. Another source was the invaluable comments and suggestions made by the teachers at the NTOEC and the staff involved in the CUTSD R&D Project: Facilitating flexible online teaching using structured frameworks, at the Northern Territory University. Both groups had input into the design and commented on any proposed designs.

### 3.4.3 Materials design, development and testing

Following the completion of the framework design the researcher created the Web-based module. During this time, her reflections on the work, time and resources involved were recorded. Comments by informants were also noted. Through the development process the researcher had opportunities to observe the staff of the NTOEC using the module. This also provided important feedback.

As materials were developed they were shown and trialed by the informants at the NTOEC. At this time, in addition to the three staff already involved, another writer, a senior science teacher, visual designer and IT manager also became involved. An

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8 As will be seen, technical issues were a real issue for the online module. However whether a survey of abilities before the course, would have helped to alleviate these problems is debatable. For further
instructional designer from the university also provided feedback on the initial design. The Web-based module was created over the Christmas holidays to a tight timeline. With these restrictions and the physical isolation of many NTOEC students, formal trialing by a group of NTOEC students was not feasible. Instead two 13-year-old friends of the researcher were used. Comments and suggestions made were noted and incorporated into the final design.

3.4.4 Delivery and evaluation of the Web-based module

The final stage was the delivery and evaluation of the Web-based module. A CD with the Web-based module was mailed to each of the students. The students, or at least a sizable number of them, come into Darwin once a year for a residential school. It had been hoped that by the time this residential school had taken place, the students would have completed the module or at least be a significant way through it. This would enable the researcher to organise face-to-face interviews with the students to evaluate the module.

A brief questionnaire\(^9\) containing seven items was also sent with the CDs. Two items covered the students' computer experience, one asked if there were any technical problems with the Web-based module, three items asked students to rate the Web-based course and how it compared with the print-based version, and the last item asked students what they most and least liked about the Web-based course. The aim of the questionnaire was to provide the researcher with some initial feedback that could be explored in greater depth in the interviews.

Unfortunately, as will be further discussed in *The Findings* chapter, initial technical problems with the CD meant that students had not attempted the module by the time they came in for residential school. So instead, the students were interviewed about their problems with the module and their feelings towards online learning.

\(^{9}\) For discussion on this please see *The Findings* chapter.
During the residential school the researcher and NTOEC teachers were also able to observe 13 of the students using the module. To overcome some of the technical difficulties students had encountered, an hour-long class using the Web-based module was held. During this class, the questionnaire surveying their equipment and technical abilities was given. Due to the limited time for the residential school it was not possible to organise any other sessions.

When the students returned home after residential school, some then attempted the Web-based module. As the Web-based module was being undertaken, the telephone conversations of both students and teachers with the researcher were recorded. Those students who completed the module were then asked to complete the initial questionnaire. In some cases this was completed over the phone.

At the end of the course, a final evaluation was undertaken which investigated the views and experiences of both the teachers and students who had managed to complete the module. These interviews were largely unstructured though, as mentioned earlier, the researcher did have a list of open-ended questions she wished to cover if the voluntary information was not forthcoming or irrelevant. For the teachers this evaluation could be organised as a face-to-face interview. For the students, it was necessary to do this evaluation over the telephone. It should be noted that only three students completed the Web-based module.

3.5 Data Analysis

It is the analysis stage that makes sense out of the data that has been collected (Dobbert 1982). It should be noted even though this stage is discussed after data collection, in practice the delineation between the two was not as clear. As has been discussed earlier, in participant observation the researcher often moves back and forth

9 See Appendix A.
between the data collection and the data analysis stages. This is unlike quantitative research, where the analysis stage tends to clearly follow the data collection stage.

Concerns with reliability and validity are clearly important in the analysis stage and the strategies outlined in section 3.3 Data Collection, such as triangulation of data and clarification of results with other observers, were also followed at this stage.

Results from the equipment survey were simply tabulated by adding the responses in each category. For the survey administered after students had finished the Web-based module, data reduction methods were not needed. Only three students managed to finish the Web-based module and their responses to the surveys were combined with the reports of their interviews. Similarly the number of interviews was not extensive and thus sophisticated high-end qualitative computer analysis methods such as NUDIST were not needed.

With participant observation studies, such as this one, hypotheses are often likely to emerge from the data rather than to be formulated prior to the research (McCall and Simmons 1969). The data collected from the questionnaires, interviews, field notes, personal reflections, direct observation of the participants and documents was integrated. This integration was essential to provide a unified basis upon which to identify emerging themes and draw conclusions, which reflected the holistic nature of the development process and subsequent delivery of the Web-based module. Throughout this process the researcher must be careful not to fall into the trap of finding what was expected at the outset (Miles and Huberman 1994, McCall and Simmons 1969).

Comparison of these tentative conclusions emerging from the data with existing studies is also important. Miles and Huberman (1994, p.279) write that explanations of findings of a study “gain added power if they are connected to theoretical networks beyond the immediate study”. Suggested ways of doing this include showing “the findings congruent with, connected to, or confirmatory of prior theory” and asking, “Have the findings been replicated in other studies to assess their robustness?” (Miles
and Huberman 1994, p 279). Accordingly, the findings of this study were compared to a number of studies throughout the analysis stage.

This study was also pre-structured. Miles and Huberman (1994, pp. 83-86) describe a methodology for a pre-structured study that has "an explicit conceptual framework, a rather precise set of research questions, and a clearly defined sampling plan". With this methodology, an outline for the study is devised and this drives the initial data collection. As the data is collected it is directly coded, without being transformed into write-ups, and entered into data displays. As conclusions emerge, these in conjunction with the outline drive the data collection.

Miles and Huberman (1994) note the importance of feedback from participants and colleagues to avoid unfounded conclusions. This is particularly important in a small study like this, and peers and informants were consulted to give meanings to the data. "An alert and observant actor in the setting is bound to know more than the researcher ever will about the realities under investigation" (Miles and Huberman 1994, p. 275). During the development stage the researcher was able to use the teachers at the NTEOC and to a lesser extent colleagues at the NTU. During the delivery of the module, the findings were also discussed at length with two of the teachers at the NTOEC.

The importance of both a formative and summative evaluation was recognised. Ip and Kennedy (1999) state, "Formative evaluation has a vital role to play in the progress of multimedia because it is the means by which we build up our knowledge of what the medium can do". Building up this understanding is important if the feasibility and reusability of the Web-based module was to be addressed. The next chapter, Development of the Web-based module, describes the development process that provides much of the data for the conclusions in The Findings chapter.

The summative evaluation addressed the overall effectiveness of the pilot project and used the standardised format recommended by Higginson (1990). As this evaluation took place at the end of this study, "the overriding concern [was] with what the
project [had] produced and with the probable impact which the project [could] expect to achieve as a result of its action.” (Higginson 1990, p.36, emphasis in original).

Following Higginson’s instrument the project objectives and indicators were specified as follows:

**Immediate objective**

To improve the learning environment for students by using a different medium and approach to teaching and learning rather than print-based materials.

For evaluation purposes these indicators were selected as benchmarks against which actual progress and performance could be measured:

- Take-up rate of module by students
- Student skills needed to access the module
- Time taken and completion rates for the module (utilisation)
- Improved learning outcomes
- Student/teacher level of satisfaction with module
- Level of contact between students and staff and students and students - isolation of students

**Developmental objective**

Online education is a growing field with increasing relevance for the NTOEC, whose objective is to find a cost effective and acceptable method of providing online education for distance students in the NT.

The accompanying indicators chosen for monitoring purposes were:

- Time and costs to develop the module
- Skills needed to develop the module
- Equipment needed to develop the module
- Time and cost to maintain the module
• Teacher time needed to deliver the module
• Reusability

These performance indicators were designed to monitor the progress of the pilot project. However a limitation of these indicators is that they tend to measure utilisation rather than impact as "direct measures of impact are very hard to find" (Higginson 1990, p. 52, emphasis in original).

Using the data collection methods detailed earlier in this chapter, each of the performance indicators detailed above can be measured. These indicators were also seen as appropriate and adequate to measure the progress or degree of success in achieving each of the projects objectives.

From the findings, conclusions and recommendations were made and these are listed in the Conclusions chapter.

3.6 Limitations

Some limitations of this study have already been alluded to earlier in the discussion. The nature of participant observation posed threats to the validity and reliability of the study. Measures taken to limit these problems and enhance the credibility of the study have already been detailed.

In a participant-observation study, the personality and characteristics of the researcher influence not only the type and strength of relationships he or she forms but also his or her interpretation of the data gathered. This was an issue for this study. Apart from discussing issues as they arose with other members involved in the pilot project and professional colleagues the researcher had no means of guarding against her values and assumptions impacting on the study. For example, the criteria used for the observation component of the project were subjective and so may be difficult to replicate in future projects.
Gold (1969, p. 37) notes that, "with increasingly more observation than participation, the chances of 'going native' become smaller, although the possibility of ethnocentrism becomes greater". As discussed earlier, in this study the researcher's role moved from being a participant-observer during the development of a module to an observer-participant in the delivery and evaluation of the module. Thus both the issues of "going native" and ethnocentrism were possible problems.

During the development stage, as the developer, the researcher was totally immersed in the project. This may have meant she lacked the ability to see events in an objective perspective and appreciate the significance of apparently trivial events. This was particularly relevant when problems arose; the researcher needed to be aware of the conflicting requirements of her roles as an information technology professional and an impartial observer. As an information technology professional there was a desire to protect her own personal credibility that could be in conflict with her role as an observer, which required her to be brutally honest in the reporting of problems and events.

At the delivery stage of the module, the researcher's lack of active involvement was more of an issue. The researcher was not responsible for delivering the course. When students, for example, had technical difficulties they rang their teacher at the NTOEC. If the teacher could not fix the problem she could choose to ring the researcher. As the researcher had a full-time job, she was often unavailable. Thus, technical help was often not readily available to the students or the teacher.

This mode of communication impacted on the study in several ways. The researcher was once removed from the students and so needed to rely in part on the teachers for timely and accurate notification of problems being experienced by students. Further, due in a large part to technical problems and the lack of readily available technical assistance\(^\text{10}\), the number of students who completed the module was fewer than

\(^{10}\) Problems experienced and the causes are discussed in greater detail in The Findings chapter.
expected. Further, these technical issues also heavily dominated student and staff perceptions of the Web-based module. Thus, not only was there limited data to be evaluated but the number of different aspects of the Web-based module that could be evaluated was also less than expected. The evaluation was certainly not as rich or as complete as had been hoped for at the start of the study.

The geographical isolation of the students also imposed limitations. Students only once came in for residential school and thus opportunities to converse face to face or to observe them using the module were extremely limited. Communication was almost entirely by telephone calls. Some technical problems that can easily be solved by a simple face-to-face demonstration become much more difficult to deal with when explained over the phone.

The funds, time and labour available for the development of the Web-based module were also quite limited. Multimedia development is expensive and time consuming and generally considered to take much longer than the equivalent project in print format (Misanchuk, Schwier and Boling 2000; Horton 1994; Benyon, Stone and Woodroffe 1997). This study had one developer (i.e. the researcher), $2000, and a timeframe of only a few months. In addition the developer was not a visual designer and only has very limited graphical ability. These restrictions obviously imposed limitations on the type of product that could be developed and so the data that could be collected. It should be noted, however, that these restrictions are realistic and probably not dissimilar to those that would most likely apply to any future developments the NTOEC may choose to undertake.

Finally, this was a small study analysing one site with all its own idiosyncrasies. The outcomes or results for this study may not be replicable at another site. It may not even be possible to replicate the findings of this study at this site, as the circumstances relevant in 1999 do not apply now. Since that time, there have been improvements in the telecommunications infrastructure and possibly the technical
literacy skills of the students\textsuperscript{11}. While this study may not be replicable, hopefully it will provide some understanding of how Web-based courses may be developed with limited resources for young and isolated distance education students.

\textsuperscript{11} With the increasing use and spread of computers and the Internet, it may well be that students technical literacy will continue to improve.
CHAPTER FOUR
DEVELOPMENT OF THE WEB-BASED MODULE

The previous chapter outlined the design of the study and the justification for the methods and procedures used. Also, outlined was the design methodology to be used in the development of the new module. This chapter details that development process, explaining and justifying the design decisions made. The sections in this chapter are:

4.1 Investigation of the site
4.2 Hardware and software selection
4.3 Designing the framework
4.4 Materials design, development and testing

The development process started with an investigation of the NTOEC to determine the requirements that the Web-based module needed to meet. Once these were clarified, the appropriate hardware and software could then be chosen. Designing and implementing the module was done in two stages. First, the overall approach and framework were determined before the individual units and pages were designed. The final task was testing and distributing the module.

Detailing this process and the justification for design decisions was seen as important as these formed the basis for some of the findings of this study. Questions explored by this study included identifying what technologies were appropriate, what were the features of an effective instructional design and investigating the likelihood of developing a template or method for transforming other print-based materials to a Web-based format. These cannot be answered properly without a detailed examination of the development process.
4.1 Investigation of the site

This section covers the results of the investigation undertaken at the start of the development of the Web-based module. The purpose of the investigation was twofold:

1. To identify clearly the nature and scope of the pilot project and
2. To learn and document what is happening in the current system and so determine the requirements for the new system.

The next sections in this chapter then describe how the information gained was used in the design and implementation of the Web-based module.

4.1.1 Purpose and scope of the pilot project

The initial discussions clarified both the purpose of the project and set the scope for the project. The agreements were informal and the scope necessarily included a degree of flexibility, as the area was new to both the NTOEC and the author.

An old Chinese proverb states, "If you do not know where you are going, you will probably end up somewhere else" (McKilliam 1990, p. 5). Thus the first step was defining the purpose and what the Web-based module hoped to achieve. Briefly, as discussed in the first chapter, the NTOEC wished to provide for a more successful educational experience for its students and this project investigated how successfully and cost effectively one of the NTOEC modules could be developed for online education using a constructivist teaching and learning approach. The Web-based module was to be developed as a pilot study and then evaluated to provide insights on how successive modules could be developed.

The materials in the print-version were to be used as the basis for the Web-based module. As was discussed in 2.3 Transforming from a print to an online format, simply converting the format of the materials from the word processor to HTML to place the materials online was unlikely to succeed. Instead, the materials had to be redesigned in a format that was more suitable for online teaching and learning. This
reliance on the print-based module clearly placed constraints on the design of the Web-based module. The researcher was limited to considering the best approaches to presenting the existing print material.

The choice of the particular module as discussed in 3.2.1 The site was largely due to practical considerations of timing for the NTOEC, researcher and students.

4.1.2 Requirements investigation

The next stage involved a requirements investigation of the module and its delivery. Information on the targeted audience, educational approach and content, administration of the course, user equipment and technical skills was collected. From this the educational, practical and technical requirements for the Web-based module were developed. Educational requirements were concerned with the pedagogical basis and learning strategy underpinning the module, course content and curriculum requirements which all needed to be suitable for young distance education students. Practical requirements were concerned with the operational and course considerations of the NTOEC. Finally, the technical requirements encompassed the equipment and technical skills of the students and teachers.

These requirements were determined through interviews with the informants and from the results of the literature review.

4.1.2.1 Pedagogical requirements

Important pedagogical requirements for the Web-based module were the need to satisfy the NT curriculum requirements and to incorporate successful teaching and learning strategies.

The NTOEC Year 8 Science course contains eight individual modules. Teachers at the NTOEC have mapped these modules to the NT curriculum profile outcomes to ensure all required profile outcomes are covered in the Year 8 Science program. In
this project only one module was transformed to a Web-based format; the other seven modules remained print-based. As not all students had access to a computer, some completed the converted module using the print-based material while others used the Web-based material\(^1\). Thus it was important that the Web-based version fitted into the overall structure of the year. The curriculum profile outcomes covered in the two versions needed to be the same and time taken to complete each of the versions also had to be comparable.

The print-based modules had been rewritten in 1998 and were reported by the NTOEC as being successful. The pedagogical approach used was similar to that found in many textbooks and tended very strongly towards an instructivist rather than a constructivist approach to learning. Educational outcomes were obviously a priority for the NTOEC and they felt that the print materials were educationally sound and effective.

4.1.2.2 Practical requirements

In this section the restrictions placed on the module design due to the practical requirements for creating successful distance education courses, the administrative needs of teachers and the resources available to develop the Web-based module are examined.

The needs of young distance education students were addressed. Working in isolation, it is easy for distance-education students to misread/misunderstand issues or instructions and so complete tasks incorrectly and misunderstand concepts. A simple and clear writing style is essential to help students understand complex concepts and to minimise these misunderstandings. If further assistance was needed teachers were available via the phone for individual help. Not surprisingly, experience with the

\(^1\) See Table 5.1 in section 5.3.1 Take-up rate of module by students for further details on student access to computers.
print-based materials shows that despite all this assistance, confusion among students is still an issue.

The print modules were deliberately written with a very structured approach. 'Structured approach' is used here to refer to the physical layout and division of the material into lessons as opposed to the conceptual framework of the material\(^2\). This was thought essential for a number of reasons. The students are young and at an age where self discipline, or more importantly the lack of it, is an issue. In a conventional classroom situation, a teacher is responsible for providing much of that discipline by pacing students through the year's work and for ensuring (or at least trying to ensure) that students keep up-to-date. In distance education, supervisors can provide part of that support by ensuring that students study regularly but the materials themselves must provide guidelines on timing for students to pace themselves. This timing information is very explicitly stated in the print-based materials with the modules being organised into fifty-minute lessons. Even with this structure the completion rates are not good. T1, a teacher of year 8 science, had a group of 21 students in 1999. By the end of August it was apparent that only 6 or 7 students in the group were likely to finish the science course by the end of the year (personal interview with T1).

This need for structure is probably even more marked when it is considered that Year 8 is the lowest level offered at the NTOEC, and for some students it is their first experience of distance education. Students can take time to adjust to much lower levels of contact with teachers and the added responsibility of managing their own studies. T1 and T2 thought this was an issue even for those students who had previously experienced distance education with the School of the Air, which provides opportunities for students to have a much higher level of contact with teachers and other classmates. Both thought a very structured approach helped with this process of adjustment (personal interview with T1 and T2).

\(^2\) The latter is addressed in 4.3.2 The module framework.
The structure in the print version revolves around a lesson. Year 8 students are required to complete four 50-minute lessons a week for science. Each module contains 20 lessons and thus should take 5 weeks to complete. The last lesson in each module is a test. The material for the module is divided into three booklets: a theory booklet and two response booklets. The theory booklet contains the 20 lessons. A lesson consists of some theory, numerous exercises and possibly some practical experiments. All the different components are clearly labeled with icons, and the structure for any individual lesson is easy to follow. The lessons are usually two or three pages long. As students progress through a lesson they have a clear sense of their current position in the lesson and how much more work is needed to complete that particular lesson. This structure is explained to the student at the start of the course and then reiterated at the start of each module.

A student's answers for exercises are written into the response books. Each module has two response booklets: one booklet for lessons 1 to 10 and another booklet for lessons 11 to 20. As the student completes each response book it is mailed to the NTOEC for marking. Some exercises are marked by the student (hopefully after they have completed the exercise) while others are marked by the teacher at the NTOEC. The different types of exercises have separate icons to distinguish them clearly and where appropriate reminders are given to students to check their answers. Space is left for answers and the layout of the questions give further clues about the length and depth of answer required. Every attempt is made to keep the language simple, clear and direct.

Providing good feedback on student’s answers in the response books is a problem. Once student response books are received they are marked and then sent back to the students. Despite the best efforts of the NTOEC, T1 and T3 explained that this feedback could be slow. The NTOEC policy is to mark all work within five working days of receiving it. However, as turnaround times for mail can be up to a month in

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3 See Appendix B for an example of a typical lesson.
some areas, most often students do not receive feedback on their work until weeks after they have completed it. By then they will usually be working on the next module. This is always true for the second response book and may well be the case for the first response book (personal interview with T1 and T3). An important requirement for feedback is that it is timely and this is clearly not being met.

Even for those exercises that students mark themselves the feedback is not as good as could be hoped for. Probably not surprisingly, despite all the cues provided, checks of student response books by T1 show that students are not very good at checking their own answers with the answers provided and in some cases appear not to do so at all. In some cases students will tick a checkbox saying they have corrected their work even though their answer may be totally wrong (personal interview with T1).

The NTOEC also had practical concerns that the Web-based version of the module would have to satisfy. Once written, the NTOEC courses have a reasonable lifetime and are designed to be quick and easy for teachers to administer. Student work is clearly laid out in the response booklets and each response book has a tally sheet to collate the student's marks. T2's experience had shown that marking the same work using email took longer as the set out was not standard and keeping track of marks was more time-consuming (personal interview with T2). Teachers are already busy and did not want the Web-based version to increase their workload substantially.

The resources available for the course were also limited. The NTOEC made available around $2000. The module was developed solely by the researcher. This is not to belittle the invaluable input given by many people but to stress that only one person was available for the construction of the module. With regards to skills, the researcher had a background in both Information Technology and Education but had very little

4 In some cases where students know they will not get the first response book back before they finish the unit they will mail both books when they complete the module (personal interview with T1 and T3).

5 Please see the section 4.3.2 The module framework to see particular instances of this help.
graphical design experience. Time was also a consideration as there was only a period of about three months available for the development of the course. The design for the Web-based module needed to consider these limitations.

4.1.2.3 Technical requirements

The computer literacy skills of teachers and students were then addressed. Clearly any Web-based course would need to match the skills and equipment being used by staff and students.

The teachers at NTOEC need to use computers extensively in their jobs and are proficient users of the technology. However most would rely heavily on IT support to fix any problems or to deal with new situations. The NTOEC does employ an IT manager who while supportive of the Web-based module had a heavy workload and so was not in a position to be able to provide much help. In particular he would be unable to provide an adequate Help Desk service to students and staff in a timely fashion.

Finding the level of computer skills possessed by the students was more difficult. Surveying the students, themselves, was not an option. Year 8 is the first year at the NTOEC and the development of the Web-based module started six months before the students had enrolled with the NTOEC. Surveying the current Year 8 was a possibility but given the isolated location of many of the students it would not be easy or quick to do. When the researcher raised the possibility of such a survey with the NTOEC staff, they were opposed to the idea, as they believed getting the survey forms returned from students would be problematical. Instead the NTOEC teachers felt confident of predicting the computer literacy skills of the students and no survey
was done at the outset. Later, as part of the evaluation of the Web-based module, students were surveyed and the estimates provided by the teachers proved accurate\(^6\).

T1 and T2 thought that the skills of students varied considerably. Some students had no access to a computer and so had virtually non-existent skills while other students understood the technology well and used their computers daily. The range in age of the computers, platforms and software used was also extensive. T2 thought that most locations students lived in would have computers though students may not necessarily have access to them for their studies. For example on stations, the children of the station owner or manager were likely to have access while children of the station employees might not. Access might also be limited to certain times. This is often the case in communities, where computers are available for students to use at local schools. An estimate that three quarters of students would have access to suitable computer with a CD player was made (personal interviews with T1 and T2).

Another problem identified was the limited computer support that was available for students in isolated locations. Families that experienced difficulties in setting up equipment or software understandably often abandon the attempt. In cases where the computer is needed for the running of a station or business, parents may have reservations with students using the computers, as fixing problems is difficult (personal interviews with T2, T4, T5).

From this it was seen as essential that the course was designed to be as technologically friendly as possible so as to be easy for both students and staff to use, install and maintain.

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\(^6\) As will be seen, technical issues were a real issue for the Web-based module. However whether a survey of abilities before the module design started, would have helped to alleviate these problems is debatable. For further discussion on this please see *Chapter Five: The Findings.*
4.1.2 Determining a user profile

The last stage in this investigation phase was to develop a student profile, detailing the characteristics of typical year 8 NTOEC students. This would help ensure the design of the module matched the intended users.

An important issue in Web design is how to consider a user's goals rather than just those of the owner of the site (Nielsen 1997a, Fleming 1998, Rosenfeld and Morville 1998). These goals are often not in agreement. For example, earlier it was noted that students are notoriously bad at checking their own answers against those provided at the back of the study guide. Here the goal of the teachers at the NTOEC may be for students to improve/check their understanding but for students the aim is more likely to be to finish the lesson as quickly as possible. Unless the student's goals are understood and catered for in the module, it is less likely the NTOEC goal of providing a successful learning environment will be met.

Developing a student profile or image of a “typical” student can help to establish what the students’ goals are likely to be. As part of this process it is important to try and predict any obstacles that may stand in their way. This requires consideration of student behaviour, preferences and resources. This was done in consultation with T1 and T2 at the NTOEC.

The “average student” was imagined to be a young person, about 13 years old

- for whom school was a necessary evil.
- whose motivation for studying was most likely to be external factors rather than any intrinsic interest in the material.
- who would most probably wish to complete his/her work as quickly and painlessly as possible. Therefore he/she would want clearly laid out steps and tasks, and to know at any stage in a day’s work how much had been done and how much remained to be done.
- whose schoolwork may well be competing with more exciting tasks like mustering.
• whose patience with problems and or reading long instructions was likely to be limited (Fleming 1998).
• who was unlikely to value tasks that were not assessed
• who preferred tasks that required some activity rather than passive responses, which suggested that long readings with limited activities were unlikely to be a successful teaching and learning strategy.
• who was likely to have limited technical skills and exposure with computers and so may be apprehensive when first presented with a Web-based module. It was expected that a few students would be very comfortable in this environment.

The design of the module would obviously need to be consistent as possible with these characteristics. It was hoped that the use of constructivist teaching and learning approaches would increase student interest and motivation and make them active participants in the learning process.

4.2 Hardware and Software selection

The investigation phase for the Web-based module was now complete and the requirements for the Web-based module established. Design and implementation options were now considered. The first such decision that needed to be addressed was the selection of the most appropriate hardware and software to use in the implementation of the Web-based module. This decision, as will be seen in subsequent sections, impacted heavily on the design of the module.

While there was a range of possible technologies that could have been used in the Web-based module, any technology chosen must match the equipment and type of connection to the Internet being used by students as well as their computer-literacy skills. As discussed in 2.1 Telecommunications infrastructure available in remote and rural areas of the NT, recent reports (Devlin 2000, Klesch and Madden 1999, HEROCC 2000a and 2000b) into the provision of Internet services to rural NT have shown there are many problems with establishing reliable links. Transmission can be slow, access problematic or non-existent and the quality of links poor. The links to
the NTOEC students are very unlikely to be more reliable, especially when it is considered that some students are situated not in rural community centres but on isolated stations. Comments from teachers at the NTOEC about their experiences with email supported this position⁷.

With these considerations, the only feasible option for the module was to use a CD and the postal system for the distribution of the course materials. Given the NTOEC's past experiences with email from students, it was decided that the design of the module could not rely on electronic communication such as email, though where available students would be encouraged to use electronic communication. HTML and associated Web technologies were still used to produce the CD. Networks and technologies are rapidly improving and in time most students will have reliable links to the Internet of sufficient quality to be able to undertake courses. Further, Web technology is platform-independent (or at least claims to be so though, as discussed in 2.5 Technical considerations in implementing an instructional design, a considerable number of discrepancies are found between different platforms) and so in theory only one version was needed for both Macs and PCs. Finally, the purpose of this pilot study was to examine the feasibility and future potential of using online technologies to provide better educational experiences and outcomes. This approach is consistent with that taken by Misanchuk, Schwier and Boling (2000).

One problem with using a CD rather than the Internet was how to remember students' answers to exercises. One of the requirements of the module was that students' work needed to be recorded as they progressed through the course⁸. This work needed to be available to the student in the context of the course and to the teacher in a format that was easy to mark and manage. Initially this was to be achieved by using a database on the NTOEC server to store the work, with the online module accessing the database

⁷ As discussed earlier in 4.1.2.3 Technical Requirements, due to practical limitations no survey of students' equipment and skills was done before the project started. Instead the experience of the staff and recent reports on the telecommunications infrastructure were relied on.

⁸ See 4.1.2.2 Practical requirements for more information on this.
as needed. When the decision was taken to use CDs rather than the Internet this solution was no longer an option.

If work could not be saved on the NTOEC server, it would need to be saved on the student's computer. This is not as simple as it sounds for the Web environment deliberately tries to prevent Web pages from accessing a user's computer. When users download a page they need to be confident that their data and privacy are protected. No users want unknown agents that are able to access or destroy information on their computers. This is essential when the wide-open nature of the Internet is considered and the fact that users often have very little idea about who is behind the pages they are accessing. Thus HTML and scripting language such as JavaScript deliberately do not provide capabilities to write or delete files or folders on a user's computer (Flanagan 1998).

The programming language Java can in certain circumstances be used from Web pages to write to a user's computer. This is why some Web users are wary of Java and disable its use in their browser. It requires that the users set the security permissions within their browser to allow Java to do this. While giving this permission to all pages on the Web would be very foolhardy, it is possible to limit the permission only to pages stored on the user's computer. Thus, in theory, the Web-based module stored on the user's computer would be able to access the user's file system but pages accessed over the Web would not.

Problems with this approach were found. Setting the permissions involves steps not normally undertaken by users and differs significantly between browsers. The researcher's personal experience was that unexpected results could easily occur and

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9 See 1.4 Definitions of Terms
10 See 1.4 Definitions of Terms
reversing the process was not straightforward\textsuperscript{11}. It is also potentially dangerous if the permissions to read and write are incorrectly set and not limited solely to the user’s computer. As the users of the Web-based module would often be in isolated locations and have limited technical skills, requiring them to set permissions was not seen as a feasible solution. It should be noted that this approach would also require that the

Java applet (or program) take into consideration the file systems of different platforms (e.g. Windows, Mac OS). One of the major strengths of the Web is that it is platform independent and implementing solutions that needed to consider different platforms seemed to be a step backwards.

Small amounts of information can be stored using cookies within JavaScript. Flanigan (1998, p. 334) describes a cookie as “a small amount of named data stored by the Web browser and associated with a particular ... Web site”. Cookies are designed to give a Web browser some sort of “memory” and are traditionally used to remember user preferences when a user leaves and returns to a page. For the Web-based module this was ideal for keeping track of small amounts of information such as the units a student had completed. However there are strict limits to the number and size of cookies that a browser will store\textsuperscript{12}. Given this it was not possible to use this mechanism for storing all student responses to exercises. Note too, cookies are stored on a user’s computer and so student responses would not be readily available to teachers.

\textsuperscript{11} The most unfortunate incident was on a Windows NT network. The researcher managed to set the Java permissions for the local domain but was then unable to access anything outside the local domain. What’s more the researcher was unable to reverse the process and when the network manager was consulted, he decided the quickest fix would be to re-install the browser. While the researcher does not doubt the process was reversible and the browser could be set-up correctly it does demonstrate the pitfalls. This was not a straightforward process and certainly not suitable for users with little technical confidence and limited knowledge.

\textsuperscript{12} Flanigan (2000, p. 337) lists these restrictions as “Web browsers are not required to retain more than 300 cookies in total, nor more than 20 cookies per Web server, nor to retain more than 4 kilobytes of data per cookie”.

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In the end a variety of methods to store student answers were chosen. For assessable work marked by the NTOEC, students typed their answers using a text editor or word processor. This was a totally separate application to the Web-based module, though the Web-based module did make reference to the e-journal where appropriate. The e-journal would be sent back to the NTOEC using either the postal system or email if it was available to the student. For exercises that students marked themselves either the answers were stored in cookies or not stored at all. Where answers were not stored, the correct answer was readily available to students via a button click.\(^{13}\)

Thus, answers written by students for the Web-based and print modules were managed in a significantly different way. In the print module students mostly wrote their answers in their response booklets\(^ {14}\). Requiring students to write their answer provides evidence that they have attempted the work. In the Web-based module there was no way of telling if students had attempted the exercise and there was concern that students might simply skip the exercises. This could be especially true for difficult or dry exercises. In theory this should not matter. The assessable exercises in the e-journal were designed to cover all the major concepts and terminology of the module. The non-assessable exercises were added to help students understand these concepts. Thus if students completed the assessable tasks it should not matter that they had not completed the non-assessable tasks. However, in practice it was felt if students completed the non-assessable exercises they were more likely to be successful with the assessable exercises. This is especially relevant when the age of the students is remembered and their probable lack of intrinsic motivation considered.

Despite this difference it is debatable whether this situation is worse for the Web-based module than for the print module. After all, in the print module students can if they wish copy the answers provided or as the teachers' experience had shown simply not bother to check their answers. Both the Web-based version and the print version

\[^{13}\text{See the section 4.4.2 The prototype for an individual unit for further discussion.}\]

\[^{14}\text{For some questions students were only required to think, but not record, what their answer was.}\]
rely on some level of student motivation. The design of the Web-based module therefore aimed to include strategies that would both encourage and check that students completed these non-assessable exercises.

Attention then turned to the browsers that students were using. It was decided that the module would use the features of Dynamic HTML (DHTML). As discussed in 2.5 Technical considerations in implementing an instructional design this required that the browsers used by students, whether IE or Navigator, were version 4 or higher. While both IE and Navigator were supported, recent surveys show clearly that IE is the predominant browser in use\(^\text{15}\), and thus developmental efforts were directed at IE. Allowance had to be made for students who were using an older version browser or had no browser at all. Browsers are freeware and relatively easy to download over the Internet. Of course, as discussed in 2.1 Telecommunications infrastructure available in remote and rural areas of the NT, for those students who did not have reliable access to the Internet, downloading browsers was not going to be possible. To overcome this the CD included appropriate versions of browsers for both PCs and Mac.

By including browsers on the CD, problems caused by inconsistencies between various versions of a browser were also partly overcome. A page that worked in one version of a version 4 plus browser (whether IE or Netscape) may well not work in another. In some cases a page would work successfully in an earlier version level 4 browser and in a later version 4 browser but not in the intermediate version being tried. By providing browsers on the CD, potential problems with particular versions of browsers were sidestepped.

While the decision to use CDs for the modules was forced by circumstances, there were some advantages to this approach. Without a reasonable bandwidth, pages which rely heavily on graphics, multimedia and the latest Web technology can

\(^{15}\) See 2.5 Technical considerations in implementing an instructional design for a discussion of figures.
produce a frustratingly slow experience for users. Surveys of Web users (Fleming 1998, Nielsen 1996 and 1999a) have shown consistently that slow download times rank as one of the major complaints, if not the major complaint. Nielsen (1996) estimates “10 seconds as the maximum response time before users lose interest” though he goes further to say “[o]n the Web, users have been trained to endure so much suffering that it may be acceptable to increase this limit to 15 seconds for a few pages”. Using a CD this problem largely disappeared and the designer was free to make extensive use of graphics, video clips and other forms of multimedia with minimal concern for loading times. This was especially relevant for the NTOEC when the age of their target audience was considered.

The module also included a few video sequences, which required a suitable plugin to run. The video clips were optional and access was not necessary to complete the module. These plugins were not provided on the CD, as time was limited for the development of the module and problems were experienced with providing appropriate plugins on the CD.

4.3 Designing the framework

Having established the project requirements and selected the appropriate technology the overall framework for the Web-based module was then designed. This defined the “character” or feel of the module.

4.3.1 The pedagogical basis

To facilitate this, the materials in the print-version were used as the basis for the Web-based course. It was decided to keep the material covered in the print and Web-based versions substantially the same. The print-based material formed the basis of the Web-based module but was rewritten and reorganised in a format suitable for a Web-based course. This ensured that the Web-based material would satisfy the curriculum requirements and fit into the structure of the Year 8 Science course. Further students completing either the Web-based or print-based materials were not
unduly disadvantaged either in terms of content or time taken to complete the material.

The print-based modules had been rewritten in 1998 and were reported by the NTOEC as being successful. The pedagogical approach used was similar to that found in many textbooks and tended very strongly towards an instructivist rather than a constructivist approach to learning. Unfortunately, as was discussed in section 4.2 Hardware and software selection, online communication technologies were not available to the Web-based module. Consequently, as collaboration is an essential requirement for constructivist approaches to teaching and learning, the Web-based module was unable to use a constructivist instructional design. In addition, developmental resources were limited and there were insufficient resources to completely redesign the module. Any use that could be made of the original print material needed to be maximised. Where possible some constructivist elements were added to the course. These elements are discussed as the organisation of the module and the writing of units is explained. It should also be remembered that educational outcomes were obviously a priority for the NTOEC and they felt that the print materials were educationally sound and effective.

4.3.2 The module framework

Having chosen the module, it was time to actually start designing the Web-based course. Consistent with other developers (Ellis, Torokfalvy and Carswell 1998; Benyon, Stone and Woodroffe 1997; Horton 1994; Reuslhe, Dorman, Evans, Kirkwood, McDonald and Worden 1999) the first step taken was to break the material into topics. Ellis et al. (1998, p. 206) explain this by pointing out that:

16 The author is very grateful for the help and suggestions that were made by the teachers at the NTOEC and the researchers involved in the CUTSD R&D Project: Facilitating flexible online teaching using structured frameworks, Northern Territory University.
What is important here is to move away from the idea of linear presentation to a series of topic areas that, when integrated and interlinked, form a coherent package of information that comprised the content of the subject. Once major topic areas have been identified, each topic area should be broken down further into detailed knowledge items.

Order had to be considered as some topics relied on prerequisite knowledge that was explained in other topics.

For the Web-based module, the print-based material formed the basis of its content but was rewritten and reorganised in a format suitable for the new environment. The print-based materials had been divided into lessons. Not surprisingly these lessons were written to cover a topic or in some cases part of a topic. Thus when the Web-based module looked at creating a series of topics, the written lessons fitted this structure well. The following table, Table 4.1, shows the lessons broken into topics. This did require some reorganisation but the lesson each topic is mainly based on is indicated.
Table 4.1 The lessons divided into topics

<table>
<thead>
<tr>
<th>The lessons (with lesson number)</th>
<th>Divided into topics (topic names in bold)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Materials around us</td>
<td>All about theories (1)</td>
</tr>
<tr>
<td>2. Particle theory</td>
<td>All about theories</td>
</tr>
<tr>
<td>3. More on particles</td>
<td>Particle Theory</td>
</tr>
<tr>
<td>4. Holding particles together</td>
<td>3 states of matter (2, 3)</td>
</tr>
<tr>
<td>5. Change of state</td>
<td>Holding particles together (4)</td>
</tr>
<tr>
<td>6. Keeping the heat in</td>
<td>Change of state (5)</td>
</tr>
<tr>
<td>7. Solutions</td>
<td>Keeping the heat in (6)</td>
</tr>
<tr>
<td>8. More about solutions</td>
<td>Solutions and Mixtures</td>
</tr>
<tr>
<td>9. Separation of mixtures</td>
<td>Solutions (7, 8)</td>
</tr>
<tr>
<td>10. Separation of mixtures</td>
<td>Separation of mixtures (9, 10)</td>
</tr>
<tr>
<td>11. Physical and chemical change</td>
<td>Types of Change</td>
</tr>
<tr>
<td>12. Rusting a chemical change</td>
<td>Physical and chemical change (11)</td>
</tr>
<tr>
<td>13. Pure substances</td>
<td>Rust (12, 18)</td>
</tr>
<tr>
<td>14. Element or compound</td>
<td>Pure Substances</td>
</tr>
<tr>
<td>15. Elements and symbols</td>
<td>Elements and compounds (13, 14)</td>
</tr>
<tr>
<td>16. Metals</td>
<td>Elements and symbols (15)</td>
</tr>
<tr>
<td>17. Chemical reactions</td>
<td>Metals (16)</td>
</tr>
<tr>
<td>18. Back to rust</td>
<td>Summary</td>
</tr>
<tr>
<td>19. Revision</td>
<td>Chemical reactions (17)</td>
</tr>
<tr>
<td>20. Unit test</td>
<td>Revision (19)</td>
</tr>
<tr>
<td></td>
<td>Unit test (20)</td>
</tr>
</tbody>
</table>

For the Web-based module the linear progression of the lessons in the print-based version was no longer appropriate. The topics were reviewed and content that was necessary before other content could be covered was identified. It was found the All about theories topic had to come first as it established the basis for the module and not surprisingly the Summary topic needed to come last. The other four topics, The particle theory, Types of change, Solutions and mixtures and Pure substances while related to each other as they covered aspects of matter, were independent in the sense
they could be completed in any order. Further there was no need for one topic to be completed before the user started on another. It was hoped that with this approach learners would better appreciate the conceptual relationships between the topics. Within the individual topics the order was more linear. The material covered in the topics tended to be sequential by nature as terminology and ideas were developed over the topic.

As discussed in section 4.1.2.2 Practical Requirements the Web-based module needed to provide a very explicit structure. The topics above are broken into units and each unit took approximately 50 minutes to complete. A unit is an individual lesson or a day’s work and these were clearly identifiable to the user. Thus the timing information was very apparent and students and their supervisors could always see how far through a module a student had reached. With this design the Web-based module followed the same structure as used in all the print-based modules for year 8. This was seen as an advantage as the adjustment for students from print-based materials to Web-based materials was facilitated.17

Once the material had been divided into topics and the relationship between the topics established, the framework for presenting this information was addressed. The module looked at properties and nature of matter and how this could be explained using the particle theory. T1 and T2 expressed the opinion that students had a lot of difficulty in distinguishing the differences between theory and fact. Their experience was that students believed the particle theory was fact rather than viewing it as the most widely accepted model to explain the behaviour of matter in certain situations. Students considered that experiments done in the module “proved” the theory rather than being supporting evidence for the theory. T1 and T2 believed that few students were aware that as a theory, the particle theory could change in future if new evidence or ideas came to light. T2 recounted how when students in later school years studied

17 As discussed in the section 2.3.3 Organising information and scaffolding literature, providing a structural framework is an important issue for any Web site. Why and how it was done for the Web-based module is further discussed later in this chapter.
light, which is represented in theories as both a wave and a particle, students could be very confronted. After all they had been “told” that matter was made up of particles (personal interview with T1 and T2).

From this it was decided to use the nature of theories as the unifying concept. The print-based materials already included a murder mystery where students where given clues and then had to develop a “theory” on who the murderer was. The difference between fact and theory was stressed and the concept of “beyond reasonable” doubt introduced. This was taken as the starting point for the module. The murder scene was introduced and the student as an ace detective was called in to solve the crime. At the same time the notion of developing a theory to explain the behaviour of matter was introduced. Students would observe facts and perform experiments about matter and see how this information could be developed into a theory to explain their observations. The idea was to run the two threads in parallel. As students completed topics and parts of topics they would gather clues to how matter behaved and clues to the murder mystery. At the end of the module, students would have collected all the murder clues and so hopefully “solved” the crime and also developed a theory about matter.

The main consideration for including the murder mystery was educational. It was hoped that by introducing a scenario (solving a murder) students were familiar with through books, TV and movies, the idea of scientific theories and hypotheses would be clarified. The game aspect of the mystery was also seen as motivational. Given the age and isolation of the students it seemed that most if not all of the students at some stage would lack intrinsic motivation to complete the module. The module needed to look at providing features to help motivate and engage the learner. Without doubt in some cases games can be used to motivate learners and create better learning environments. However, it is important that the game is related to and part of the learning objective. Games should not be used as a “reward” for successfully completing a task (Jones 1998, Horton 1994). The murder mystery met this requirement.
This section covers the first stages in the development of the Web-based module. It describes issues in the investigations undertaken and the creating of the framework for the module. The next section investigates the creation of the actual units (or lessons).

4.4 Materials design, development and testing

The framework for the module had now been established and the strategy for the module determined. This completed the first steps in the design and development of the module.

The next steps were:

- Using the information from the first step to map the site architecture. This involved determining the organisation of the site, developing the top-level design described in the previous section and designing the navigation for the module.
- Designing the prototype for an individual unit (or day’s work). Tools needed were identified and developed and, from this, a template for the units determined.
- Writing the individual pages and units following the prototype determined for the units. The necessary resources needed to be found or created.
- Testing the module on a number of different browsers and platforms.

While these steps are listed as sequential, in practice the development shunted between the various steps. While the first two steps, creating the site architecture and prototype, were largely determined at the start, it was still necessary to return to these steps and change elements as problems or possible improvements were found. The last two steps, creation of pages and testing, occurred almost simultaneously. As pages were completed they were shown to the staff at the NTOEC and interested friends. Any problems were then fixed. Creation of the first unit took a considerable length of time. After that the other units were much quicker as many of the problems had already been addressed.
Dreamweaver 2\textsuperscript{18} was used to create the pages and manage the site. Both the time and the resources available for the development of Matter were limited\textsuperscript{19}. This did restrict the options available and as will be discussed had a significant effect on the design of the eventual module.

4.4.1 The site architecture

The next step was to map out the site architecture ensuring that the qualities of good navigation identified in 2.4.3 The qualities of successful navigation were followed. The organisation of the site needed to be determined and the top-level design developed following the chosen framework.

The design of the module revolved around the topics and these quite naturally became the organising theme for the module. The first page designed was the topic map and this formed the “heart” of the module. The topic map, or simply the topics as the page was referred to, is shown in Figure 4.1. Each icon represents a unit of work. Units were either designed for a day’s work (50 minutes) or those with a x2 for two days’ work. As discussed earlier, some units depended upon other units being completed. To keep track of this a unit could be in one of four states: available to do, currently being undertaken, not available or completed. The four different icons used for these states are depicted in Figure 4.2. If a unit was unavailable it could not be entered from the topic map.

The topic map was central to the module’s navigation and interface. It provided quick and easy access to all areas (with some restrictions detailed below in the text) of the module. The different icons were designed to provide a clear visual message on the status of the units to the students and so help to make the navigation more intuitive. An improvement to the icons’ design would be to make the distinction

\textsuperscript{18} Later versions of Dreamweaver have since been released but at the time the project started these were not yet available.

\textsuperscript{19} As discussed under 4.1.2.2 Practical requirements
Figure 4.1 Topic Map: all the topics bar the test have been completed

- Topic not available to be selected – earlier topics need to be completed before students are ready to select this topic.
- Topic not yet started but available to be selected
- Topic has been started but is not yet completed. Once started a topic must be completed before another topic can be selected.
- Topic has been completed

Figure 4.2 The four different icon states
between the double and single units more visually apparent. This could easily have been achieved by using different sized icons but unfortunately, due to a misunderstanding between the icon designer and author, this did not happen. As both time and money were limited, it was decided not to rectify the problem.

While students did not need to complete the topics one after another, they were required once they started an individual unit to complete it before going onto a new unit. Given the age of the students and their probable lack of intrinsic motivation this discipline was seen as important. Thus, once a unit became current, students were unable to enter any other available unit. Completed units were always accessible so that students could review material if they wished. Thus quick access was provided to all available areas of the module.

Controlling access to units provided not only guidance and structure to students but it also fitted well with the murder mystery. Each unit had clues to the murder and making the units unavailable prevented students from finding clues prematurely. This mirrors many games where, as participants go up levels or complete tasks, more resources become available to them. Needless to say, vital clues were contained in the later units of topics so as to prevent students solving the mystery too early. Throughout *Matter* references to the murder and developing a theory were made.

Controlling access to units and recording which units had been done was achieved by using cookies and JavaScript. One improvement that could have been made would have been to use the murder mystery in some way as a metaphor on the interface design. Unfortunately this possibility did not occur to the researcher until after the topic map had been designed and implemented.

The map gives a graphical representation of the different topics in the module. It shows how the topics fit into the whole and the relationship between the individual topics. This can help students visualise the conceptual structure of the material

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20 How clues become available is discussed in 4.4.2 The prototype for an individual unit.
(Reushle, Dorman, Evans, Kirkwood, McDonald and Worden 1999). The map also
provided a very structured layout to the module. By using the different icons students
could always see what work they had done, what work they were currently doing and
what work they still needed to do. This provided students not only with some
guidance on the order to complete the units but also with the necessary timing
information to pace themselves through the module. The changing icons hopefully
also provided encouragement to students. Students started with all but one icon
grayed out and as they progressed through the module completing work the icons
were updated, providing positive feedback each time a student completed a unit.

While the topics were the centre of the materials, the topic map was not an
appropriate front page for the module. One of the requirements of successful
navigation is that the module is easy to learn. This is especially important when it is
remembered that for many students Matter was their first experience of online
education. Presenting these users with the topic map could have been overwhelming
and threatening. Thus a very simple front page with only three options was added as
shown in Figure 4.3. The options are:

1. How to get started: A straightforward introduction explaining what the module is
   about and how it works.
2. Topics: A link to the topic map described above
3. Help with Computer problems: Help for students if they were having trouble
   running the module.

All three links came with JavaScript rollovers, which explained the options. Once
students understood the workings of the module they could either click directly on the
Topics link or bookmark the topic map to go there directly. In this way the navigation
supported both new and experienced users.

For first-time users the link How to get started quickly explained the workings of the
module. Keeping this brief as possible was seen as important as in the user profile it
had been identified that students disliked long instructions and were unlikely to read
them carefully. As well as explaining the course workings the murder mystery was
Figure 4.3 The front page for Matter
introduced. Students were placed in the role of an ace detective and asked to give their detective a name. This was used to focus the attention of the students and try and personalise the module (Fleming 1998, Basiel, Jones and Dudman 1999). At the end of this explanation, one of the links provided was to the first unit.

The last link provided on the front page was *Help with Computer problems*. This largely repeated a typed sheet sent with the CD containing the module. The requirements for the course, in terms of browsers, plugins and cookies, were explained. While some technical terms were obviously necessary, these were kept to the minimum as it was recognised that users with few technical skills and little confidence in their technical ability are easily deterred. Even relatively simple questions such as asking users to identify their browser can be very off putting (Fleming 1998). Providing solutions for these problems was beyond the scope of the module so the offered solution in many cases was to ring the NTOEC for help. The page was designed to provide reassurance and to encourage students and their families to seek help. The link to the page was positioned on the front page as it was thought students were most likely to have problems at the start of the course. Once students had started it was hoped any difficulties would have been resolved or students would be more likely to ring for help. This is consistent with providing navigation in context where it is most likely to be needed.

Much of the organisation for the module had now been determined. A structure had been implemented with a front page that provided one main path into the module and from there built in complexity. The topics and access to the units through the topic map had been established. The last step in the high level design was to identify any other necessary tools and to implement a global navigation bar.

Three other links/tools were needed: *what u need*, *clues*, and *email*. The units included practical experiments, which required students to organise the relevant equipment. Ideally, students should do this before starting work on the unit. So students would be able to do this, a page detailing the practical equipment needed for each unit was added. This page was titled *what u need*. A *clues* page showing
students which clues in the murder mystery they had collected was also added. Initially this page started with a table of search icons. As students found clues the table was filled in. The final tool was an email link. While this would not be an option for all students it was seen as a very valuable tool for those students with email access. Placing it on the global navigation bar made it easy to access at all times and would hopefully encourage students to use it.

Glossary and search facilities were considered. Two possible options for providing a glossary were discussed. One was based on the traditional print glossary where a list of terms is provided in alphabetical order. The other was more in keeping with the Web environment. Key words in the text of pages would be linked and definitions provided in situ. As the latter was seen as being more valuable and easier to use, it was implemented. Ease of use and relevance are key issues when it is considered that students are reluctant to check their answers in the back of the book. With respect to the search facility it was decided after some discussion not to implement it. Search tools are quite sophisticated and the students would need to be taught how to use them. Given the age group and the lack of opportunity naturally provided in the material for searching it was felt a search facility would not be well used. Time and money for development were limited and it was important to use both as profitably as possible.

The global navigation bar was composed of five links: the front page (the Matter logo), topics, what u need, clues and email. In Figure 4.4 it can be seen at the top of the screen where it appeared on every page with the exception of the front page. Providing a global navigation bar is a very common design on the Web as it ensures both that navigation is consistent throughout the site and that it is always readily available (Fleming 1998, Rosenfeld and Morville 1998). The topics link provided access to all the units so the students could easily and quickly access any part of the module. This partly solves the problem of students being lost in hyperspace as at least now students can always return to a known point. The issue of students always knowing their current location is discussed in the next section 4.4.2 The prototype for...
an individual unit. The other links provided on the toolbar were chosen as these were seen as features students may wish to access at any time. JavaScript rollovers were also used for the links so as to provide feedback to the students.

The toolbar was placed in its own frame and this guaranteed that it would always be available on the screen. Frames are a contentious issue and some designers are strongly opposed to their use (e.g. Nielsen 1996a and 1996b, Muehlbauer 1998). The main objection is that pages using frames do not meet normal user expectations of Web pages. Bookmarking of specific frames is not possible, printing is problematical, pages from another site can end up framed within the frameset and the certainty of where information from links will be displayed is lost. While these are important considerations, Matter was being used by a small group of students for whom it was felt that many of these issues were not as relevant. Students would use the pages over a period of time and as long as the layout was very consistent problems of uncertainty over the page behaviour would disappear. Students were not required to connect to the Internet so the issue of pages being incorrectly framed was unlikely to arise. Given the age group, bookmarking was unlikely to be missed by the end user. Printing, however, did remain a disadvantage for this approach. The pages could have been developed without frames but the time taken to do so would have been longer. As stated before, time for development was limited and it was felt the time saved using frames outweighed any disadvantages. It should also be noted that there is support among some Web designers for well-designed frames (e.g. Niederst 1988, Fleming 1998) and even Nielsen (1996b) in an article titled, Why Frames Suck (Most of the Time), acknowledges this.

The money available to the project ($2000) was used to commission a graphic designer to design the graphics for the front page, topic map and toolbar. This was

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21 Where outside URLs were referenced a new browser window was opened. While not done for this reason this prevented pages from another site becoming framed within the Matter pages. This is described in more detail in the next section 4.4.2 The prototype for an individual unit.

22 The designer also helped with some of the graphics in the body of the units.
seen as important as the topic map in particular was central to the module and a set of
original, recognisable, consistent-style icons for it was needed. Kirsanov (1997)
describes this as “an immensely difficult task even for a person with good design
skills”. The graphics helped not only to give the module its “own personality” but
also provided a more polished and professional finish to the module. Young students
are probably more susceptible to the impact of colour and graphics than older users
and so this was an important consideration.

4.4.2 The prototype for an individual unit

Once the high level or global framework had been considered the next step was the
individual units. To increase the usability of the site these needed to have a consistent
look and feel. A prototype or template for one lesson was developed and then this was
used for all the subsequent units.

The prototype development involved three steps:

- The different types of links needed were identified and methods for implementing
  them devised.

- Tools for handling student answers needed to be identified and developed.

- Style sheets and the template for the individual lessons were developed

4.4.2.1 The different links

Ginige, Lowe and Robertson (as cited in Benyon, Stone and Woodroffe 1997, p. 201)
identify three types of links: referential, associative and structural. Referential links
point to simple annotations of key terms, associative links point to related pages while
structural links provide the structure for the material. ‘Structure’ here refers to the
organisation used for the material and could for example be linear, hierarchical or
networked. The links used in Matter fell broadly into these three categories. While
each of these different types of links had a different implementation, from the user
perspective all the links appeared the same. In each case to activate the link the user
needed to click on the link.
The first type of link implemented was the structural link. The hierarchical structure for the module had already been implemented through the topic map and the following discussion is concerned with the structure within an individual unit. The material for each unit was broken into separate pages with each page as far as possible covering one main idea. The length of the individual pages varied considerably from the shortest pages, which were only one screen full, to the longest page which was five or six times this length. The length of the page was determined by the complexity and needs of the subject content being covered and there was no attempt to standardise the length of the page. Both standardised and non-standardised page lengths are used on the Web (Horton 1994) and the approach used here was in line with guidelines made by Gillespie (2000).

Within a unit, ideas and concepts were developed over the pages in the unit. The pages were with a few exceptions designed to be linear and have students work sequentially through the material. This is consistent with providing students some degree of scaffolding so that they can efficiently structure their learning activities. Use of essentially linear paths may seem inappropriate for electronic media. However, as Misanchuk, Schwier and Boling (2000, p.246) write in relation to their course, “Our primary audience would be students ... who would be unfamiliar with this content and therefore most comfortable working through sections or subsections in a guided, or linear, manner.” It is important that decisions are educationally driven and not technologically driven.

However, providing only a linear structure was seen as too restrictive. Different students will learn and use the materials in their own unique way and even an individual student is likely to use the materials in different ways at different times. For example, a student accessing the material for the first time may use a linear route but, when revising, the same student may well wish to access the pages in a more random order. The overriding concern, however, was to ensure that with the increased range of choices students did not become overwhelmed by the possibilities and lose sense of the overall structure.
The design chosen used two vertical frames. The left hand side frame is narrower and contained a table of contents. Each page in the unit was listed and a direct link to that page provided. The right hand frame was used to display the individual pages making up the unit. At the bottom of each of these pages are forward and back arrows to move through the unit. Figure 4.4 shows a typical page with the navigational bar and arrows. For students working through the unit for the first time the arrows would probably be the most useful. Students revising or rereading earlier passages may find the links in the table of contents more useful.

The design chosen is in common usage on the Web and it was hoped students would find the navigation intuitive. As both the global navigation bar (in the top frame) and the table of contents (in the left hand frame) were always available, students could move quickly and easily between all the different parts of the module. To help students with a sense of location the name of the current unit was displayed in the table of contents frame. Links to visited pages were displayed in orange while links to still-to-be-done pages were displayed in yellow. This is shown in Figure 4.4. Thus students could easily tell what pages they had done, what page they were on and what pages still needed to be done. This format was used for all the units so the navigation remained consistent within the module.

Separating the table of contents bar from the tool bar clearly highlighted the structure of an individual unit. Each entry in the table of contents was a page, which was designed to contain one main idea or concept. Thus the framework of the unit was made explicit and, as explained earlier, this can help students visualise the conceptual structure of the material. Different colours were used for the links to pages students had already done and to pages students still had to do. This allowed students to visualise clearly their current location in the unit and how that location fitted into the conceptual framework of the unit. This design also provided timing information to students. The length of the unit was apparent, as was the student’s location in it. Thus students had a clear indication of how far through a unit (or a day’s work) they were and how much was still to be done. This was only an indication as the pages were not
a standard length or designed to take a similar time to complete. Despite this, it was still an important guide.

The next type of link was the referential link, which point to simple annotations of key terms. In *Matter* this type of link was used for much more than just this. For these links a separate window was opened. The size of this window varied with the amount of content but it ranged from being sufficient for a couple of sentences to approximately half the screen size. As can be seen in Figure 4.5, the window has no menu bars and a close button to exit. This type of link was used whenever a link needed to be associated to the current location rather than jumping to a new page. The advantage of this type of link is that the current context remains the same and the natural flow of the text is not lost. Basiel, Jones and Dudman (1999) report success with using a separate window in this way.

Referential links proved useful in several different situations. The most obvious was to provide definitions or remind students of details that had already been covered. For example, whenever the electronic journal was referred to, a link to a pop-up window (i.e. a referential link) describing it was provided. In some cases the link was used to provide extra information on a topic. One example was at the end of the metals unit where extra information on five or six different metals was provided. For each metal the relevant link opened a window with a couple of paragraphs describing the metal. For clues, this type of link was also appropriate. As students completed units, links to clues became available and these appeared in a separate window. All these situations are similar in that these links are in-line. When the link window is closed the student’s context has not changed.

The last type of link was the associative link that provided links to related pages. These links could be to pages within the same unit, to pages in other units or to pages on the Internet. While the three appeared the same to the students they posed different implementation problems. Links to pages within the same unit were straightforward. All that was needed was to change the contents page, as the table of contents
Materials are made of matter

All material is made of matter. Everything that you can see, touch, smell, hear or taste is made up of matter.

Look around you: chairs, desks, cupboards, beds, cars, trucks, grass, cattle, aeroplanes, rivers, fish, air. These are all examples of matter.

The particle theory of matter

Scientists have a theory that all matter is composed of particles. These particles are so small that they cannot be seen even with a powerful microscope. Scientists have come up with this theory after looking at all the available evidence.

Figure 4.4 Typical course page: Navigational bars and arrows can be clearly seen.

Figure 4.5 Referential link: Popup window appears when link on underneath page (electronic workbook) is clicked.
navigation bar remained the same. To return to the previous page, students could either use the table of contents or the browser’s back button.

The intra-unit links were particularly useful for providing hints. For example, at the end of some units there were summary quizzes, which were marked by the computer. Rather than provide answers for wrong questions students could be directed via the link to the page with the answer. As students needed to get a certain number of questions right before they could proceed to a new unit, there was certainly motivation to follow these links up.

Unfortunately, links to pages in other units were not as neatly handled. Unlike going to a new page within the unit, changing to a new page outside the current unit involved not only changing the content page but also changing the table of contents page. This did not pose a problem in going to the new page but rather in how to return to the previous page. Returning is an important requirement as after students have looked at a referenced page they are quite likely to wish to return to the previous context and continue working. As two pages had changed, students needed either to press the browser back button twice or return to the page through the topic map. Neither of these options were particularly satisfactory solutions. It should be noted that if time had permitted and tables had been used rather than frames, there would be no difference between intra and inter unit links.

The associative links between units were used only to refer students to related material in earlier units. In keeping with the need to provide guidance on the order to complete units it was decided not to link earlier units to later units. While this would represent the relationship between concepts in the material better, there was a danger that students who followed such links to later units would become disoriented. It was even possible students may not realise they had changed units and would try and complete the wrong unit. Given too that the material in later units built on earlier units these links would only be useful for revision or review purposes. Students working through the material for the first time would be unlikely to understand it fully. Links to earlier units were not a problem as students would have seen the
material before and should understand it. This is similar to the approach taken by Misanchuk, Schwier and Boling (2000, p. 246) who chose to “de-emphasize browsing and ad hoc linking from one topic to another” as they were primarily designing for students “who would be unfamiliar with [the] content” and not designing for it “to be used primarily as a reference”.

Deciding which units are earlier than others is somewhat problematical as the order of topics and units was flexible. Within an individual topic the units are ordered but between topics it is not possible to say which units are earlier than others. Thus associative links were used only within topics or from the summary topic to earlier topics. In practice this was not found to be a limitation.

The last type of associative link was to pages outside the Matter module and on the Internet. For a number of reasons these links were used sparingly and were never essential to the module material. As discussed earlier in the section 4.2 Hardware and software selection, many students would not have access to Internet connections. Further, even if students did have Internet access, due to cost factors students were unlikely to be connected to the Internet while working on the module. Connecting to the Internet was likely to involve dialing up and unless the link was particularly worthwhile it could easily be an unwanted distraction.

These links were implemented by opening a new browser window for the link. This was done so students could easily return to the page they had been working on before going to the link on the Internet. With a separate window students would only need to close the window (and the Internet connection) to return to their place in the module. While this implementation is similar to the referential links implementation, there are differences. Unlike with referential links these were full-sized browser windows,

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23 ISPs can charge by the time connected and being connected with an idle line can become expensive. Even when a customer has unlimited access, some providers will disconnect them if their line has been idle over a period of time.
which included the menu, tool and address bars. All features normally available in a browser were enabled. This was not the case for referential links.

Nielsen (1999a) lists opening a new window as one of his top ten new mistakes of Web design. He comments, even ignoring the "user-hostile message implied in taking over the user's machine", that users often do not notice that a new window has been opened and wonder why the browser's back button no longer works. This can lead to the user feeling lost in hyperspace and wondering how to return to familiar territory. Designers open new windows to try and stop users leaving their site but he notes the resulting confusion can actually defeat this purpose. These objections were not raised when discussing referential links, as Nielsen was obviously not targeting this form of use.

While agreeing with Nielsen's objections, the researcher felt that Matter was a special case; any links to the Internet were clearly explained so students were aware that they needed to connect to the Internet and that a new window would open. They were told that when they had finished looking at the site all they needed to do was close the window. This would hopefully limit any confusion experienced by the students over a new window opening. In addition by explaining both what was happening and why it was happening, it was hoped students would not resent a new window being opened but rather would see it as a helpful tool.

4.4.2.2 Handling student answers

The different types of links had now been identified and ways of implementing them devised. Attention was then turned to the next step in developing the prototype of a unit, which was the handling of student answers. This was discussed in 4.2 Hardware and software selection where various different methods for handling assessable and non-assessable work were identified. The assessable work that students would submit for marking was to be stored in an e-journal. A template of the e-journal was sent on the CD and students could use any text editor (e.g. Notepad, Word, ClarisWorks) to add their answers. The e-journal was then sent back by e-mail or post to the NTOEC.
for marking. To minimise the impact on teachers and their workload, the format of the e-journal was designed to be quick and easy to mark. Students were requested to send their work after they had completed half the units and at the end of the module. The module displayed reminder messages on the screen when it was time for students to send their e-journal.

Using a text editor or word-processor for the e-journal, which was not part of the Web-based module, did have some advantages. Tools for spell checking, editing and formatting typically come with text editors and word-processors and these would be available to the students to use. In addition students could use and build on the skills they had already developed with these packages. The disadvantage was that the electronic journal was not linked to the module and so the student was required to switch between the two applications i.e. the Web browser and text editor. Ideally, this transition should be seamless and not be dependent on the student to manage it. This was not the case.

Where students had access to email, teachers would provide fast feedback on the e-journal. This is obviously important as feedback needs to be timely and in general the quicker the feedback the more valuable it becomes. Email also allowed for more flexibility. For example it was now possible for students to send draft copies of work for comment from teachers. Or if students misunderstood or missed questions the work could be resent after corrections had been made. These options were not feasible using the postal system as turnaround times are too long. Note too, students were also not limited to sending their work only twice in the module. This was seen as the minimum but, if either the teacher or the student felt it was necessary, work could be sent more frequently.

For students who did not have access to email and so had to rely on the postal system, feedback times would remain the same as for the print module. As discussed in the earlier section 4.1.2.2 Practical requirements, feedback could be slow with mail turnaround times of up to a month. In these cases opportunities for timely feedback would be limited to phone calls. Unfortunately, the students with the slowest mail
connections tended to be the most geographically isolated and these are the group least likely to have access to reliable Internet connections. Conversely students closer to rural centres and hence more likely to have regular postal services were also more likely to be able to connect reliably to the Internet. Thus, in general, those with the most to gain were the least likely to be able to take advantage of email.

Non-assessable work, or those exercises that students marked themselves, was handled differently to the assessable work in the e-journal. Student self-assessment is a powerful method of encouraging reflection, a necessary part of the learning process (Laurillard 1993). Basiel, Jones and Dudman (1999) suggest using self-assessment as a formative method of evaluation or feedback in the learning system in addition to the traditional summative assessment techniques. As discussed earlier in 4.2 Hardware and software selection, storing student answers was a difficulty for the Web-based module and so students' answers to these exercises were usually not stored. Cookies could be used to store some answers but unfortunately the limitations on the number and size of cookies meant that they could not be used to store all of them. Thus, unlike the print module, the Web-based module did not have a way of ensuring students had attempted all the exercises. The print modules, however, were not without their problems. In the section 4.1.2.2 Practical requirements, it had been noted that students were notoriously bad at checking their answers against those supplied. This is even though the answers were readily available and at the end of each set of exercises students were required to tick a box stating they had checked their answers. Design strategies to encourage and check that students firstly completed the exercises and then secondly checked their answers were needed for the Web-based module.

One strategy was to include automatic markers. Many of the non-assessable exercises were recall and simple comprehension exercises, which were included so students

24 This need not necessarily be always the case. Devlin (2000) notes that the level of communication services varies considerably in isolated communities.
could check they had understood the material correctly. These exercises included multiple-choice questions, close exercises and questions with one-word answers. These sorts of exercises are suitable for automatic marking as the questions have one unambiguous right answer. Where possible automatic marking was included by adding a solution button at end of the exercise. Depending on the exercise, when activated the marker would highlight which answers were wrong, allow students to have another attempt and finally provide model answers. Automatic marking did not ensure that students completed the exercises but it at least highlighted wrong answers. It was still up to the student to review why their answer was wrong. Crown (1999) used similar quizzes in an engineering graphics class and found in his evaluation that students reacted very positively to the quizzes and noted “The JavaScript quizzes gave the best return given the limited investment of time”.

Another use made of automatic marking was to provide a random quiz of the atomic symbols. Students were required to learn the atomic symbol for common elements and the quiz chose 10 elements at random and tested the students on their atomic symbols. Thus each time the test was taken, different elements were chosen. It was hoped students would continue taking the test until they consistently achieved 10 out of 10.

Automatic marking was not appropriate for all exercises. Some examples were exercises requiring sentence or descriptive answers. For these exercises when the solution button was clicked the answers were displayed without any comments first being made on the students’ answers. The answers were displayed in blue and appeared straight after the questions. They stood out clearly from the surrounding black text. Here again, as with the print module, the onus was on the students to check their answers.

Strategies to ensure that students had completed at least some of the non-assessable exercises and checked their answers were still needed. The Web-based module kept track of the units students had completed. A unit was marked as finished when students found the clue to the murder mystery. Using the automatic markers from
above it was possible to ensure that students completed certain exercises before making the clue available. This fitted well in the game aspect of the module, where as players progress up levels in the game (or complete units), more tools (or clues) become available to them. Desire to find the clue would also helpfully motivate students to complete these exercises.

The content of the units was examined. Some units finished with an assessable exercise from the e-journal. These were often summative and to complete them successfully students would need to understand the work from the non-assessable exercises in the unit. Thus for these units, while the completion of the non-assessable exercises was obviously desirable it was not seen as a major concern. This left the units where this was not the case. Summary quizzes that covered the major points of the unit (and hence the non-assessable exercises) were added to the very end of these units. These quizzes were automatically marked and students were required to achieve a certain minimum score (normally around 8 or 9 out of 10) to complete the unit. As students could not proceed to a new unit until they had finished the current one, it was important to ensure that eventually all students could achieve the required score and so move on. Hints for each question were provided. These were links to the relevant passages in the text. Thus if students had skimmed and skipped pages the first time through they would now need to reread them. As students jumped from page to page looking for the answers it was necessary that their answers to earlier pages were remembered. Cookies were used to do this.

4.4.2.3 Developing style sheets and templates

Methods for handling student answers had now been devised and implemented. These coupled with the implementations developed for the different links could now be combined to produce a prototype for the unit. This involved establishing style sheets and page templates. The importance of style was discussed in 2.5.1 Functionality of the browser. Style sheets were used to ensure the pages throughout the module had a consistent look and feel. They also simplified maintenance as global changes to all pages could easily be made. On a technical note, style sheets were used for style rules
to be applied to HTML elements as specified in the Cascading Style Sheets Level 1 (CSS1) recommendations and did not use the positioning elements recommended by the Cascading Style sheets-Positioning workgroup (CSS-P). Dynamic positioning was done on the fly under JavaScript control so as to accommodate the differences between Netscape Navigator and Internet Explorer browsers\textsuperscript{25}.

The last step was to establish the page templates in *Dreamweaver*. Templates can be used for documents that have a common structure and appearance, as was the case for the unit pages. Information common to the unit pages was added to the template. This included the navigation bars, arrows, layout of the page content, common JavaScript and links to the style sheet. Part of template included an HTML table with a fixed width for the page text. This ensured that regardless of the browser or monitor the line of text would always be around the recommended line width of eight to ten words\textsuperscript{26}. To enhance the appearance the text was also centred on the screen.

Once the template was applied to all the unit pages it allowed for information to be edited on all the pages by simply editing the template and then reapplying it to the unit pages. The elements unique to each page remained unchanged but the common template elements were updated on all the unit pages. This ensured the unit pages had an identical layout and format and helped enormously with the maintainability of the pages. Frame templates were also established for the unit frame sets.

The templates not only allowed for features such as uniform formatting, reuse of materials, easy modification and flexibility found in traditional templates but also allowed for the limited inclusion of teaching and learning strategies. The latter included the quizzes, automatic marker, murder mystery clues, hints and other such tools that were largely achieved through DHTML and JavaScript.

\textsuperscript{25} See 2.5 Technical considerations in implementing an instructional design for more discussion on this.

\textsuperscript{26} See 2.4.2 Qualities of well-written online pages for more details.
4.4.3 Writing the individual pages

The site architecture and organisation had been developed. Templates for individual units and pages within the unit had also been established. These templates not only defined the structure and general layout but also contained the tools that would be needed within the units. The last step was to write the actual content. While it might be the last step in the development of the module its importance cannot be underestimated. The purpose of the module is after all in its content (Nielsen 1997a).

The content of the module was based on the print materials written by the NTOEC. The writer, T1, had considerable experience in writing science lessons for secondary-aged distance education students. Consequently, the presentation, activities, and style of writing within the module had been carefully chosen for the target audience. The materials had also been used and found to be successful. Thus this in conjunction with the page template which controlled the line length of the text and some minor adjustments meant that the style of writing was also appropriate for the Web.

Developing the individual units was a two-step process:

- The instructional design for an individual unit was established. This included designing the organisation of the unit and choosing the activities.
- Resources needed were created or found.

While this process is listed here as sequential, in practice it was far more cyclical. The resources available obviously impacted on the instructional design chosen for a unit. Discovery of new resources or difficulty in creating the required resources often caused the instructional design stage to be revisited.

4.4.3.1 Instructional design of units

As identified in 4.1.2.1 Pedagogical requirements, one of the aims was to include a more constructivist approach to learning in the Web-based module. The materials in the print version were still to be used as the basis for the Web-based version but the manner of delivery was modified.
The following discussion refers to lesson 4 in the original print-based course. The print-based materials and the Web-based version are included in Appendix B. In the print materials the following learning sequence was largely applied:

1. An explanation of the theory was given: for example, the particle theory was introduced at the start of the block of work on it.

2. Experiments or exercises highlighting features of the theory were added: for example, in lesson 4 an experiment showing that surface tension existed was done.

3. A scientific explanation was then given of the completed experiment or exercise: In the example, surface tension and how it related to the particle theory was explained.

4. Examples of the phenomenon were then given: examples of using surface tension for washing up, waterproofing and cleaning up oil spills were given.

A more constructivist approach would involve turning the lessons around. Instead of beginning with the explanation of the theory, the starting point could be the examples or experiences of the phenomena. In this way the students' prior knowledge would be activated, which can aid in the construction of knowledge. After having set the context, a more problem-solving process to explain the phenomena could then be followed. Students could be asked to devise a hypothesis, carry out an experiment to see if their hypothesis works, check the solution and then look back and learn from the process.

This process was implemented for the lesson on surface tension. The resulting pages needed to be very structured and could not assume that any communication with others was available. Even though phone calls to teachers can always be made, due to time and money constraints this is generally reserved for student problems rather than as a teaching strategy. Thus a modified version of the problem-solving strategy suggested above was needed.

The Web-based version starts with leaves floating on water and asks students why they think this happens. Space is left for the students answer and it is assumed that
they will hypothesise that it is because leaves are light. This is then given as the hypothesis that needs to be tested. While, ideally, students would now devise their own plan to test their hypothesis (which may not have had anything to do with weight), this was not feasible for the Web-based version. Accordingly, the Web-based pages then asked students to complete an experiment (that was from the print version) that shows weight alone cannot explain why leaves float. Students are specifically asked to try and explain the phenomenon in terms of weight and should hopefully realise that this is not possible. Answers explaining why this is not possible are included to ensure students can stay on track. The need to modify their hypothesis is discussed before the particle theory explanation of surface tension is given. Surface tension is a complicated concept and it was not thought feasible to expect students to devise it by themselves.

It was hoped that this approach would at least encourage students to think more about the concept and realise that weight alone was not enough to explain it. To further encourage this thinking process the pepper scatter experiment was included. It is an unusual phenomenon and needs an understanding of surface tension to explain it. The idea of developing a theory also tied in well with the murder mystery and the theme of the module.

The Web-based module also offers the chance to include more interactivity. An example of that was at the end of the change of state unit and is shown in Figure 4.6. A video showing red-coloured water in a sealed conical flask was added. As the air above the water is heated, the water will rise up the tube and when the heating stops the water falls back into the flask. The students were guided through a series of steps to explain why this was happening.

Other changes were also made to the Web-based module. As discussed earlier, within each unit of work the sequence was mainly linear. Concepts and ideas are developed

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27 The idea for this experiment came from the Questacon Web site at www.questacon.edu.au.
'Seeing' the particles move faster

While we obviously can't actually 'see' the particles or atoms speed up we can observe the effects. We are gathering evidence to support the particle theory.

In the following video clip, a flask is half-filled with coloured water. A stopper and glass tube are put into the flask. A bunsen burner is then used to heat the air (gas) above the water. Look what happens.

Heating a gas

Why is the water rising up the tube?

How can the particle theory explain this? Let's work through it slowly.

When the gas (air) was heated above the water, the particles in the gas were heated up and this caused the particles to do what?

The particles speed up as they get hotter. Now if the particles in the gas are going faster, what can you say about the force they will hit the surface of the water?

The hotter the particles, the faster they travel and thus the harder they hit the water. As the gas particles hit the water particles harder they push the water level down. This forces the water to rise up the glass tube.

What happens once the heating stops?

If that all makes sense, have a think about this. What do you think happened once we stopped heating the air above the water? Can you explain it in terms of the particle theory?

To help you think about these questions:

What happens to the temperature and speed of the gas particles after they are no longer being heated?

What will happen to the force with which the gas particles heat the water?

What effect will that have on the water level in the tube?

Remember you can always discuss this with your teacher by phone or email.

Figure 4.6: An example of text from the change of state showing use made of videos and interactivity in the Web-based module.
over the unit and this requires students to work through it in a sequential manner. There were however exceptions. For example in the unit on Metals, there was a section explaining how to tell metals from non-metals. This consisted of a list of differences and there was no need for it to be presented in a linear manner. In these sorts of situations, a slide show presentation as shown in Figure 4.7 could be used. As the cursor is moved down the list passing over State, Lustre, Ductility etc. the text and graphics change. It was felt that this style of presentation would be less daunting than a lengthy page of text. It also more accurately represents the structure of the knowledge.

The delivery of the final unit test was also changed. In the print version, the module test was at the end of the second response booklet. In the Web-based module, students were not allowed into the test until they had completed all the units. They were also only allowed into the test once. Once they completed it, they either emailed it to the NTOEC (automatically done by clicking on the submit button) or, if they did not have email, they needed to print the test out and mail or fax it to the NTOEC.

Due to time and money constraints, the changes made to the Web-based module were not as extensive as the researcher had hoped. This is discussed in much greater detail in the next chapter, The findings.

4.4.3.2 Creating or finding resources

The appropriate use of graphics and colour was seen as important. The students were young and there was a need to make the materials as appealing as possible. This was reflected in the print-version, which though in black and white (due to cost considerations) included numerous pictures, tables and diagrams to break up the text. The Web-based module only had limited funds available and it was not possible to
Telling metals from non-metals

Click on Guide or Automate to see the slides.

More on Malleability

Solid non-metals are brittle and shatter when hammered.

You have metals strips in your science kit. Using a hammer, beat one end of the zinc strip. See how it can be flattened without cracking.

Figure 4.7 Slide Show: presentation used within the Metals unit
create all the necessary graphics. The graphics designer\textsuperscript{28} employed by the project converted some of the print-based graphics for the Web and added colour to them where appropriate. The Web includes many clip-art libraries and these were scanned for appropriate graphics. All but one of the libraries used were free. Finding appropriate pictures was a very time-consuming business. Unfortunately too, as the graphics were not created for the module they lacked a certain cohesion with each other. This gave the module a slightly mish-mash look and detracted somewhat from its final appearance.

With the use of CDs it was now possible to include video clips. The module materials themselves took up very little space and there was ample room to include some video segments. The print-based modules already made use of such videos either as additional material for interested students or as an alternative to parts of the text. As not all students had access to video machines, alternatives to video always need to be supplied. Similarly, with respect to the Web-based module not all students had suitable equipment to view the videos so it was necessary to provide alternatives.

Under current copyright laws, schools such as the NTOEC can videotape and reproduce educational programs from the TV for use in their courses. There is no charge payable and consequently TV programs are the main source of the NTOEC's educational videos. Unfortunately, putting the videos on the CD would involve converting them to a digital format. Schools have no rights under copyright law to do this or to produce digital copies for students. The permission of the copyright holder is needed. Copyright holders were approached and were prepared to discuss the issue. Not unreasonably they had concerns over unauthorised access and reproductions. As time was limited and the negotiations had already taken some time this avenue was not further investigated for this project.

\textsuperscript{28} As discussed in 4.2.1 The site architecture a Web graphics designer was employed to create the front page, topic map and navigational bars.
During the project, the NTOEC acquired a digital camera and so could produce its own video clips. Five clips showing various experiments were made for inclusion on the CD. The experiments chosen include those that students did not have the equipment for, were too dangerous for students to do, or were experiments students had historically had trouble in doing. One was chosen to experiment with a more constructivist approach to learning.

Educational games were also added to the module. The print-based materials already had a crossword as revision at the end of the module and using JavaScript this was included in the Web-based version. T2 felt that these sorts of activities were popular with students and any additional activities along these lines would be beneficial (personal interview with T2). As the Web environment has an increased level of interactivity, this allows for the inclusion of a range of activities not possible in print. One such activity was a Web-based version of hangman, which was used at the end of the Change of state topic to help students learn the new terminology in the topic. The game included a range of words from the topic and for each game one was randomly selected. Another was a jigsaw puzzle of the change of state diagram. Both these were implemented using JavaScript.

4.4.4. Testing and Distribution

So far in this chapter the design and development process followed for creating the module has been described. The last step in the developmental process was to test the module in a range of different browsers on both Macs and PCs. Some testing had obviously been done during the creation of the module. However as discussed in the 2.5 Technical considerations in implementing an instructional design, there are so many variables in page display that extensive testing of Web pages is essential.

Care had been taken throughout the development to make sure pages worked in both Internet Explorer and Navigator. The development was done on a PC but T1 at the NTOEC, who had been constantly involved, used a Mac. Thus it was hoped that as both browsers on both platforms had been used during the development many of the
possible problems would already been identified and addressed. Unfortunately, in practice this was not the case as a significant number of new problems surfaced during testing.

Some of the problems were due to known differences. Forms render differently on Macs and PCs and making sure the display was reasonable on both platforms was tedious. Other problems were caused by differences in functionality, which were not always clearly documented (if at all). Once realised, most of these problems could be solved in a relatively simple way; the difficulty was in realising there was a problem in the first place. Various Web sites on Web development were particularly useful in identifying potential problems. The most difficult problems were those due to bugs in the actual browser software. These could take a considerable amount of time to track down and in one case required rewriting substantial sections of code. Internet Explorer 5 was released during the project and pages that had worked in earlier versions of Internet Explorer now crashed. This required a rewriting of some pages.

A couple of identified problems were never solved. None was critical, as ways of working around them always existed. The most annoying problem was found in Internet Explorer 4 on Macs. When students returned to a page they had already accessed, any JavaScript on the page was not rerun. Thus when students returned to the Topic map after having completed a unit, the map would not be updated to reflect this change. Clicking on the Refresh button in the browser solved the problem. This was clearly documented for the students but even so it is an unsatisfactory situation. Pages should work as expected and not rely on students to perform workarounds.

The CD was then distributed to the students. A letter explaining the project, some information on how to get started and an initial questionnaire were also included.

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30 Some versions of Internet Explorer 4 on Macs do not correctly handle option buttons in forms. If the page is to work in these browsers, JavaScript referring to option buttons have to do so in an awkward and non-intuitive manner that is both less maintainable and flexible than the original code.

31 Goodman (1998) reports that IE 4.0 on Macs is well known for not supporting all features.
CHAPTER FIVE

FINDINGS OF THE STUDY

The findings of this study have been organised with reference to the research problem and questions asked in Chapter 1. The overriding problem this study investigated was stated as follows:

If an online module is developed from a set of pre-existing printed materials is the resulting course likely to be cost effective? What technical issues will need to be addressed? What is an appropriate instructional design? Will the resulting product result in improved educational outcomes? Having created one online module, what are the implications for transforming other modules online? In other words, is the whole exercise worthwhile from an administrative, educational and technical point of view?

The specific questions the study addressed were:

1. Given the situation of the NTOEC and its students, what technologies were the most appropriate to use in the delivery and development of the new module? Which desirable features of these technologies could be incorporated successfully in the design of the module?

2. What limitations are placed on the instructional design if only those technologies identified in the response to the last question are used? Given these limitations, what would be the distinguishing features of an effective instructional design? Once determined, can the design be implemented so that it is easy for the staff and students of the NTOEC to navigate?

3. As a result of using the new module, what were the student and staff levels of satisfaction with the learning and teaching and how did the educational outcomes of the students compare with using the print-based materials?
4. How did the money, time, skills and other resources needed to develop, run and maintain the new module compare to those required for the print-based course? Can the process, developed for one module, be readily reused for another module?

The first two questions are primarily concerned with the development process in creating the new module and their answers rely heavily on the material presented in the last chapter. The last two questions address the comparative success or failure of the pilot project and the long-term viability of online education and their answers rely heavily on the summative evaluation detailed in section 3.5 Data analysis.

Part of the summative evaluation is assessing the impact or the long-term effect of the pilot project. When writing this thesis, a more cohesive approach to these discussions was found possible when impact was addressed as part of Chapter Six: Conclusions of the Study. It avoided the necessity of repeating points in both chapters and accordingly is found there.

This chapter has five sections: one section for each of the four questions detailed above and one section for the conclusion.

5.1 The first research question

The first question asked by this study was:

Given the situation of the NTOEC and its students, what technologies were the most appropriate to use in the delivery and development of the new module? Which desirable features of these technologies could be incorporated successfully in the design of the module?

The answer to this question is presented in two sections:

5.1.1 What technologies were the most appropriate to use in the delivery and development of the module?

5.1.2 Which desirable features of these technologies could be incorporated successfully in the design of the module?
It should be noted the choice of technology is traditionally one of the first steps in any software development because it can impact heavily on the subsequent design (Shelly, Cashman, Adamski and Adamski 1995; Benyon, Stone, and Woodroffe 1997; Ellis, Torokfalvy and Carswell 1998; Bell and Lefoe 1998). This was clearly the case for this study and thus the basis for this answer has already been largely detailed in the section 4.2 Hardware and software selection.

5.1.1 What technologies were the most appropriate to use in the delivery and development of the module?

Summary
The module was forced to use CDs rather than the Internet to deliver the module, as the level of the telecommunication infrastructure available to the students of the NTOEC was inadequate to support the delivery of a Web-based module via the Internet. Web technologies rather than other CD authoring tools were used to develop the module, as in theory if not entirely in practice, these technologies are platform-independent. Thus only one version of the module needed to be developed and this could be used on all platforms. Similarly, implementing the e-journal using text editors (e.g. Word, Notepad, Claris Works) native to each student's machine also negated any need to consider different computer file systems (e.g. Mac OS, Windows).

Justification
While there is a range of possible technologies that could have been incorporated in an online module, many of these options were simply not feasible in the NTOEC's situation. Any technology used needed to match the equipment and type of connection to the Internet being used by students and staff of the NTOEC. As discussed in 4.2 Hardware and software selection, the provision of Internet services to remote and rural areas of the Northern Territory was poor and so using the Internet to deliver an online module was not possible. The only practicable option was to use CDs and the postal system to deliver the CD.
Web technologies were used for developing the *Matter* module, as they are platform-independent, so that in theory at least only one version of the pages was needed and those pages would work on any platform with a Web browser. However, in practice when the *Matter* module was developed, a considerable number of discrepancies were found between different platforms and dealing with these discrepancies took about 3 weeks. While this was a significant amount of time, it was still incomparable to the time it would have taken to produce separate versions of *Matter* module for different platforms. Using web technologies also caters well for future developments. The telecommunications infrastructure in the NT will surely improve and using the Internet to deliver online courses will become a feasible option for the NTOEC. This approach of catering for the future is similar to that taken by Misanchuk, Schwier and Boling (2000). For these reasons, Web technologies as opposed to other CD authoring software were most appropriate for this study to use.

Ensuring only one version of the module was needed was important when considering how students' work or their e-journal should be handled. In *Matter*, a template of the e-journal was sent on the CD and students could use any text editor (e.g. Notepad, Word, ClarisWorks) to add their answers. The disadvantage\(^1\) with this approach was that the e-journal was not linked to the module and required the students to manage the switch between the two applications i.e. the Web browser and text editor. However, managing the answers directly from the pages would require consideration of the different file systems used and thus require variations for different platforms (e.g. Windows, Mac OS), which would have substantially added to the development times and costs. A considerable advantage of this approach was that tools for spell checking, editing, printing and formatting which typically come with text editors and word-processors were available to the students to use. For these reasons, using a word processor external to the application was clearly the best option for this study.

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\(^1\) As will be seen in the answers to the third and fourth research questions managing the switching between applications was a significant problem for the students.
5.1.2 Which desirable features of these technologies could be incorporated successfully in the design of the module?

Summary
Using CDs instead of the Internet to deliver the module impacted on which features of the online environment could be successfully incorporated into the design of the module. All forms of electronic communication (e.g. email, chat, discussion groups) were not available. The advantage of CDs was that multimedia was included with little consideration of bandwidth issues. Other desirable features, such as extensive hyperlinking of pages and client side coding, that allowed for dynamic rather than static pages were also incorporated. Restricting the use of all these features was economic considerations as most of these features are expensive to produce when compared with traditional print production. The establishment of page templates and code libraries helped to reduce the costs involved in producing web pages.

Justification
With the use of CDs rather than the Internet to deliver the modules all forms of electronic communication such as email, chat, discussion groups and list servers were not available. As the response to the next research question points out, this imposed a serious limitation on the instructional design of the Matter module.

While the decision to use CDs for the Web-based module was forced by circumstances, there were some advantages to this approach. Without a reasonable bandwidth, pages which rely heavily on graphics, multimedia and the latest Web technology can produce a frustratingly slow experience for users. Using a CD the issue of loading times disappeared and the design of the Matter module made extensive use of graphics and video clips.

While graphics, videos and multimedia all hopefully added to the educational merit and students’ enjoyment of the Web-based module, they were time-intensive and
costly to create. For example, the topic map depicted in Figure 4.1 and Figure 4.2 took a graphic designer 70 hours and cost $1750² to create. As the project could not afford to create all the graphics it needed, extensive use was made of clip art libraries. While this approach made economic sense, it did detract from the overall cohesive “look and feel” of the Web-based module. A major concern was to ensure a mish mash of pages did not result, which would have affected both the effectiveness of the graphics and the professional appearance of the pages. The compromise taken was to create the graphics used in navigation, the topic map, the tool bar and the main page while almost all the graphics found on individual pages were sourced from clip-art libraries.

The time and effort involved in making the video clips for Matter was also extensive. There were only five clips and in total all five only ran for between one to two minutes. The actual shooting of the videos involved three people and took around three hours. Some of this time was due to unfamiliarity with the equipment. However, even when the clips were retaken the next day due to a recording problem, filming still took well over an hour. Considering the organisation and planning time before the shoot of about three hours, the total time is considerable. The end product, while adequate was certainly not of a professional standard, due both to the technical limitations of the equipment used and the lack of expertise of the staff involved.

Other desirable features identified and included in the Web-based Matter were extensive use of hyperlinks and client-side coding. Including hyperlinks in the Web-based module was found to be both quick and cheap as long as sufficient thought was given to the structure of the material before coding started. Substantially changing the links after the material had been developed was time-consuming.

Client-side coding using JavaScript was also used extensively in the Web-based Matter. For example, JavaScript was used for form processing, the games (e.g.

² Please see section 5.4.1 Time and costs to develop the module for more details on costing.
hangman, crossword, picture puzzle), automatic markers and managing the murder mystery. Client-side coding was found to be cost-effective. The use of JavaScript libraries ensured that code need only be written once and then could be reused throughout the project with minimal effort. Libraries can also help limit the problems caused by client-side coding discrepancies found in the different browsers. The Matter experience found considerable differences in the JavaScript available under the different browsers. Some differences are intended while others are bugs, but in either case the onus was on the developer to ensure they pick a subset of commands that work in all of the target browsers. Given this, any code needed to be carefully checked on a variety of platforms. Once checked, the code was placed in a library and then was used with confidence by other pages. This helped to reduce the development time of pages and helped ensure high quality, bug-free code.

The use of templates also needs to be stressed. Using templates, as was described in section 4.4.2.3 Developing style sheets and templates, had numerous advantages including ensuring consistency between pages, quicker page development and easier maintenance. The JavaScript libraries were included in the templates and so JavaScript code was readily available to any page. This use of templates was in the style advocated by Jones and Jo (1999). They argue that such templates not only simplify design and offer cost and time savings but also importantly can enhance the learning performance of students. Incorporating tools encourages their use and can help to develop an interactive and successful educational environment.

5.2 The second research question

The second question asked by this study was:

What limitations are placed on the instructional design if only those technologies identified in the response to the last question are used?

3 Target browsers refer to those that the pages are suppose to work under and for Matter these were version 4 browsers and above.
Given these limitations, what would be the distinguishing features of an effective instructional design? Once determined, can the design be implemented so that it is easy for the staff and students of the NTOEC to navigate?

As with the answer to the previous question, much of the basis for the answer of this question is provided in the previous chapter Development of the Web-based module.

Summary
The lack of electronic communication tools severely limited the effectiveness of the instructional design of the Web-based module. "Pure" constructivist approaches to teaching and learning were not possible as collaboration is one of the essential components of these approaches. The lack of adequate communication tools to supplement the content also meant that some benefits that had been hoped for at the start of the project such as more timely feedback and the potential to lessen student isolation could not be realised. Distinguishing features that were possible to implement included the adding of constructivist elements and increased interactivity to the instructional design. Constructivist elements included the Murder Mystery, multiple structures and paths through the material, the use of multimedia to provide multiple perspectives on the material and rewriting some lessons so they started from the students' experience rather than the theory. Increased interactivity was provided with the inclusion of quizzes, automatic markers, games, slide shows, multimedia and videos. Unfortunately the full potential of these benefits was not realised, as the scope of the project was too large for the time, money and resources allowed. Consequently the final instructional design lacked cohesion and some features, such as the Murder Mystery, were not incorporated as well as the researcher had hoped. On a more positive note, staff and students found navigation around the Web-based module trouble-free.

Justification
The choice of technology made for a particular software development can impact heavily on the subsequent design. This was clearly the case for this study where the limited choice of technology appropriate for the NTOEC situation severely limited
the instructional design of the Web-based module. At the start of this study, among the main benefits envisaged of the online environment was its potential to lessen student isolation, provide for increased interaction, provide for more timely feedback and with the increased collaboration possible allow for the implementation of constructivist teaching and learning strategies. Without any communication tools, as was the case for Matter, these benefits were restricted.

Initially, this study had started with the intention of investigating how constructivist teaching and learning approaches could be incorporated into the Web-based module. Unfortunately this became very difficult, as collaboration is one of the essential requirements for a constructivist learning environment (Tam 2000, Jonassen 1996). Thus for the NTOEC, the use of CDs precludes the inclusion of many constructivist strategies. The next best option was to attempt to include constructivist elements where the opportunities arise (workshop with Dr. Penny Little on 22 October 2000).

One such constructivist element included trying to limit the linearity naturally found in the print version and highlighting the interconnectedness of the material. Hyperlinks, as discussed in section 2.3.3 Organising Information and scaffolding, through providing nonlinear links between pages of information can model the conceptual interconnectedness that is core to the notion of knowledge. This representation provides not only a realistic portrayal of knowledge but can also help support higher-levels of cognition. However, with this style of representation it is essential that sufficient scaffolding be provided to students so that they are encouraged to engage deeply with the material rather than simply skip and scan through it. Matter, as discussed in previous chapter, attempted to design this style of learning environment. Central to this design was the reorganisation of topics and deciding how and where to provide links to related material.

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4 For further discussion see section 2.2 Constructivist theory of learning,
A unifying concept for the module, the nature of theories, was identified and this provided a conceptual framework for all the learning. In support of this, the murder mystery was designed as an ongoing theme throughout every unit in the module. Unfortunately, as time and money ran out for the development of the module this was one of the casualties and was not integrated into the module as well as had been hoped.

For some of the individual units the order of the material was changed. Instead of starting with the theory and then explaining some examples the unit started with the examples or experiences of the phenomena and then led the students through the process of developing a theory to explain the phenomena. This is more akin to the constructivist theories of learning where central to the learning process is a problem which is the trigger for a learner’s “puzzlement”. Again lack of time and money prevented most of the units being changed to this approach.

Tools that maximise interactivity and feedback were used to enhance the value of the constructivist elements and create a better learning and teaching environment. Quizzes, automatic markers, games (e.g. hangman, crosswords, picture puzzles) and slide shows were examples of such tools. This is consistent with the approach taken by Crown (1999) in an engineering graphics class where he used quizzes similar to those in *Matter* and found them both effective and popular with students.

Videos and graphics were used to provide different views or perspectives of the material. The visual appearance of the material is especially important when the age of the students is considered. As discussed earlier, economic considerations limited the extent that videos and graphics could be used. An important design issue was identifying those elements that most improved the actual educational experience for the students rather than those that simply improved the appearance of the page. For

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5 See section 4.4.3.1 *Instructional design of the units*

6 See section 2.2 *Constructivist theory of learning* for more details.
example the video clips produced were selected either because they demonstrated an experiment too difficult for the students to do at home or to present a problem for the students to solve. The latter use allowed for a more constructivist approach to learning and teaching to be used.

Developing the Web-based module turned out to be a much more ambitious project than the researcher or the staff at the NTOEC had initially realised. In retrospect, there were probably insufficient funds, time and resources to fully do justice to a project of this size. Simply producing the lessons and testing them on a range of different browsers and platforms was much more time-consuming than had been thought. Without the necessary funds, time and resources, the advantages that the Web-based environment offers to teaching and learning were not fully explored or realised. Many ideas, such as the Murder Mystery, were not properly developed. Consequently, the final module was not as complete or as polished, as those involved with the development of the module had wished.

As well as not developing some ideas fully, other ideas were not even attempted. For example, at the start the researcher had ambitions of including an interactive Java simulation of the atoms in solids, liquids and gases. Students would have been able through controls on the screen to interactively change the temperature of the atoms and change the size of containers holding the atoms. Compared to the print descriptions, such a presentation on the behaviour of atoms in matter would have been very much more concrete, visual and dynamic. Such an approach would also have allowed for what-if experimentation. Students could then have been guided towards developing a theory to explain what they had observed. Such an approach was more likely to engage the students and encourage meaningful learning. Implementing such a simulation was certainly feasible as the researcher had the necessary Java programming skills.

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7 See section 4.4.3.1 Instructional design of the units
With the benefit of hindsight, this study would have been better served if only part of the Matter module had been transformed into a Web-based module. For example, transforming only the lessons on the particle theory would have enabled the researcher to develop the simulation discussed above, incorporate the Murder Mystery fully and rewrite the lessons to start from the student’s perspective. Time would have been available too, to include videos, games and quizzes where appropriate. Such a project, about a quarter of the size of the one undertaken, would inevitably allow for a more finished and educationally exciting module than the one undertaken.

Unfortunately this study implemented the whole of Matter and as discussed many of the changes to the instructional design were not fully implemented due to a lack of time and money. Accordingly, it limited this study’s capability to collect meaningful data on the effect of these different approaches on teaching and learning. A smaller study clearly would have been better positioned to provide more data on what constitutes an effective instructional design for a Web-based course. Having said this, personally the researcher has doubts on whether without communication tools the change in the teaching and learning approach embodied in an instructional design would be sufficient to generate measurable changes in student learning.

The final part of this question addressed whether the design could be implemented so that it was easy for the staff and students of the NTOEC to use. On this, the findings of the study are more definite and positive. Note that this question only considers usability in terms of information design as opposed to usability from a technical standpoint i.e. whether once in the module, students could find and use the necessary resources. Usability from a technical standpoint is covered in the next two sections. As students and staff used Matter, the researcher observed that they had little difficulty in navigating around the site and finding resources. The teachers, too, did not report any instances of students being “lost” in the module. The participants did not offer unsolicited comments and when directly asked reported no difficulties with the information design. Somewhat perversely, this lack of response was pleasing to
the researcher, as the better the information design the less aware the users are of navigation and movement through the pages. The important characteristics of this design included the topic map, toolbars, menus and different link implementations. These were detailed in more depth in *Chapter Four*.

While this study did not obtain hard data to answer this research question, it did provide strong indications to the NTEOC on some elements of an effective instructional design. The approaches indicated above and explained in much greater detail in *Chapter Four* follow from constructivist principles. They are consistent with Web design principles, are relatively straightforward to implement using Web technologies and are applicable to the current print versions of the modules. Remembering that this study looked specifically at using existing print materials as a basis for a Web-based development, the strategies developed in *Chapter Four* would appear to offer the basis for an appropriate and, hopefully, educationally effective approach to online developments. If and when communication technologies become available as an option they could certainly be integrated into this approach.

### 5.3 The third research question

The third question asked by this study was

> As a result of using the new module, what were the student and staff levels of satisfaction with the learning and teaching and how did the educational outcomes of the students compare with using the print-based materials?

**Summary**

The student and staff levels of satisfaction with the new module was very low. This was mainly due to technical difficulties experienced by the students and staff with the delivery of the Web-based module. So overwhelming were these problems that only three out of 13 students who attempted the Web-based module managed to complete it. Surprisingly, despite these negative experiences all but one of the participants was still positive about the potential of the online environment and expressed interest in
future developments. Due to these technical problems the study obtained little data on the educational outcomes of the Web-based version but the researcher's early impressions are that there would not have been any significant difference between the print and Web-based versions. Given that the Web-based version was based heavily on the print version this is not unexpected.

**Justification**

Unlike the first two questions, much of the data used to answer this question and the next comes from the summative evaluation detailed in section 3.5 *Data analysis*. The evaluation identified two objectives and for each of these objectives a number of performance indicators were chosen. This section addresses the first of those objectives and its performance indicators before more fully answering the research question posed above.

The first objective was stated as:

> To improve the learning environment for students by using a different medium and approach to teaching and learning than is possible with the print-based materials.

Indicators to measure this objective were:

1. Take-up rate of module by students
2. Student skills needed to access the module
3. Time taken and completion rates for the module (utilisation)
4. Improved learning outcomes
5. Student/teacher level of satisfaction with module
6. Level of contact between students and staff and students and students

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It should be stressed that it was only the researcher's impression that there was no difference in the educational outcomes between the two versions. Given the problems students faced in running the web module, the study was unable to determine if the animations, videos and structuring of links between concepts had the capacity to change the educational outcomes.
Each of these indicators will be assessed before the research question is discussed.

5.3.1 Take-up rate of module by students

Twenty students had completed Matter to some degree in either the print-based or electronic format by the end of the academic year. The take-up rate, that is the number of students who attempted the electronic version of Matter, is given in Table 5.1.

<table>
<thead>
<tr>
<th>Number of students</th>
</tr>
</thead>
<tbody>
<tr>
<td>No suitable access to a computer</td>
</tr>
<tr>
<td>Had access to a computer and attempted the Web-based module</td>
</tr>
<tr>
<td>Had access to a computer but did not attempt the Web-based module</td>
</tr>
</tbody>
</table>

Of the six students with no suitable access, two were traveling around Australia and four lived in locations that did not have computer access at home or near by. One student approached her local library about the possibility of using their computers but was refused permission. The library expressed concerns over the use of an outside CD. Even intervention by her teacher from the NTOEC was not sufficient to change the library's position. The student concerned had reasonable computer skills and was keen to try the Web-based module.

...
The other fourteen students had access to a computer. Of these half had a computer at home that they could use while the other half relied on access through a school or office. For the latter group, their access was limited to certain times and required that they walk to the school or office. This walk took less than five minutes in all but one case when the walk was 20 minutes.

Of the fourteen students who did have access to a computer, thirteen attempted the Web-based course. This high participation rate was in part due to most students only being sent the CD initially, though in these cases the printed version was sent as soon as requested. The only student who chose not to attempt the Web-based module had had problems in term two and was behind in her studies. She undertook Matter after most of the other students had completed it and in consultation with her teacher decided not to attempt the Web-based module. Both were afraid that, given the experience of other students who had attempted the Web-based module, it would slow her down when she was already attempting to catch up. This apprehension becomes very understandable when the low completion rates and the difficult experiences of the students detailed in the next few subsections are considered.

A generally positive initial attitude towards learning online was evident when the students were interviewed during the residential school in Darwin. At this point most students had been sent the CDs and had had significant trouble in using them to access the Web-based module. Despite this, 12 out of the 13 students expressed an interest in online learning and a willingness to be involved. This included the student, discussed above, who chose not to attempt the Web-based module. The general feeling appeared to be that it was something new and exciting. For example, one student who had had difficulties in accessing the Web-based module felt “it was a shame as books were boring”. None perceived reading and learning from the screen to be potentially more difficult than printed matter such as the booklets.

The only student who expressed a strong preference for learning from books had never been keen to try learning online. He had attempted the Web-based module and disliked the experience, which had further reinforced his preference for the printed
material. This student had a computer at home but was not particularly interested in computers.

5.3.2 Student skills needed to access the module

During the development of the module, every effort was made to ensure that the Web-based module was easy to use for both students and staff. In particular, the technical skills needed by the staff and students to use the module were kept to a minimum. The skills needed were identified as general file-handling skills, word processing, using a browser, sending emails if the student had access to the Internet and some typing skills.

A survey of student computer skills was done during the residential school. Students were asked about their computer experience and rated their level of skill. Thirteen students completed the survey including 10 of the 13 students who attempted the Web-based module. The results are detailed in Table 5.2 to Table 5.5.

Table 5.2 Frequency of computer usage

<table>
<thead>
<tr>
<th>Frequency of Computer Usage</th>
<th>Number of students</th>
<th>Students who attempted the Web-based module</th>
</tr>
</thead>
<tbody>
<tr>
<td>More than once a week</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>About once a week</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>About once a month</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Never or very occasionally</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Eight out of the 13 students or over sixty per cent had at least weekly access to the computer. Of the students attempting the Web-based module, this figure was even higher at eight out of ten or eighty per cent.
Next the skills of the students were examined. As Table 5.3 shows all students rated their typing skills as reasonable. Half of those who attempted the Web-based module believed they could “type pretty fast”. The other half rated themselves as “not too slow”. None of the students felt they were slow typists.

Table 5.3 Typing skills

<table>
<thead>
<tr>
<th></th>
<th>Number of students</th>
<th>Students who attempted the Web-based module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch type</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Can’t touch type but have had a lot of practice and type pretty fast</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Use two fingers and are not too slow</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Pick at the keyboard with two figures and it takes a long time to type anything</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The next two tables look at the particular applications students used. Table 5.4 displays what students nominated as their major computer activities while Table 5.5 displays the specific skills students believe they have.
Table 5.4 Main activities nominated by students

<table>
<thead>
<tr>
<th>Activity</th>
<th>Number of students</th>
<th>Students who attempted the Web-based module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Games</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Web or internet access</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Typing or doing schoolwork</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Other</td>
<td>1 Web page creation 1</td>
<td>1 email 3</td>
</tr>
</tbody>
</table>

The three students who used the computer monthly or less did not specify any activities. Thus the total number of students answering was ten.

Games and doing schoolwork were the most common uses of the computer. Half of those who attempted the Web-based module already used the computer for schoolwork and only three of the students nominated email as a common task. The main activities students used the computer for were then compared with the applications they felt they could use.

Table 5.5 Number who could use various applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Number of students</th>
<th>Students who attempted the Web-based module</th>
</tr>
</thead>
<tbody>
<tr>
<td>A word processor (such as Word)</td>
<td>13</td>
<td>10</td>
</tr>
<tr>
<td>Email</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>Using the Web to find information</td>
<td>11</td>
<td>8</td>
</tr>
</tbody>
</table>
would mean that students would have few skills for dealing with new, unusual or problem situations in computer applications.

5.3.3 Time taken and completion rates for the module (utilisation)

The completion rates for the Web-based module were very disappointing. Only three out of the thirteen students who attempted the Web-based module completed it.

The reasons for the low completion rate were entirely due to technical reasons. The major problems were negotiating the computer file system and managing answers to assessable questions. To do this, a file on the CD containing the questions needed to be copied onto their computer’s hard drive. As they completed the units they would be prompted by the Web-based module to fill in the relevant answers. These requirements appeared to create insurmountable difficulties for the students.

Problems started as soon as the CD was sent out. Two students thought their computers did not have a CD player, which seemed unlikely as in both cases their computers were relatively new. Another student managed to jam the CD player when trying to load the CD and as a result her mother refused to allow her to continue using the computer. About half reported being overwhelmed when the CD arrived and being unable to work out how to get started. An instruction sheet, which had been designed to be easy to understand and follow, had been sent with the CD.

Unfortunately these printed instructions proved insufficient for the students to enable them to get started. Two students reported loading the CD, clicking on the module and the browser or computer freezing. In both these cases the students seemed very unsure about what they had actually done and what exactly had happened. One possible and likely explanation is that the students clicked on a file other than

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10 Ideally students would copy the online module from the CD to their hard drive and run it from there. This would lead to faster loading times for pages. However this was not essential and the course could be run successfully from the CD.

11 The researcher had taught introductory computer skills to both school students and adults and had felt confident that students would understand the notes.
This could cause the difficulties described. Unfortunately, in neither case could the fault be repeated and so the problem could not be accurately identified.

To try and overcome these difficulties, during the residential school the students were shown how to access the module and use it. As described in the previous section, the students' skills in file handling were limited and they had difficulties in accessing the module, but once in the module they had little trouble in using it. After the completion of the residential school students returned home and to varying degrees had another attempt at using the Web-based module.

Four of the ten students who did not complete the Web-based module made little subsequent effort after the residential school. One had trouble accessing a computer at school and found the process too inconvenient. The other three lacked confidence and chose to use the book. Notably, despite their lack of confidence, all these three students expressed positive sentiments towards online learning.

The other six all attempted the Web-based module. The student who much preferred books to online learning went as far as completing the second unit. At this point his father rang up and requested that his son complete the book instead of the CD as he was not enjoying it and it was slowing him down.

A difficulty for this group, one that had not been anticipated, was the use of cookies. The Web-based module used cookies to remember a student's position in the course and some of their answers. The browser stores the cookies on the local computer being used. Thus students needed to always use the same computer. Further, as there was no idea of individual log ons, only one student could use each computer. If a second student used a computer the work of the first student would be displayed. Three of the students were using computers at a nearby school and another used two different computers. They did not realise that this was an issue that could have been dealt with and accordingly they became frustrated as they felt they were continuously losing work. Unfortunately, they did not make early contact with their teacher and, not surprisingly they switched to the booklet.
Trouble using the word processor for the assessable work and losing some of their work was also a common student complaint. The difficulties seem to revolve around managing both the browser and word processor, saving work and finding work again. In a couple of instances where students had lost work, the researcher was able to help them over the phone to find it by using the find file feature in the file manager program.

This lack of technical expertise by the students was compounded by the lack of technical help available to them. Both teachers responsible for delivering Matter undoubtedly did their best. However, while they are competent computer users, both reported that their skills were insufficient to help students over the telephone. Identifying the problems over the telephone was difficult, as students were often very unsure of what was or had happened and often could not judge what facts were relevant. For example, the problem described above of students using more than one computer, took a while to identify as the researcher did not think to ask immediately, nor did the students mention that they were using more than one computer. Another difficulty was that the hardware and software used by the students varied considerably. Both the teachers used PCs but half the students used Macs, which neither teacher had any expertise in. This made it very difficult for them to solve any problems. Both teachers made use of the researcher to solve some problems.

Communication problems also existed between those involved in developing the module and those running it. The two teachers teaching the module were not involved in the development of the module and had no choice about teaching it. One in particular admitted to finding the idea of teaching online daunting. Both reported a lack of confidence at the start, which may have been transmitted to their students. One teacher in particular stated that she thought managing Matter the second time would be much easier.

Of the three students who completed the Web-based module the time taken to complete it varied considerably. One student who is very computer literate reported that the Web-based module was quicker as all the non-assessable exercises were
integrated with the notes. Typing answers, he also felt, was faster than writing answers longhand in the print-based booklets. The second thought that the online and the print materials took about the same time. He did mention teething problems when he started and thought that if these were solved the Web-based module may be faster. The last student found the Web-based module much slower to work with than the print-based one. She experienced almost daily technical problems with the software and felt it ended up putting her five weeks behind in her studies.

5.3.4 Improved learning outcomes

Of the three students who completed the module there were no apparent differences in the learning outcomes achieved. Their grades were consistent with their marks for the other modules. One student, who attempted the Web-based module but did not finish it, received a markedly poorer grade. For the first half of the course he sent work from both the print and Web-based versions of the course. As parts were missing his grade for Matter suffered accordingly. For the second half of the course he used only the print version and his grade improved.

Both teachers felt the learning was essentially the same. T5, however noted

It is the same course, but as I said, if you could also incorporate a little bit of the computer learning in it, [don't] you think the kids are learning something more?

T4 felt the technical difficulties overshadowed any other benefits. However she said

But I think if you can get it up and running ... its got the potential to go really well, you can get nearly instant feedback ... I like the visual things in there, I like having the video clips. ... I like it and think it is the way to go.

Both teachers felt that while the Web-based module did not make any positive differences to learning outcomes, there was potential. The need to resolve technical issues was stressed.
5.3.5 Student/teacher level of satisfaction with module

Given the technical difficulties encountered, not surprisingly the level of satisfaction with the module was very low.

The teachers thought that the whole experience had been “a bit of a nightmare” and “it was so difficult to deal with all the technical problems”. Both commented on how little technical issues could create huge hassles. For example, T5 had received email from a student using a Mac computer that she had been unable to process until another teacher had “fixed it” for her. Both had felt some helplessness and lack of control over the process.

Student responses, among those who had attempted the unit but had not been able to finish it, were similar. They had found the whole experience very frustrating and stressful and some noted how it had put them behind in their studies. Their supervisors echoed this response.

The level of satisfaction for those students who completed the Web-based module varied considerably. One who experienced no technical difficulties found the whole experience very positive and much preferred the online course to the print version. The second student who experienced few technical difficulties was not as positive but still liked the Web-based course. He enjoyed the interactive nature of the media. His mother was very positive and thought her son had been more motivated and enjoyed it more than the printed books. The last student had experienced numerous technical difficulties and had shown great perseverance to complete the Web-based module. She commented, “[there were] problems with everything, there was not one thing that went smoothly” and as a result she strongly preferred the printed course.

The experience of the students who completed the course was very much determined by their technical skills and their access to technical help. Of the two students who liked the course, one was very much at home in the online environment, having already created Web pages, while the other student’s father had some technical skill.
The only time the latter student rang his teacher with problems was when his father was away. The last student who completed the module had limited technical skills and needed to rely on the NTOEC and the researcher for help.

5.3.6 Level of contact between students and students and students and staff - isolation of students

As noted in section 1.1 Background to the problem, student isolation is a major concern for distance education centres, which actively try to foster contact between students and students, and students and staff. It had been hoped that using the online environment would facilitate this type of contact.

Unfortunately this was not the case with the Web-based module. Given the poor Internet connections in remote and rural areas the Web-based module had to be designed using a CD rather than downloaded pages. Thus, in the design of the course the inclusion of communication tools such as discussion groups were largely precluded.

During the running of the Web-based module all contact for help with teachers was via the telephone. No help on content or technical problems was sought by email. The three students who completed the module all had access to email but only one student actually managed to send all his work via email. The other two cited “technical difficulties” and resorted in part to using the post. The researcher was not aware of any student-to-student contact via the Internet in conjunction with the Web-based module.

Even for those students who had Internet connections, regular use was not made of email. Only three out of the thirteen students surveyed nominated email as one of the applications they regularly used on their computer\(^{12}\). Thus for the majority of the

\(^{12}\) See section 5.3.2 Student skills needed to access the module.
students involved in the Web-based trial, email and other forms of communication via
the Internet were not a feasible option.

5.3.7 The research question

The research question to be answered in this section is

As a result of using the Web-based module, what were the students' and staff levels of satisfaction with the learning and teaching and how did the educational outcomes of the students compare with using the print-based materials?

As the previous sections have detailed, technical issues largely dominated the online experience for staff and students. With a couple of exceptions the experience was not successful for those involved as the technical difficulties they encountered totally swamped any benefits they might have experienced.

This problem with technical issues is a recurring theme in the literature (e.g. Cooper 2000, Gibson 1997, MacKinlay 1999, Warner and Christie 1999, Eastman 1999). Cooper (2000) considers her experiences of teaching online and states, “[T]he majority of the problems students encounter are computer-related”. Gibson (1997) when discussing the success of a trial in using the Internet for teaching and learning writes

Some students had difficulties receiving their email and became very frustrated simply because they had not entered their address correctly, or misunderstood the process of receiving email into their mail program. Any students who are not already proficient with Internet use will experience difficulties of various kinds.

Gibson’s reflections are even more noteworthy when it is considered that the students in her trial were adults enrolled in an Information Technology course.

MacKinlay (1999) reports on an email pilot study involving a small number of students where email was used as a major communication tool. Here they experienced
very low learner-participation levels to the extent that when, due to technical difficulties, email access was not available for a week the learners were unaffected. She believes the poor response "may be due to most learners not being regular email users as well as not being expected to use email in any other part of their course". This experience is very similar to that experienced in this pilot study.

What was surprising was the positive attitude that many of the participants maintained to online learning even after the somewhat disastrous experience of Matter. Many expressed a belief in the potential of the approach if the technical problems could be resolved. For example, even after they had started using Matter and experiencing technical difficulties, most students were still positive about online learning and expressed an interest in being involved. Likewise the teachers at the NTOEC are planning to use the online Matter module with the next group of Year 8 students.

This positive sentiment towards the adoption of computer technology as an innovation in teaching and learning is not always the case. Some studies report considerable resistance from participants to technology initiatives (Walker and Lê 1999, Suen and Szabo 1999). Walker and Lê (1999) write, "strategies have to be developed to facilitate acculturation of new users to this paradigm [use of technology] to prevent hostility and rejection of the advantages they bring to regional, rural and remote communities". For this study there was little resistance to the technology.

Due to the technical problems overwhelming all other issues, this project was unable to reach any other conclusions about the effect of the online environment on students' educational experiences. This was unfortunate, because as was discussed in chapters one and two, the online environment has the potential to transform distance education.

5.4 The fourth research question

The fourth question asked by this study was
How did the money, time, skills and other resources needed to develop, run and maintain the new module compare to those required for the print-based course? Can the process, developed for one module, be readily reused for another module?

Summary

The development of the Web-based module does not compare favorably with the print-based version of the module. Compared to the print-based version, the Web-based module was much more expensive to produce, took significantly longer and required a greater range of skills. Further due to the individual nature of each of the modules, it is suspected that despite the experience gained from this project any future Web-based development is unlikely to be significantly cheaper or less time-consuming to produce. Indications are that maintaining the Web-based module is also likely to be more expensive. While the Web-based module did take longer for staff to deliver and students to complete this was mainly due to the technical problems they experienced and it is suspected that once these problems are solved the Web-based module could be slightly quicker to teach and take.

Justification

Before answering the last research question the second objective of the evaluation and its performance indicators are addressed. The second objective was stated as follows:

Online education is a growing field with increasing relevance for the NTOEC, which want to find a cost effective and acceptable method of providing online education for distance students in the NT.

Indicators to measure this objective were:

1. Time and costs to develop the module
2. Skills needed to develop the module
3. Equipment needed to develop the module
4. Time and cost to maintain the module
5. Teacher time needed to deliver and manage the module
6. Reusability
Each of these indicators will now be assessed before the last research question is discussed.

5.4.1 Time and costs to develop the module

The amount of work and time taken to complete the project was considerably more than the researcher or the NTOEC had initially estimated. As stated earlier the researcher was an experienced Information Technology professional with a reasonable familiarity with HTML and considerable experience in converting printed text to HTML. Despite this, she grossly underestimated the time needed to restructure the material in a format that was both appropriate for the Web-based environment and which could take advantage of the increased interactivity offered by this environment.

The start-up to the project was slow, as neither the NTOEC nor the researcher had been involved in developing Web-based courses before. Exploring the different options available and learning about the technology took time. This happened on a part-time basis over about four or five months.

Realistic estimates from the design stage through to the implementation and testing phases are possible. The starting point was taken from the print-based module, which was used as the basis for the Web-based version. The time taken at various stages is detailed in the Table 5.6.
Table 5.6 Development time for the module

<table>
<thead>
<tr>
<th>Activity</th>
<th>Time Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designing the overall framework for the Web-based module</td>
<td>2 weeks</td>
</tr>
<tr>
<td>Implementing the framework i.e. the menu, topics maps, tool bars and</td>
<td>5 weeks</td>
</tr>
<tr>
<td>prototype for a unit including the necessary JavaScript and graphics.</td>
<td></td>
</tr>
<tr>
<td>Implementing the individual units including finding and creating any</td>
<td>8 weeks</td>
</tr>
<tr>
<td>necessary graphics.</td>
<td></td>
</tr>
<tr>
<td>Testing, debugging and distributing</td>
<td>3 weeks</td>
</tr>
<tr>
<td><strong>Total development time</strong></td>
<td><strong>18 weeks</strong></td>
</tr>
</tbody>
</table>

These times include only the hours spent by the researcher and the Web graphic designer in the development of the module.

The only actual significant cost for the development was the $2000 made available by the NTOEC and used to employ a Web graphic designer\(^\text{13}\). The rest of the labour was provided free to the project. However a more accurate cost of the project will be obtained if this labour is also charged. Using the rate charged by the Web designer of $25 an hour the total labour costs become:

\[
16 \text{ weeks} \times 40 \text{ hours} \times 25 \text{ per hour} = 16,000 \\
+ \text{ graphic designer costs} = 2,000 \\
\text{Total Costs} = 18,000
\]

\(^{13}\) This ignores the cost for incidentals such as the CDs, some graphics and postage. These costs pale to insignificance compared to the costs for labour.
These figures are conservative. The hourly rate used for the labour is very much towards the low end of the scale. These cost estimates also do not consider the costs for software or equipment.

The time estimates were also conservative. During the investigation phase many of the resources were traced or created and were thus already available to the project when it started. The staff at the NTOEC also spent considerable time testing, reviewing and suggesting changes and this time has also not been included.

5.4.2 Skills needed to develop the module

The skills needed to produce the Web-based course fell into three distinct categories:

- Instructional design skills were needed to ensure sound pedagogical principles were followed in the design and development of the module. As discussed in the literature review, instructional design for the online environment should be treated very differently from what is required for the print-based environment.

- Graphical skills were also important, to provide a professional appearance to the course, given that the Web is very much a visual environment.

- Technical skills were the final skills needed and covered page creation and scripting.

The set of skills above concentrates on those particular to a Web-based course. It assumes that course content has already been determined and also does not include skills such as project management, which are needed whether the course is print-based or Web-based. This set of required skills is consistent with those cited by other Web developers (e.g. Veen 2001).

The NTOEC staff have the skills needed for developing Web-based courses in varying degrees. Its teachers have had little or no exposure to the issues in instructional design for Web-based courses though their considerable expertise and experience in developing external print-based materials should significantly help them to make this transition. In terms of graphic design the NTOEC is well placed as
it does employ a graphical designer. However, given the time consuming nature of graphical development, there is a limit to what one person can achieve. Finally, in terms of technical skills, the NTOEC has had very limited experience in developing Web pages.

5.4.3 Equipment needed to develop the module

The equipment needed in the development of the Web-based module was not extensive or particularly expensive. The hardware used were standard PCs, a digital camera and CD burners while the software used was Dreamweaver for the Web pages and Adobe Photoshop and Flash for the graphics. At the start of the project, the NTOEC already had all necessary software and hardware.

5.4.4 Time and cost to maintain the module

Maintenance covers activities such as fixing errors in the page, ensuring the course works with new technology and adding minor modifications requested by students and staff.

With Matter, there were very few complaints or instances concerning actual errors in the pages\textsuperscript{14}. With sufficient testing there is no reason why this should not be the case for any future module.

Ensuring the course works with new technology will require constant attention. For example, Internet Explorer 5.0 was released as the Matter development was being finalised. Matter had already been tested successfully in several earlier versions of Internet Explorer but when it was trialled in version 5.0 it not only did not work correctly but actually crashed the browser\textsuperscript{15}. The researcher, in her role as the

\textsuperscript{14} As explained in the previous research question, setting up the module and running the word processor were the major problems - actual coding errors in the module or content errors were rare.

\textsuperscript{15} This experience with Internet Explorer 5.0 was not limited to the researcher. The Interactive Learning Division of the Northern Territory University reported similar problems with version 5.0 when it was first released (personal interview with ILD Director, Barbara White).
developer, had made a deliberate decision to follow standard coding practices and there appeared no reason why the crash should occur. The fix, in this case, was relatively straightforward but it did demonstrate the need to test the course continually as new technology is released.

The last of the maintenance activities, adding minor modifications to the module, is potentially the most time consuming and hence the most expensive of these activities. For example, with *Matter* the need for an *autorun* feature has been identified and it is planned to add this before the *Matter* course is used again. While it may appear that this sort of maintenance would decrease over the life of the module this is not necessarily the case. As the technology advances the desire to add new features may well increase and some changes to the content of the pages over the life of the module has to be expected. These latter changes are also an issue for the print-based version of the module. However, as illustrated in 5.4.1 *Time and costs to develop the module*, creating print documents is less time-consuming than the corresponding Web-based documents.

5.4.5 Teacher time needed to deliver and manage the module

The time needed by teachers to manage and deliver the Web-based version of the course was considerably more than that needed for the print-based version. Students experienced numerous technical problems and this consequently resulted in more contact with their teachers. As students and staff often had difficulty in first identifying and then solving these problems\(^{16}\) students spent more time contacting teachers than would normally be the case. Dealing with student frustration and trying to encourage students also took time and emotional energy. In instances when the teachers could not solve the problem and the researcher was contacted, more time had to be invested.

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\(^{16}\) The difficulties experienced by students and staff in identifying and solving technical problems were discussed in the previous section 5.3.
Of the three students who did complete the course, the time they required varied significantly. The one who had no problems rang once and, while speaking to the teacher, fixed a temporary difficulty. Another only “rang a couple of times” including a long conversation with the researcher when his work disappeared. The last rang “practically every day” and had several conversations with the researcher. Almost all of this contact had to do with technical issues and both teachers involved with the trial were confident that if the technical problems could be solved the contact time with students was likely to be comparable with that needed for the print-based module.

Both teachers involved in the trial thought that less time was taken up with administration tasks such as marking. One of the teachers said

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\text{It [marking] was just like that. You didn’t have to run your eye over all the other check questions that they did, because they obviously did that, you just got the assessed bits through and it was quick and it was neat.}
\]

5.4.6 Reusability

This section will consider the possible time and cost savings in transforming another Year 8 Science module in light of the Matter experience.

The first stage in the development of the Web-based module was exploring the different options available and learning about the available technologies. As the NTOEC becomes more experienced in online development, this step may become progressively quicker. However, online teaching and learning is a relatively new field based on technologies that are in a constant state of change and development. Hence exploration and research to keep current with the latest developments will always be needed and is likely to continue to be relatively time consuming.
Table 5.6 details the time taken by the various steps in producing the Web-based module. The first step was to design the overall framework for the module. Much of this basic design used in Matter could easily be reused in subsequent modules. The design ideas behind the main menu, topic map, toolbar and the individual unit layout are sufficiently generic as to be usable by any new module. What will be unique to each individual module is its particular grouping of lessons into topics and the addition of any overarching theme such as the Murder Mystery. Given the similarity between all of the print-based modules, grouping the lessons of a new module into topics should neither present a problem nor take very long. However, finding an overarching theme and considering how to integrate it successfully into an individual module is very particular to that module and thus the task is unlikely to become significantly quicker as more modules are transformed online.

After the framework has been designed, the next step was to implement it. If the new module incorporates a theme sufficiently different to the Murder Mystery, little of the Matter framework will be relevant. In this case, the time taken for the implementation of the new framework will depend on the particular theme chosen but it is reasonable to assume that the time taken will be similar to that for the Matter implementation, i.e., around five-weeks. Even if the Matter framework is relevant to a new module, the framework makes considerable use of icons and graphics. These were particular to the Matter module and would need to be redesigned and created for any new module. Creating the graphics took about half of the total time for the implementation of this stage. Thus, while the Matter experience will be helpful and some parts of its implementation can be reused, any new implementation will still take a substantial amount of time.

Having established the framework, the next stage was implementing the individual units and finding and creating any necessary resources such as graphics. These tasks are heavily reliant on the individual content of the units. With Matter, the researcher

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17 This framework was detailed extensively in the previous chapter.
found that the time taken to transform the last unit into a Web-based format was only about 10-20 per cent less than that to transform the second unit. Graphics, videos and games can both add to the educational merit and to the students' enjoyment of the module. However, all are time intensive to produce or find, as was the case with the clip art graphics. As their reusability is usually very limited, this task needs to be basically started from scratch for each new unit; the experience of past units does not significantly help the process with a new unit.

Having created the module, the last stages undertaken were testing, debugging and delivery. As with the unit creation these stages are very particular to the module. The experience gained while testing and debugging Matter will be useful but is unlikely to result in substantial timesavings. Links still need to be tested, new browsers tried out and any new technologies thoroughly tested.

Thus, transforming a new module into a Web-based format using the process followed in the Matter implementation is unlikely to take less than three months. This compares with the four and half months suggested for Matter. If new technologies or approaches were to be investigated and tried, the time taken for any new module is likely to be similar to that for Matter. It should be remembered that this discussion so far has revolved around the transformation of another Year 8 Science module into a Web-based format. If a module from another subject or year was to be transformed, the time and cost savings, as small as they are, would likely to be even less.

5.4.7 The research question

The research question to be answered in this section is

How did the money, time, skills and other resources needed to develop, run and maintain the new module compare to those required for the print-based course? Can the process, developed for one module, be readily reused for another module?

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18 The first lesson is largely developed as part of the overall framework for the module.
The Web-based development costs detailed in section 5.4.1 *Time and costs to develop the module* did not compare favourably with the development costs for the print-based materials. In that section the conservative estimate for transforming *Matter* to a Web-based format was four and half person months at a cost of at least $18,000. A print-based module is usually written in a month and this time includes finding the content and sequencing that content into units (personal interview with T1). As the Web-based module was based on the print-based version, this investigation time was not even included in the estimates for the Web-based version. The production costs of printing and distributing the print-based module are more than for the Web-based module, but these extra costs are insignificant when compared to the development costs.

The high costs for online development appears to be a recurring theme in the literature (e.g. Rosenfeld and Morville 1998; Benyon, Stone and Woodruff 1997; Misanchuk, Schwier and Boling 2000; Luca, Wilson and Sinclair 1999; Crown 1999). Gibson (1997, p.12) estimates that “current production and development methods can have costs which quadruple the initial writing cost”. Underestimating the cost and time also seems a common lament. As Misanchuk *et al.* (2000, p. 225) write:

> Having written a couple of books each on the subject, we felt confident we knew the amount of work involved in creating an equivalent project in a multimedia format. However, we rather quickly discovered that we had seriously underestimated the amount of time and effort involved and had to limit our content to visual design. In retrospect, it should not have been surprising that creating multimedia HTML pages would take substantially longer than writing an equivalent amount of material for a book. Researching and producing the text and graphics, per se, were no more time-consuming in this instance than when writing a conventional book. However, determining the optimal structure and sequence of the content and working out the consequent navigation system took far more effort and time than we had anticipated.

And further on they go on and write:
The project took a long time to complete ... It seems that even experienced professionals are capable of falling prey to confusion, regression and generally forgetting all they know when faced with a new medium, technology or format. ... The lesson to carry away from our experience, then, is that multimedia development (as we have so often warned our students, but had to relearn the hard way) takes longer than it does (Misanchuk et al., p. 226).

To develop the Web-based module also required new skills in instructional design, graphics and technical areas. This is not to suggest that these skills, especially the first two are not needed in the development of the print-based modules. Veen (2001, p. 16) argues that the “the only way to successfully communicate through a printed page is to tie together the stories being told with how they are presented in such a fundamental way as to achieve something greater than the sum of their parts”. With the online environment it is not only that the content and presentation need to be considered but also the added dimension of interactivity and user behaviour. It is the interplay of these parts that will ultimately significantly determine the success of the course. Thus, as the experience of this project demonstrated, the NTOEC will need to develop both these new skills and a new approach to the development of modules that successfully integrates these skills together.

When the increase in time, costs and skills for development of the Web-based module are considered it was hardly surprising that maintaining the Web-based module was also found to be more time consuming than for the print-based module. The same difficulties experienced in developing the course are also experienced in maintaining it.

With respect to delivering and administering the Web-based module the results from this study are less clear-cut. While this study found that the delivery time of the Web-based module for teachers was greater than that for the equivalent print-based version, this was mainly due to technical difficulties that can reasonably be assumed to be solvable. If this is the case, the delivery time for an online course appears to be similar to that for print-based courses. Marking and administration for teachers using the Web-based module was quicker than for the print-based one.
The extent to which the time and costs for developing one Web-based module can be harnessed by subsequent modules is an important consideration for the NTOEC. The first module was time-consuming and expensive to transform online, but if the costs and effort significantly decrease as more modules are transformed online then the process could well become economically viable for the NTOEC. Unfortunately, it was clearly demonstrated in section 5.4.7 Reusability that little if any of the Matter implementation was reusable.

In summary the answer to this research question is overwhelmingly negative. The development and maintenance of the Web-based module was far more expensive than that for the print module. As the development of each module is highly individual, the process is unlikely to become more economically viable. From an economic viewpoint there seems to be little value in developing Web-based modules such as Matter.

5.5 Conclusions

This chapter has detailed the findings of this study, which have not been overly positive. With the existing telecommunication infrastructure in the NT, the only feasible option was to use CDs. This limited the options for the instructional design and thus some of the anticipated benefits that had been hoped for. However, an improvement in the telecommunications infrastructure in the NT is only a matter of time and thus so is the use of the Internet to deliver online courses. This study detailed an approach for an appropriate and effective instructional design.

The delivery of the pilot study was not a success and did not deliver an improved educational experience for students. Technical problems dogged the delivery of the module. The evaluation also found that online development was much more expensive than for equivalent print-based materials.

Despite the negative findings of this study, the researcher still believes that the online environment offers much potential to the NTOEC. The approach taken by this study
was clearly not feasible but other approaches may well be. The next and last chapter in this thesis looks at what has been learnt from this study and considers new ways forward for the NTOEC.
As detailed in previous chapter, the online module was not a success. The delivery of
the online module experienced significant problems and the development approach
taken in creating the online module was not economically viable. Despite these
findings the online environment still offers much potential\(^1\) to the NTOEC and should
be investigated further. The pilot study highlighted many areas for further
investigation and suggested some possibly more effective approaches that the
NTOEC could follow for future online developments. These suggestions may well be
the most significant impact of the pilot project on the NTOEC.

This chapter reviews the findings from this study and gives a series of
recommendations for future online developments undertaken by the NTOEC. The
recommendations only address issues directly raised by the study. Some areas such as
organisational infrastructure and change management issues while clearly important
are not addressed as these were outside the scope of the study. The sections in this
chapter are:

6.1 The technical expertise needed to use the online environment effectively
6.2 Technical issues in developing online courses
6.3 Selecting potential online projects
6.4 Developing an appropriate instructional design for online projects
6.5 Conclusion

\(^1\) See details in Chapter 2: A critical review of the literature
6.1 The technical expertise needed to use the online environment effectively

As detailed in the last chapter, technical problems experienced by the students were the major failing of the online module. The online module assumed a level of technical skill which the vast majority of students did not possess. Of the two students who had few difficulties in completing the module, one had excellent technical skills and the other had a parent who could provide the necessary technical help. Any future online developments by the NTOEC would clearly need to rectify this imbalance between the technical skills required and those possessed by the participants.

Addressing the imbalance can be handled in two ways: either the skill level needed to use an online course can be lowered or the skill level of the participants can be improved. Obviously both approaches have potential. The first correlates well to a general consideration in all software development that a program should be as user-friendly and as easy-to-use as possible. After all, if a user can’t successfully use a program, its capabilities and features are largely irrelevant. This was clearly demonstrated by the experience of the online module. One improvement to increase Matter’s usability, the inclusion of an autorun feature on the CD, has already been identified. This feature could automatically setup the module on the user’s computer and provide icons on the desktop to both run the module and access the e-journal. As many of the problems experienced with Matter were with accessing the module and managing the e-journal, an autorun feature is likely to significantly cut back on the problems experienced.

Recommendation 1: The skill level required for using any online course needs to be minimised and the addition of any features such as an autorun that limit the technical skill needed by the participants must be a priority.

The other approach suggested for closing the imbalance between the technical skills required and those possessed by the students is improving the skill level of the students. Given that we live in a world increasingly dominated by technology, for
young people in particular a reasonable level of technical proficiency must surely be an educational priority. Students of the NTOEC should be able to manage basic file handling, use a word processor or spreadsheet program, browse the Web and send emails. While these skills are arguably essential for students to have in the twenty-first century, they are also necessary if the NTOEC wishes to realise the potential of online education. The NTOEC should investigate ways of providing such training to students. This could be done via specific computing courses and the residential school could be used to demonstrate and practice some skills. Another more holistic approach would be to embed the skills within a context. For example, a suggestion made by one of the teachers involved in the pilot project was to teach Social Science, English and Computing together in an integrated package.

Recommendation 2: Appropriate courses need to be provided to ensure all students have basic computer literacy skills.

A concern for the NTOEC is that not all students will have access to a computer. For example, with respect to the online module, 30 per cent of students did not have access either at home or at a location nearby. The NTOEC will need to always ensure that for any online course they provide an appropriate alternative. Not only does this add to the cost, but more importantly, there are also equity issues to consider. The importance of ensuring access for all students was highlighted in the Human Rights and Equal Opportunity Commission's *Education Access: National Inquiry into Rural and Remote Education* (HREOC 2000a, 2000b, 2000c and 2000d) and many of its recommendations deal with ways of achieving this. The NTOEC is obviously aware of these issues and needs to continue to be so.

Recommendation 3: All steps that can help students to have access to the necessary technical equipment need to be pursued.

Access is only the first step in using an online course. It also requires the availability of adequate technical help for those times when students experience difficulties with the online course. While the teachers at NTOEC are proficient users of the
technology, as this project found, expecting them to provide a comprehensive Help Desk facility for their students is unrealistic. Fixing problems over the phone is difficult and is further complicated when the extensive range of hardware and software being used by students is considered. However, if this support is not provided in a timely fashion, small problems can totally stall a student’s progress. Teachers, too, need access to adequate technical help to deal with problems that arise\(^2\). If the NTOEC is serious about continuing with online education, this facility must be provided.

Providing both a separate Help Desk and relevant professional development courses for teachers involved in delivering online courses would appear to be an excellent option. Training teachers to provide a Help Desk service to their individual students would be inappropriate, and wasteful of resources, given the level of expertise needed for such a function. A dedicated Help Desk, as is found in most large organisations, would allow for the concentration of resources and the development of expertise in a few individuals. Having stated this, basic training for teachers about some of the technical issues involved would clearly also be beneficial and it would increase their level of confidence in dealing with online learning.

**Recommendation 4:** A dedicated Help Desk needs to be established to provide adequate technical help to students and staff in a timely fashion.

**Recommendation 5:** Basic technical training with an emphasis on issues related to online learning should be provided to all teachers involved in delivering online courses.

The economic cost of these first five recommendations will be considerable and the NTOEC has only limited resources. However, while these recommendations are

\(^2\) See section 5.3.5 *Students’ and teachers’ level of satisfaction with the module* for details of situations that can arise and need for adequate and timely technical support.
framed in terms of online education, technical literacy skills are a fundamental issue in education that concerns much more than online education. Most educators would accept that technical literacy skills are essential for students in the twenty-first century. Thus, providing for the teaching and learning of these skills should be a priority for the NTOEC and decisions about the allocation of the necessary resources should be made from this viewpoint. Online education only provides extra evidence as to the importance of these skills.

Technical skills are a precursor to online education in the same way that basic numeracy and literacy skills underpin all other scholastic studies. While economic costs will be considerable, the experience of this study showed that, without adequate technical support and training, online teaching and learning is likely to be a frustrating and unsuccessful experience for the participants.

### 6.2 Technical issues in developing online courses

This section starts by continuing with the technical skills discussion of the previous section and discusses the technical expertise necessary to develop and maintain online courses. After looking at the technical skills needed the discussion then turns to recommendations on some technical issues in developing online courses. This discussion assumes that the NTOEC will use Web technologies in developing any future courses. This assumption is clearly reasonable as these technologies are, in theory at least, platform-independent and this approach also prepares the NTOEC for the future when using the Internet to deliver online courses will be a feasible option.

Technical expertise was one of three important skill areas identified in section 5.4.2 *Skills needed to develop the module* as it is obviously needed for the production of online courses. Issues arising from the other two, instructional design skills and graphical skills, are covered in later sections. Examples of the technical expertise used in the online module include the use of scripting languages to develop tools (e.g. quizzes, games, murder mysteries), creating templates, building libraries and keeping
current with the constant and rapid changes to the technology. This level of technical expertise needed to develop and maintain online courses is obviously greater than that needed to teach these. As discussed in the Findings chapter, the NTOEC had very limited experience in either developing or maintaining online pages and without some outside assistance, as provided by the researcher for the pilot project, the development of online courses would not be feasible.

Given that managing a Help Desk facility requires a level of technical expertise that would be beyond most teachers at present, expecting teachers to develop and maintain online courses is not feasible. A much more effective approach would be to employ specialist Information Technology professionals for these functions. This is not to imply that the teachers’ role in course development should be downgraded or limited, as only teachers can bring their unique experience of the learners and their needs to the development process. Theirs is clearly a critical role. To further enhance the effectiveness of teachers in the development process, professional development courses in producing basic Web pages, using simple Web tools and explaining the technical aspects of the development process would be beneficial. It should be noted that employing specialist staff as suggested above is consistent with the approach taken by many higher educational institutions such as universities and TAFEs.

**Recommendation 6:** While teachers must be actively involved in the development process, Information Technology professionals need to be employed to provide the necessary technical skills. Appropriate professional development for teachers in the online development process would enhance the teachers’ ability to contribute to the instructional design of any proposed online courses.

Again it is recognised that implementing this recommendation will be expensive but it would appear the NTOEC has no other alternative if online development is to be successful for the students and staff.
Employing Information Technology specialists to develop future online course will enable the development of expertise within the NTOEC. Such expertise should hopefully lead to a more sophisticated and effective use of the online environment. New courses can build on the successes of earlier courses while hopefully avoid their pitfalls and disasters. This experience is particularly valuable when the issue of reusability is remembered. This study found that having developed the Matter module transforming a similar module online was unlikely to be much cheaper or quicker. This lack of reusability is cited as a common problem in the literature. Many Web site designers (e.g. Rosenfeld and Morville 1998, Flemming 1998, Horton 1994, Shedroff 1994) stress the importance of the content when determining a site’s organisation and navigation. Misanchuk, Schwier and Boling (2000, p.226) write about their experience in developing a hypertext book

The nature of the content is highly influential in determining both the structure and the navigation system, and that – were we to do another hypertext book on a different topic – we would once again be faced with the same array of challenges and false starts.

Where reusability is possible is in the collection of a pool of resources, such as graphics, video clips, other forms of multimedia, JavaScript code and page templates. Having such a pool of resources will help to reduce the time and money involved in producing courses and allow for greater consistency in the “look and feel” between courses and in a course. Such an approach will also minimise the problems caused by discrepancies between browsers and platforms.

**Recommendation 7: Building libraries of resources and expertise for online developments should be a priority for the NTOEC.**

For this study, ensuring platform-independence required that the student’s e-journal be implemented using a word-processor or text editor native to the student’s machine. However in future, if the Internet is used to deliver an online module, a database on the NTOEC server could be used to store the student’s work and the online module would access that database as needed. This would seamlessly integrate the e-journal
with the module and eliminate the need for the student to switch between the two applications i.e. the word-processor and Web browser. Desirable as this seems, especially when the experience of this study is considered, this is unlikely to be a good solution. Implementing a suitable database involves considerable work and the most likely screen interface for entering the work would be simple text boxes on a form. Such an interface would be very primitive and would not offer any of the word-processing tools, such as spell checking, editing, printing and formatting, which are so essential for efficient electronic writing. This approach will also help encourage work of a more professional standard.

Using a word processor for the e-journal would also support recommendation 2 in the previous section, which recommended that, “Appropriate courses need to be provided to ensure all students have basic computer literacy skills”. Students would be using and building on the skills they had already developed with the word-processor. This approach would also solve the potential difficulty of getting students to draw diagrams and graphs electronically. In the pilot study, the issue was avoided by writing the online module so as not to require these skills. A long-term solution would be to use an external spreadsheet program, which has all the benefits that using an external word-processing tool does.

**Recommendation 8:** The NTOEC should use external programs such as word-processors and spreadsheets for student work as it is both more efficient and effective for the student and encourages the development of good technical skills and standards.

### 6.3 Selecting potential online projects

One of the major findings of this study was that producing a module online was far more expensive than producing a comparable print-based module. Given the small number of students who completed the Web-based module no findings on the students’ educational experiences are justified. However it is the researcher’s opinion
as the approach used is unlikely to result in better educational experiences for students it needs to be reassessed.

In hindsight, the size and nature of the pilot project was overly ambitious given the available time, money and resources\(^3\). As a result may of the features and approaches the researcher had hoped to include were not possible in the project's timeframe. Identifying only four or five lessons that could be adapted for online use, rather than the whole *Matter* unit, would have been a more effective approach. In this way the researcher would have had more time to investigate how to provide an effective online teaching and learning environment.

**Recommendation 9:** If resources are limited, the scope of any new project should be kept relatively modest so that the effort of the developers is not overwhelmed by the size of the project. The tendency to underestimate the potential costs of an online development should also be remembered.\(^4\).

As well as the size of the project being unworkable the initial aims and objectives of the online module were also too ambitious. The project had not only aimed to create an online module with many new features (e.g. graphics, videos, quizzes and automatic markers, puzzles) but also to change its underlying instructional design to incorporate a constructivist approach to teaching and learning. Had the project's objectives been less expansive and more targeted (e.g. fully develop the Murder Mystery\(^5\) to explore its effectiveness in explaining the notion of theories) the outcomes of the project may well have been improved. In future, developments the NTOEC should be careful to ensure that their aims are carefully directed and targeted. This would appear to the best way to maximise the returns for the cost and time invested.

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\(^3\) See section 5.4.1 *Time and costs to develop the module*

\(^4\) See section 5.4.7 *The research question*

\(^5\) See section 4.3.2 *The course framework* for more details on the Murder Mystery.
The project’s over ambitious size and objectives also contributed to the developer of the online module following the process Mioduser, Machmias, Oren and Lahav (1999) describe:

As experienced educators we hold substantial models regarding the varied facets of our practice (e.g., how to build a lesson plan, to assess a learner’s performance or behavior, to develop a learning unit). These models are usually tied to the (technological) resources at hand, and they affect each other mutually. It seems reasonable to assume that when facing the assimilation of a new technology we use these models as input to the process. The result is usually a transition period at which we replicate the known models by means of the new technology.

Clearly, given the differences between the online and print environments, using models developed for the print environment in the online environment is not advisable. The online module too closely replicated the print-based module instead of having its own differentiating “character” and instructional approach, which reflected the online environment. Thus in selecting potential online developments it is essential that a differentiating approach be clearly identified and the purpose for transforming a print-based course online be clearly understood. Transforming a course online simply because the online environment is available should not be the driving purpose behind such a development regardless of the potential advantages that the online environment offers.

Recommendation 10: Each project should have a specific and explicit educational objective and further those projects whose instructional designs specifically feature characteristics unique to the online environment should be targeted.
6.4 Developing an appropriate instructional design for online projects

In the pilot project, due to the lack of an adequate telecommunications infrastructure in the Northern Territory, the increased options for communication and student collaboration that the online environment offers when compared to the traditional distance education environment could not be investigated. This was a severe limitation on the instructional design of the material as collaboration offers a whole new dimension to appropriate instructional designs for young distance education students. In particular, without collaboration “pure” constructivist approaches to instructional design were not possible. This was unfortunate as one of the aims of the pilot project had been to investigate how a constructivist approach to teaching and learning could be incorporated into an online course. For the pilot project, the compromise decision made was to include constructivist elements whenever possible.

This study was unable to draw conclusions on the effectiveness of this approach. The module, as implemented, lacked a constructivist approach to teaching and learning, not only because of the lack of collaboration but also due to the lack of time many ideas for constructivist elements were not fully implemented. To the extent that the researcher follows and advances any one educational philosophy it is a constructivist one. Accordingly it is still her personal belief that an instructional design with a constructivist philosophy is likely to lead to a successful teaching and learning environment. However this study found no evidence to support or refute that position.

It was not in the scope of this study to consider any other educational approaches than constructivism. This is not to suggest that there are not many other appropriate learning theories that can underpin successful secondary science education (e.g. see education.au 2002). Given the identified need for structure in the material, the isolation of the students and lack of communication tools, it could be argued that constructivism in many ways proved to be quite inappropriate to the NTOEC situation. For the NTOEC it is clearly important that they continuously assess the educational underpinnings of their online and Web-based modules.
As the telecommunication infrastructure improves in the NT, incorporating communication and collaboration will become progressively more feasible for the NTOEC. This will not only increase the range of possible instructional designs that can be considered but is also likely to be economically sound. Many communication tools such as email, listservs and bulletin boards are relatively inexpensive or free to acquire.

The relative cost of communication tools is even more important when the lack of reusability is considered. In section 6.2 Technical issues in developing online courses the prime benefit to the NTOEC of previous developments was seen as the development of expertise that would lead to more successful implementations and effective uses of the online environment in the future. Thus developmental approaches incorporating communication tools which appear to offer significant educational benefits at a reasonable cost and with some degree of reusability, are clearly ones that the NTOEC should target with its relatively scarce resources.

Recommendation 11: The NTOEC should constantly monitor the telecommunications infrastructure in the NT and look for opportunities to include online communications. Constructivist approaches to teaching and learning which rely heavily on collaboration may then become feasible. It is important that the NTOEC selects an educational philosophy that suits the particular characteristics of each module.

While moving towards a more constructivist philosophy of teaching and learning will involve rethinking the underlying instructional design, use can still be made of the existing instructional material. For example, Herrington and Standen (2000) detail a very imaginative way of moving towards a constructivist-learning environment. An overarching constructivist shell was added to a series of lessons firmly based in the behaviorist mould that transmitted knowledge in a linear fashion. Their approach “was to incorporate a ‘non-constructivist design’ into a learning environment based upon a constructivist philosophy” (ibid., p. 196). The overarching constructivist shell provided a context or problem for the learning while the instructivist lessons provided
the necessary background resources for solving the problem. Collaboration between students in solving the problem was seen as an essential and integral component of the teaching and learning environment.

Such an approach has obvious economic merit for the NTOEC as it maximises the reuse of existing instructional material while still implementing a more constructivist instructional design.

**Recommendation 12:** The successful reuse of existing instructional material into new and innovative instructional designs needs to be considered given the economic restraints the NTEOC operates under.

When considering the design of a development, the differing characteristics of media such as print, online and CDs need to be considered. For example, in the pilot project, due to the poor telecommunications infrastructure in the NT, CDs rather than the Internet were relied upon for delivering the online module. Thus download times for multimedia elements such as videos and graphics were not an important consideration. In future as the telecommunications infrastructure improves, using the Internet for delivering future NOTEC modules is likely to be an attractive and feasible option. In this case download times will again become a consideration and one possible solution may be to combine the use of both the Internet and CDs. The Internet could be used for communication and changing resources while the CD could be used for bandwidth intensive multimedia materials such as videos. With careful design the two parts of the course can be integrated successfully (e.g. OAC 2000).

This hybrid approach to combining various media has much to recommend it. Each medium, such as print, a CD or the Internet, has its own characteristics and advantages. Print is arguably the best medium for presenting lengthy passages of text, the Internet for interactivity and communication and, as mentioned above, CDs for delivering large multimedia elements such as videos. Combining the strengths of each of these media is likely to produce a course that makes the most effective use of all the resources available.
Recommendation 13: The characteristics of each different media should be recognised and imaginative ways of combining the best of each should be attempted where possible.

An important characteristic of the online environment is its increasing reliance on digital means of visual communication. The ability to include multimedia, such as graphics or videos, is an important addition to online pages (Fleming 1998, Veen 2001). The potential educational benefits of multimedia when combined with the increased interactivity the Internet (or CDs) offers is substantial. For example, different paths and structures through the material are possible and can be used to offer different perspectives and interpretations of concepts and issues. Choices offered to the learner can be used to cater for different learning styles. With the increased interactivity, active rather than passive learning can be encouraged leading to greater engagement from the learner and a more enjoyable learning experience.

These considerations are especially relevant for the NTOEC when the age of their target audience is considered. Willie, Ng See Pu and Allan (1999) found that in their study, materials that had videos combined with explanatory text were the most popular resource out of a range of possibilities. The only complaint from students concerned the slow download times.

Unfortunately, while multimedia may both be effective and integral to the online environment, the findings of this study have clearly demonstrated that their development is very expensive. Thus while these elements may offer many benefits that make them worth including, economic considerations will limit the extent to which they can be used.

Recommendation 14: An important design issue for an online developer will be to identify multimedia elements that significantly improve the educational

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6 See Chapter 2, A critical review of the related literature, for more discussion
experience of the learners rather than those that simply improve the appearance of the page.

6.5 Conclusion

While the online environment appears to have almost limitless potential, like all organisations the NTEOC will be limited by economic considerations. It has strictly limited resources and all its projects should be both economically feasible as well as effective and efficient solutions to particular situations. Decisions about proposed course developments need to balance the likely educational effectiveness of courses and the economic constraints.

The findings of the pilot study indicate that the online environment is an expensive option. Section 5.4.1 Time and costs to develop the module, clearly showed that the approach taken by the pilot study to online development was not economically viable. Delivering the module also encountered significant problems and many of the recommendations of this chapter to address these problems will also involve considerable expense to implement.

However, this is not to suggest that the NTOEC should abandon the online environment. In this new century, the digital environment can only increase in importance and become more integral to all our lives. The challenge for the NTOEC is to find approaches that engage their students successfully at a reasonably cost to the organisation. This study has suggested some such approaches for the NTEOC to investigate but as this study also demonstrated the educational, technical and distance factors involved ensure that the size of the challenge is considerable.
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APPENDIX A

The following surveys were used in this study:

Equipment Survey: covered the technical skills students undertaking the module had.

Student Survey: completed by students after they had finished the online module.
Equipment Survey

1) Please circle one of the following:
   a) You have no access to a computer
   b) You have a computer you can use in your house
   c) You can go elsewhere and use a computer
      i) Where do you have to go? ________________________________
      ii) How long does it take you to go there? __________________
      iii) How do you get there? (by foot, bike, car) ______________
      iv) Can you use the computer whenever you like or is it only available at certain times?
      ________________________________

2) How often do you use a computer?
   a) Never or very occasionally
   b) About once a month
   c) About once a week
   d) More than once a week

3) What the main activities you use your computer for? (eg playing games, email etc)
   ________________________________

4) How good are you at typing?
   a) I pick at the keyboard using two fingers and it takes me a long time to type anything
   b) I only use two fingers but I am not too slow
   c) I can't touch type but I have had a lot of practice and type pretty fast
   d) I can touch type

5) Can you use the following:
   a) A word processor (such as Word) Yes/No
   b) Email Yes/No
   c) Web or Internet to find information Yes/No
6) Please answer as many of the following questions about the computer as you can. If you do not know the answer, just leave the space blank

a) Is the computer a Mac or a PC? __________________________

b) Can the computer use CDs? __________________________

c) Did you use Internet Explorer or Netscape Navigator? (If you know the version please write that down too)

_____________________________________________________

d) Roughly how old is the computer? __________________________

e) Do you know what model your computer is? (eg Power Mac, Pentium II)

_____________________________________________________

Thanks for your time
Student Survey

After you complete the Matter course, we would appreciate if you would complete this brief questionnaire. Please tick the most appropriate boxes.

1) What type of computer did you use?
   a) PC (ie a Windows based computer)
   b) Mac

2) Before you started Matter how often did you use a computer?
   a) 3 or more times a week
   b) 1 or 2 times a week
   c) once or twice a month
   d) never or very rarely

3) Did you have problems: (Tick all the boxes that apply.)

<table>
<thead>
<tr>
<th></th>
<th>No problems</th>
<th>Problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Getting started with the course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Running the videos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Using the electronic workbook</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) The topic map not working properly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e) The final test not working</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f) Trouble with email</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g) Pages not working and strange error messages appearing when using the course</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h) Pages not displaying correctly</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Any other problems: ____________________________________________________________

4) Compared to the print based books you have been completing do you think the online course has taken you a longer or shorter time to complete?
   a) The online course takes considerably longer
   b) The online course takes slightly longer
   c) They take about the same
   d) The printed material takes slightly longer
   e) The printed material takes considerably longer
   f) I'm not sure
5) How would you rate the online course?
   a) Very good
   b) Good
   c) Ok
   d) Poor
   e) Very Poor

6) Do you prefer using an online course or a printed book (Tick one)
   a) I definitely prefer the online course
   b) I probably prefer the online course
   c) I don't have a preference
   d) I probably prefer the printed book
   e) I definitely prefer the printed book

7) What did you like
   a) Most about the course: ________________________________
      ________________________________
      ________________________________
      ________________________________
      ________________________________
      ________________________________
      ________________________________

   b) Least about the course: ________________________________
      ________________________________
      ________________________________
      ________________________________
      ________________________________
      ________________________________

 Thank-you
APPENDIX B

Same sample of pages from the CD:

The original lesson on surface tension from the printed materials

The same lesson in the online module
Lesson 4

What holds the particles together?

You can pick a cricket ball up off the ground and the whole ball stays together. Could you pick up a drop of water or the steam coming out of a kettle? (Don't try it!)

Think

What does this suggest about the attraction between the particles in a solid, a liquid and a gas?

Particles are held together

- tightly in solids
- weakly in liquids
- not at all in gases

In this lesson we will look at one of the forces that holds the particles together.
Holding particles together

You will need:
- a glass
- an eye dropper
- a paper clip
- detergent

Fill a glass with water so that it is level with the top of the glass.

Next, use an eye dropper to add water drop by drop to the glass.

Look carefully at the surface of the water. What do you notice?

Do Exercise 11 in Response Book 1.

Now empty out a little bit of the water and try to float a paper clip on top of the water. Make sure the paper clip is dry before you start. Look carefully at the surface of the water around the paper clip.

Finally, add a drop of detergent to the water. What happens to the paper clip?

Do Exercise 12 in Response Book 1.
Using the particle theory to explain these observations

The surface of a liquid, like water, behaves as though it is covered by a thin film. Did you notice how the weight of the paper clip was pressing down into the water but the water was still supporting the paper clip? The particles of water at the surface seem to be holding on to each other very tightly and this supports the paper clip.

The particles of water are attracted to one another. They seem to stick together. This 'sticking together' in a liquid is called surface tension.

Decreasing surface tension

You will need:

- Sheet of greaseproof paper
- Detergent
- Toothpick or match stick
- Eye dropper

Put a drop of water onto a sheet of greaseproof paper. Examine its shape closely.

Dip the toothpick or match stick in the detergent. Then move the toothpick slowly towards the drop of water and touch it.

Do Exercise 13 in Response Book 1.
How detergents work

When a drop of water is placed on the greaseproof paper the drop sticks together. The water particles are attracting one another and this holds the drop together.

If detergent is added to the drop, the surface tension decreases. The detergent particles get in the way of the water particles so that they can't hold on to each other so closely and the drop spreads out.

Investigating detergents

You will need:
- 2 large test tubes
- test tube rack
- detergent (washing-up liquid)
- cooking oil
- eye dropper

Half fill two test tubes with water.

Drop half an eye-dropper full of cooking oil onto the surface of the water in each test tube. Note how the oil forms a layer on top of the water.

Add half an eye-dropper full of washing-up liquid to one of the tubes.

Shake each of the test tubes.

Do Exercise 14 in Response Book 1.
Extra reading:

Using surface tension

We use surface tension in our daily lives.

1 Water doesn't wet dishes very well, especially greasy ones - the water tends to clump into droplets rather than spreading out. Adding detergent allows water to wet the dishes and get at the dirt. Because detergent particles attract dirt particles, the detergent then helps remove the dirt from the dishes.

2 We spray waterproofing on things that we don't want to get soaked with water e.g. canvas tents and ski gloves. The waterproofing prevents the water wetting the fabric. The water stays as drops; it doesn't spread out.

3 Detergents can be used to help clear up oil spills in the sea. If oil escapes from a tanker, or an oil rig, the spilled oil floats on the surface of the sea forming a slick which spreads out and out and can be carried by currents from one area to another.

The oil kills fish and sea birds and makes a mess of beaches.

One method of getting rid of these slicks is to spray foaming detergents onto the slick to break up the layer of oil into small drops.
Exercises in the response booklet

11 Draw a scientific diagram of the glass showing the surface of the water. (Remember, a scientific diagram shows things in cross section - as though they have been cut in half.)

![Water in glass diagram]

Now return to the Information Book.

12 What happened when you added a drop of detergent to the water?

Now return to the Information Book.

13 Describe what happened when the toothpick touched the drop of water.

Now return to the Information Book.
14  (a) What happens to the oil layers in each of the test tubes after being shaken?

(b) Explain what is happening to the oil and detergent particles when they are shaken together.

(4 marks)
Developing a theory

Remember in the beginning of this unit we discussed how scientists develop theories by looking at the evidence. They then carry out experiments to test their theory. Let's have a look at doing this by examining a very simple fact.

Fact: Some objects like leaves float on the top of water.

Developing a theory:

1. Ever thought about why leaves float on the top of a pool or a water tank? Why do you think that is so? (Remember at this stage you are putting forward your most likely idea and there is no correct answer. Be sure to have a go!)

   Type your answer here

2. Why do the leaves sometimes sink to the bottom?

   Here is a possible idea

   (Your idea may be quite different - after all at the moment we are only trying to develop a theory and then test it. As we find more facts we will need to modify the theory so that it can explain them.)

   One theory that you may have come up with is do with weight:

   1. Ever thought about why leaves float on the top of a pool or a water tank?
      The leaves are light and so float on the top of the surface

   2. Why do the leaves sometimes sink to the bottom?
      When the leaves get wet they become heavier and so sink to the bottom

   Now here is another question. Does this theory have anything to do with the particle theory?

   Yes C   No C
Testing the theory: Now let's see how complete our theory is. It seems sensible that weight is somehow involved. After all bricks sink while leaves can float on the surface.

But is this enough? Our idea makes no reference to the particle theory even though all materials are made up of particles. Not every theory is going to need the particle theory but...

The following experiment may help us.

Holding particles together

You will need:
- a glass
- an eye dropper
- a paper clip
- detergent

1. Fill a glass with water so that it is level with the top of the glass.

2. Use an eye dropper to add water drop by drop to the glass. Look carefully at the surface of the water. What do you notice?

3. Now empty out a little bit of the water and try to float a paper clip on top of the water. Make sure the paper clip is dry before you start.

4. Look carefully at the surface of the water around the paper clip. What do you notice?

5. Add a drop of detergent to the water. What happens to the paper clip?

---Solution---
5. Add a drop of detergent to the water. What happens to the paper clip?

**Solution**

**Answers**
Could you see that the top of the water was actually above the top of the glass?
Did you notice that the weight of the paper clip was pressing down into the water but the water was still supporting the paper clip?
The paper clip sank to the bottom of the glass.

**Checking the theory with the experiment:** Now let's think how well our ideas match with our proposed theory. Remember we thought that objects floated or sunk depending upon their weight.

**THINK**
- Can this explain why the paper clip floats before the detergent is added?
- Can this explain why the paper clip sinks when the detergent is added?
- Can this explain why the water level can be above the rim of the glass?

**Solution**

**Answers**
Yes the paper clip floats because it is light enough.
No when the detergent is added the weight of the paper clip has not changed and so with our theory it should still be floating.
No our theory says nothing about the level of the water being above the glass.

So it looks like we are going to have to change our theory. Facts have come to light that our theory cannot explain. Maybe we will need the particle theory after all to fully explain these observations.
Using the particle theory to explain these observations

This is the theory scientists have come up with to explain why some things float. Weight as we thought is part of the story but there is more to it.

The surface of a liquid, like water, behaves as though it is covered by a thin film. Remember how the weight of the paper clip was pressing down into the water but the water was still supporting the paper clip? The particles of water at the surface seem to be holding on to each other very tightly and this supports the paper clip.

The particles of water are attracted to one another. They seem to stick together. This 'sticking together' in a liquid is called surface tension. This sticking together also allowed for the level of the water to be higher than the glass.

So how does this explain the paper clip dropping after we add the detergent?

**Decreasing surface tension**

You will need:
- sheet of greaseproof paper
- detergent
- toothpick or match stick
- eye dropper

1. Put a drop of water onto a sheet of greaseproof paper. Examine its shape closely.
2. Dip the toothpick or match stick in the detergent. Then move the toothpick slowly towards the drop of water and touch it.

**THINK** Describe what happened when the toothpick touched the drop of water?

**Solution**

Did you notice that when the toothpick touched the water the drop spread out?
How detergents work

When a drop of water is placed on the greaseproof paper the drop sticks together. The water particles are attracting one another and this holds the drop together.

If detergent is added to the drop, the surface tension decreases. The detergent particles get in the way of the water particles so that they can’t hold on to each other so closely and the drop spreads out.

Investigating detergents

You will need:
- 2 large test tubes
- test tube rack
- detergent (washing-up liquid)
- eye dropper
- cooking oil

1. Half fill two test tubes with water.
2. Drop half an eye-dropper full of cooking oil onto the surface of the water in each test tube. Note how the oil forms a layer on top of the water.
3. Add half an eye-dropper full of washing-up liquid to one of the tubes.
4. Shake each of the test tubes.

Believe this??

Put some water into a clean tray, plate or dish. Sprinkle some pepper on top of the water. With a cake of soap or a drop of detergent touch the water. Sound pretty dumb? Well look what happens (If you can’t play the video clip you will just have to do the experiment yourself!)

Pepper Scatter

Now try it yourself. After all seeing is believing. It is actually more dramatic if you do not put as much pepper on the water as we did in the video. (We had to so it would show up on the video).

What’s happening?

Surface tension on water makes a strong ‘skin’ which is tight and not very elastic. The pepper stays on the water until soap or detergent touches the skin. Soap and detergent reduce the attractive forces between water molecule - that is, they reduce surface tension. The skin stretches, scattering the pepper.
The idea and explanation for this experiment came from Questacon in Canberra. Check out the link below to their web site for more interesting ideas.

If you choose to have a look at Questacon you will need to be connected to the Internet. The web pages are also pretty large and if you have trouble downloading pages from the Web unfortunately this site is not for you. The link will open in a new window and to return to the course simply close that window.

Questacon

Extra Reading: Using surface tension

We use surface tension all the time. If you are interested in seeing how click below.

Did you know?

This is the end of the topic. Now to celebrate, here is a close.