Information, knowledge and learning: Is the Web effective as a medium for Mathematics teaching?

by

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Abstract

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Title: Information, knowledge and learning: Is the Web effective for Mathematics teaching?

This document is a report on an experiment in which mathematical skills were taught to first year university students using the Web as a method of instructional delivery. Special attention was paid to the ability of students from disadvantaged backgrounds to cope with this method of delivery. Overall, the results obtained by students using this method were slightly better than that of students on the equivalent paper-based course. However, students from disadvantaged backgrounds fared marginally worse than those on the paper-based course. The results of these students allow extrapolation to a broader context where Web-based teaching of disadvantaged communities may be used.

Definitions for knowledge, information, learning and teaching were developed. These definitions were then used as the foundation for creating the Web pages used in the experiment.

Keywords Knowledge; information; learning; teaching; Web-based teaching; Web-based learning; technology-enhanced learning; mathematics skills; underprepared students; Logo.

Opsomming

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Titel: Inligting, kennis en leer: Is die Web effektief vir Wiskunde onderrig?

Hierdie tesis is 'n omskrywing van 'n ondersoek waarin wikundige vaardighede aan eerstejaar universiteitsstudente oorgedra is deur middel van die Web as vervoermedium. In hierdie studie is voorsiening gemaak vir die moontlikheid dat studente van voorheen benadeelde groepe met hierdie vervoermedium nie sal byhou nie. In die algemeen, is die uitslae van studente wat hierdie metode gevolg het effens beter as die van studente wat die gelykstaande papier-gebaseerde kursus geloop het; maar studente van voorheen benadeelde groepe het effens slegter gevaar as studente op die papier-gebaseerde kursus. Die uitslag van hierdie oefening laat die uitbreiding toe tot 'n wyer gebied waar Web-gebasserde onderrig in voorheen benadeelde gemeeskappe gebruik mag word.

Definisies ten opsigte van kennis, inligting, leer en onderrig is ontwikkel. Hierdie definisies is gebruik as die fondament vir die skepping van die Web-blaaie wat in hierdie studie gebruik is.

Sleutelwoorde Kennis; inligting; leer; onderrig; Web-gebaseerde onderrig; Web-gebaseerde leer; tegnologie-versterkte leer; wiskundige vaardighede; ondervoorbereide studente; Logo.

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Notes to the reader

Referencing books In this document, when a book is referenced, the page number is included as part of the reference in the body text. The reason for this being that anyone (including me) wishing to check on a book reference will know exactly where in the book the item under discussion was obtained without having to wade through the whole book.

Quotations Quotations in the body text are surrounded by quotation marks ("). Where the quotation is a paragraph, an indented paragraph is used with the text in italics and no quotation marks.

Chapter 1 Introduction

Chapter guide

1 Introduction

1.1 Introduction

> *... the Internet is making it possible for more individuals than ever to access knowledge and to learn in new and different ways. At the dawn of the 21st Century, the education landscape is changing. Elementary and secondary schools are experiencing growing enrollments, coping with critical shortages of teachers, facing overcrowded and decaying buildings, and responding to demands for higher standards.* (WBEC, 2000: i)

This excerpt from the Web-based Education Committee (WBEC) report, and many other articles in the current literature, say a great deal about using the Internet (and more specifically the World Wide Web) as a learning and teaching tool. However, little quantitative work has been carried out in this field. Most reports are based on very small sample sizes which often casts doubt on the validity of the findings (IHEP, 1999).

In this study an attempt is made to make the data and findings more representative by using a sample of more than 200 students and a study period of five years. All four of the research methodologies recommended by the Institute for Higher Education Policy (IHEP) (IHEP, 1999)[1] are used in this study. Science Orientation, an undergraduate course offered in the Faculty of Natural and Agricultural Sciences at the University of Pretoria, was used to test the questions outlined in section 1.5. The answers to these questions are then extrapolated in an attempt to find solutions to the major questions outlined in section 1.3. Patterns in the data are examined, rather than a rigorous statistical analysis, in order to interpret the findings.

In the next section, a brief history of the World Wide Web is given in order to demonstrate the relevance of this research. This is followed by the major research questions that focus on the Web as a delivery medium of learning material. Then follows a discussion of the course on which this report is based, and the project specific research questions.

1.2 Historical overview of the World Wide Web

Since the invention of the World Wide Web by Tim Berners-Lee in 1990 (CERN, 1997), its uses (and usage) has grown beyond all expectations. Originally designed as a means

[1] Descriptive research, case studies, correlational research and experimental research.

for physicists to communicate their research findings electronically (CERN, 1997), it soon became apparent that the Web could be an important tool for information scientists, especially for those working on hypertext systems. With the development of a graphical user interface for the Web browser in 1993 (Basch, 1998; Gromov, 2000), the Web became more accessible to everyone. From 50 servers in 1993, the World Wide Web grew to more than 650 000 servers by the end of 1997 (CERN, 1997). Currently, there is no accurate measurement of the number of Web servers in the world, let alone the number of Web pages. With this surfeit of information available on the Web, information and computer scientists realised as early as 1993, the need to catalogue the information in order to make it more accessible (Sonnenreich, 1998). The Executive report of the School of Information Management and Systems of the University of California Berkeley maintains

> *The world's total production of information amounts to about 250 megabytes for each man, woman, and child on earth. It is clear that we are all drowning in a sea of information. The challenge is to learn to swim in that sea, rather than drown in it. Better understanding and better tools are desperately needed if we are to take full advantage of the ever-increasing supply of information...* (SIMS, 2000).

Initially, access to information on the Web was by "word of mouth", where useful sites were shared amongst interested people by Email and through UseNet special interest groups. In order to make this information accessible, several universities started developing software which attempted to index the Web pages available at the time. These programs had quaint names such as *Veronica*, *Jughead*, *Wanderer*, *Webbots* and spiders, but eventually all became known as search engines. The biggest disadvantage of these early search engines was, that in doing their indexing, they consumed more Internet bandwidth than the users. It was only once the Internet bandwidth increased and the search engines moved off university computers into the corporate world, that the World Wide Web became an effective research tool (Sonnenreich, 1998).

Once control of the Web moved away from academia, business realised its importance mainly as an advertising medium (Basch, 1998). However, in 1994, Pizza Hut became the first Web-based store to open. Shortly thereafter, the first Web-based banking system went on-line (Basch, 1998).

In addition to the information available on the World Wide Web, its hypertext roots give it a strong educational foundation. Firstly, hypertext is said to match human thinking in that memory is organised in a semantic network where concepts are linked together by associations (Kearsley, 1988 as cited in Alexander, 1995). Secondly, as hypertext is a linked system based on semantic structures, it can be mapped onto the structure of the knowledge representing it (Jonassen, 1988 as cited in Alexander, 1995). Hence it is easy to see why Web-based teaching has become so popular. The most common method of Web-based teaching is to put lecture notes and tutorials on Web pages with links to other useful pages elsewhere in the world (Sheard *et al*, 2000). In this way a learner can follow information paths in a way which is unique to him or her (Alexander, 1995). The biggest advantage of Web-based teaching is that course material is available to the learner anywhere and at any time, provided that the learner has access to the Web.

Modern Web page development tools, such as *Flash* and *Shockwave* (www.macromedia.com), allow teachers to add programmed, interactive hypermedia to their pages. This interactivity is a shift away from the static nature of the original definition of the Web. Other tools include *WebCT* and *Blackboard* which allow the teacher to administer and manage courses via the Web.

According to the WBEC, "The World Wide Web is a tool that empowers society to school the illiterate, bring job training to the unskilled, open a universe of wondrous images and knowledge to all students and enrich the understanding of the lifelong learner." (WBEC, 2000: 1). However, the IHEP report on technology-based distance education cautions that learners require special skills, as well as sophisticated technical support, if Web-based learning is to succeed (IHEP, 1999).

In trying to map World Wide Web technologies to teaching and learning, especially in developing countries, several questions are raised. Some of these are introduced in the next section.

1.3 Major research questions

The following table lists the research question and sub-questions pertaining to Web-based learning and teaching in general, which will be addressed in this study.

Table 1.3.1 *Major research questions*

1. What is *information* and what is *knowledge*? • How do *information and knowledge* relate to *teaching and learning*? • How do *information and knowledge* relate to *the World Wide Web*? • What is the relationship between *the World Wide Web* and *teaching and learning*?
2. To what extent can Web-delivery of lesson material be used to address the education shortfall in disadvantaged communities? • How will students from disadvantaged communities cope with this method of lesson delivery?

In order to find possible solutions to the second question, it is necessary to use a study on a smaller scale in which the target population is represented. Students on the Science Orientation course in the Faculty of Science at the University of Pretoria provide such a sample. An overview of the history of the Science Orientation course is given in the next section, with the research questions relevant to the Web-based presentation of the course given in section 1.5.

1.4 Historical overview of the Science Orientation course

The Science Orientation course was first implemented as an add-on to the bridging program (Project Renaissance[1]) of the Faculty of Science in 1994. The original reason for the course was to expose the students to skills required for successful study in the Sciences as well as to computer technology (hardware and software). With the poor level of mathematical reasoning skills that these students posessed, it became apparent that they needed assistance in developing problem solving skills, especially those involving logic. As an experiment, an introductory module in programming, using Logo as the programming environment, became part of this course. Logo was chosen for the following reasons:

- it has a strong mathematical foundation;
- the results of commands being executed can be seen immediately; and
- the language lends itself to analysis of geometrical problems and the structured synthesis of their solutions.

The Logo part of the course ran for eight weeks in the first semester, and consisted of a one hour lecture followed by a four hour practical each week. Another three sessions were then allowed for the students to complete a Logo project in the second semester.

In keeping with the original aim of Project Renaissance, the number of students on the course was kept below 40 to allow maximum contact time between the students and the lecturer/tutors. This contact allowed problems, encountered by the students during a practical session, to be discussed in depth, with staff guiding the students towards a successful solution of the problem at hand.

Prior to the 2000 academic year, lectures consisted of a discussion (in which the students were encouraged to participate) of solutions to the previous week's problems followed by a preview of problems in the current assignment. This preview would include a short discussion on new Logo commands, possible pitfalls in the problems and sometimes a hint or two. A practical worksheet was given to the students each

[1] Project Renaissance was an initiative of the former Dean of Science at the University of Pretoria, Professor Nico Sauer, to find potential science graduates amongst school leavers from the disadvantaged communities.

week, which meant that students worked through their practicals synchronously and linearly. This eased the workload on the lecturer and the tutors, as questions during a practical were all concerned with the same assignment.

In 1999, the Management of the Faculty of Science decided to modularise the course and double the number of students that could be admitted to the course. Both of these led to problems with the logistics of presenting the course.

- Modularisation meant the course was restricted to a single semester. As mentioned earlier, prior to 2000, the students were allowed time at the beginning of their second semester to complete their LOGO projects. This time would thus have to be telescoped into the first semester so that the students could complete the module in a single semester.
- The increase in the number of students meant a loss of the one-to-one contact time between the students and the lecturer/tutors. It also meant that the lecture hall used prior to the 2000 academic year was too small to accommodate all the students. With the high premium on lecture room space at the University of Pretoria (van Harmelen, 1997: 56), especially those with network connectivity and data projection facilities, this problem was critical as some students had to sit on the floor during the computer literacy lectures in 2000.

To overcome these problems, the author decided to experiment with Web-delivery of the lecture material and the assignments. The advantages of this were fourfold:

- the practical session would be extended by an hour which would mean that the lecturer/tutors would be able to spend more time with the students;
- students could be encouraged to work asynchronously as all assignments would be available at the start of the course;
- students would have to learn some form of time management to complete their assignments and project on schedule; and
- the students' computer literacy experience would be extended to include Web-browsing.

Furthermore, Web-delivery of course material is in keeping with the telematic teaching approach advocated by the University of Pretoria (Anon, 2001a) to promote flexible learning patterns by students of the University. Such flexible learning patterns should enhance the students' ability and motivation to become lifelong learners.

Unfortunately, little research has been done on the influence of a student's background on his or her ability to successfully complete a course delivered by the Web. In order to see the effect of scholastic background on the students' ability to cope with this different method of teaching, it was necessary to group them according to some criteria so as to be able to compare the results of the different groups. Table 1.4.1 shows how Herselman (1999) grouped advantaged and disadvantaged learners according to their access to resources.

Table 1.4.1 Group definitions from Herselman (1999)

Group name	Group abbreviation	Definition
Resource advantaged learners	RA	"...learners from favourable socio-economic environments in which they have ready access to electricity, water and food. ..."
Resource deprived learners	RD	"...learners from disadvantaged or deprived socio-economic environments where they often lack even basic amenities like electricity and running water. ..."

In this study, the students were also grouped according to their access to resources, but here a resource does not refer to a public utility, such as water or electricity, but rather to some form of study aid such as a library or an Internet connection at school.

Table 1.4.2 Group definitions used in this study

Group name	Group abbreviation	Definition
Resource advantaged learners	Ra	Learners from schools with resource centres, who have had to use the resources, with minimum input from the teachers, to complete tasks.
Resource disadvantaged learners	Rd	Learners from disadvantaged schools without resource centres. In these cases, learners have to rely solely on teachers as a source of information. Often these teachers lack suitable qualifications in their subjects.

The definitions given in the table were made on the basis of extensive discussions and interviews with the students on the SCI 152 course (and its predecessors) since 1994. These definitions will be discussed in more detail in section 3.2.A.

1.5 Research questions pertaining to this project

As a sequel to the research questions posed in Table 1.3.1, the following table is an outline of the research questions specific to the Web-delivery of the Science Orientation course.

Table 1.5.1 *Project research questions*

1. How did the students cope with the Web as a medium for lesson presentation? To what extent • did the students need face-to-face contact? • did the information in the Web pages meet the requirements for the students to complete the assignments? • could the students manage their time in the absence of formal lectures? • did the students use the study aid pages? ▪ Objectives ▪ Useful information
2. What were the students' attitudes towards Web-delivery of course material?
3. How did the digital divide affect the students' performance? To what extent • was prior exposure to computers beneficial in successfully completing the course? • did prior exposure to computers affect the students' ability to complete a solo computer-based project? • did open Internet access affect the students' performance?
4. Was there any difference in the ability of Ra and Rd students to complete the course successfully?

1.6 Limitations of the study

Limitations of this study, which must be borne in mind, are

- The Science Orientation Course discussed in this document was not a distance-teaching course, but rather a contact course delivered via the Web.
- The subject matter was limited to a highly specific area of mathematics.
- Questionnaires were completed only by students in 2000.
- Open Internet access was available to students in 2001 only.

1.7 Other research

The following table lists current, and recently completed, research projects on teaching and learning via the Internet, in South Africa. The data was compiled from a search of the Nexus research database at the National Research Foundation[1].

[1] http://www.nrf.ac.za/nexus The database query was carried out on 13 September 2001, with search terms "Web" and "Internet".

Table 1.7.1 *Current, and recently completed, research on teaching and learning via the Internet.*

Author	Title	Year	Degree
de Jager, A.	The use of the Internet as constructivist resource in the teaching the mole concept	1995	MEd
Owusu-Sekyere, C.	The application of computer technology in South African distance education.	1997	MSc
Brown, S.	A framework for Internet supported collaborative learning in South Africa.	1998	MTech
Butcher, N. & Roberts, N.	The Internet, satellite and the professional development of educators: building appropriate teaching and learning models.	1998	NDP
Cilliers, W.J.	Formative evaluation of an Internet-based introduction program.	1998	MEd
Clarke, P.A.	Telematic teaching of adults via the World Wide Web: a case study.	1998	MEd
Dickson, M.	Superhighway or cul de sac: the Internet as a tool for learning school mathematics.	1998	MEd
Nolte, M.	The use of the Internet in the integration of information sources for a first-year anatomy course.	1998	MEd
Pete, M.M.	The design and development of a resource-based, open learning system on the World Wide Web.	1998	MEd
Voster, B.	Possibilities and constraints of teaching adults on the World Wide Web	1998	MEd
Wissink, H.F.	An interactive, Internet-based, multimedia system for the delivery of masters degree modules.	1998	NDP
Botha, J.S.	How did a Web-based learning environment facilitate the development of critical higher-order thinking during the presentation of an MEd Computer Based Education course?	1999	MEd
Cloete, L.M.	The education and training of cataloguers through distance education: a Web-based model.	1999	DPhil
Davey, M.G.	Teaching the net generation: problems and possibilities of developing content for a language learning Website.	1999	MA
de Bruyn, A.M.	Guidelines for the use of the Internet in teaching.	1999	DEd
Lautenbach, G.V.	Learner experiences of Web-based learning: a university case study.	1999	MEd
Letshela, P.Z.	Rendering information services to rural communities through Web technology.	1999	DLitt et Phil
Delmont, E.	Development of Web-based teaching and learning resource materials.	2000	NDP
de Villiers, G.J.	Evaluation of the Web-based information resources to support learning: an exploration.	2000	MA
Lehr, R.H.	Web-based distance learning for power system engineering.	2000	MSc
Mabathoana, S.T.G.	The logistical and didactical support needs of computer-based education MEd learners who participate in Web-based courses.	2000	MEd
Ohlhoff, C.H.F.	The use of the computer in literacy research and teaching.	2001	NDP
Staak, L.P.	Hypertext and the act of reading and learning: a study of the use of hypertext on the Web in the secondary school English literature classroom.	2001	MPhil
van Ryneveld, L.	An exploration of cost-effective solutions for Internet based learning.	2001	MEd

The table shows the high level of research interest shown in Internet-based teaching and learning at South African tertiary institutions, especially since 1998. Hence, the research reported on in this document is relevant. By comparing the research titles in Table 1.7.1 with the research questions outlined in sections 1.3 and 1.5, one can see that these research questions are unique, yet topical to the work of de Villiers, Lautenbach, Voster and Cilliers.

Furthermore, the Web-based Education Commission of the United States government recommends that research into Internet-based learning needs to be expanded and revitalised (WBEC, 2000: 55). Much of the research into technology-based distance learning is inconclusive and more needs to be done (IHEP, 1999). Historically, research emphasis has been placed on the development of technology-based material rather than on evaluating the effects of technology on learning (Laurillard, 1993:223).

1.8 Data collection methods

The following tables show the methods that were used in answering the research questions outlined in sections 1.3 and 1.5.

Table 1.8.1 *Data collection matrix for the major research questions posed in Table 1.3.1*

	Literature survey	Interviews and discussions	Extrapolation[1]
1. What is *information* and what is *knowledge*?	❖	❖	
• *information/knowledge* related to *teaching/learning*	❖	❖	
• *information/knowledge* related to *WWW*	❖		
• *WWW* related to *teaching/learning*	❖	❖	
2. To what extent can Web-delivery of lesson material address the educational shortfall in disadvantaged communities?	❖	❖	❖
• Will *students* cope?	❖	❖	❖

[1] Data will be generated by extrapolating from the results obtained from the SCI 152 course.

Table 1.8.2 *Data collection matrix for the research questions posed in Table 1.5.1*

	Course results	Questionnaire	Web-server logs	Assignment hand-in date	Observation & discussion
1. How did the students cope with the Web as a medium for lesson presentation?	❖	❖	❖	❖	❖
• face-to-face contact	❖	❖			❖
• sufficient information in Web pages	❖	❖			❖
• successful time management strategies	❖	❖	❖	❖	❖
• use of study-aid pages		❖	❖		❖
2. What were students' attitudes towards Web-delivery of course material?	❖	❖		❖	❖
3. How did the digital divide affect the students' performance?	❖	❖		❖	❖
• prior exposure to computers	❖	❖			❖
• successful completion of a solo computer-based project	❖			❖	❖
• open internet access	❖			❖	❖
4. Was there any difference in the ability of Ra and Rd students to complete the course successfully?	❖	❖			❖

1.9 Thesis outline

The following table is an outline of the rest of the chapters in this report.

Table 1.9.1 *Thesis outline*

Chapter	Title	Description
2	Literature survey	A review of the relevant literature, including discussions of information, knowledge, learning and teaching as well as the design of Web pages.
3	Research methodology	A discussion and motivation of the methodology and tools used to collect and interpret the data in this study.
4	Results and discussion	An analysis of student results, student opinions and Web-server logs.
5	Conclusions and recommendations	Conclusions drawn from the results with recommendations on improving Web-delivery of academic material.

Supporting chapters include

- Future work
- Bibliography
- Appendices.

A CD, with an electronic copy of this document as well as non-standard references referred to in the text, is included in an envelope on the inside back cover.

1.10 Summary

In this chapter, overviews of the World Wide Web and the Science Orientation course were presented. From these overviews, research questions pertaining to this project were developed. In Chapter 2, relevant literature will be analysed in an attempt to find pointers to solutions to some questions, and to put the research into a theoretical context.

Chapter 2 Literature review

Chapter guide

2. Literature Review

2.1 Information requirements

In designing a Web replacement for lectures, one first has to evaluate the information required by the student so that s/he can understand the subject sufficiently well to be able to solve problems associated with the subject, *with a minimum input from the lecturer*. In the current study the complexity of the information requirement was exacerbated by the students being faced with two new technologies: the Web browser and the Logo programming environment. Fortunately, they had already become reasonably adept at using different software packages in completing assignments during the computer literacy component of their course.

Before looking into the information requirement for the course, the link between information and knowledge will be examined.

> *...knowledge is structured integrated information and information is fragmented knowledge...* (Brookes, 1981 as cited in Todd, 1999)

2.2 Creating knowledge from information

> *In order to extract, integrate and use information, the cognitive system must develop ways of representing the available information. ... a representation is an encoding of selective information about an external event; it does not encode all possible information available. What gets selected for encoding is a function of the organism's present interests and abilities.* (McShane, 1991:17)

In the following sections the views of a variety of researchers and philosophers on the meaning of, as well as the link between, information and knowledge will be discussed.

2.2.A The Brookes equation

Brookes (1975 and 1977 as cited in Ingwersen, 1992:31) developed a pseudo-mathematical[1] relationship between a knowledge structure[2], $K(S)$ and new information, I to yield a new knowledge structure.

$$K(S) + I = K(S + \Delta I) \quad (1)$$

[1] The term **pseudo**-mathematical is used as none of the variables are measurable.

[2] Knowledge or cognitive structures are the categories and concepts on which a person's (or machine's) model of the world is based (Ingwersen, 1992:229)

In words, the new knowledge structure is the old knowledge structure *plus* a portion (ΔI) of the new information at hand, which has been assimilated. The form of the Brookes equation used here is after Ingwersen, 2000a. The author prefers this form to that originally proposed by Brookes (1975)

$$K(S) + I = K(S + \Delta S) \quad (1a)$$

as equation 1a implies a synonymity between knowledge and information, whereas the author believes that these are separate entities, as will be discussed in subsequent paragraphs.

A problem with equation (1), found by Brookes' detractors (Ingwersen, 2000a) is that the reverse equation is also implied

$$K(S + \Delta I) = K(S) + I \quad (2)$$

This means the new knowledge structure could devolve back to its original state. In order to show that knowledge gained is never lost (Ingwersen, 2000a), Brookes formulated a one way relationship

$$K(S) + I \rightarrow K(S + \Delta I) \quad (3)$$

It is a moot point as to whether information added to a knowledge structure is always retained. It is common knowledge that humans possess both short- and long-term memories. With short-term memory, information is definitely lost from a knowledge structure after a period of time. This means equation (2) should hold for short- term memory in humans. However, one would expect that the relationship (3) should hold for a machine's knowledge structure.

Brookes (1980) noted that the amount of information, ΔI accommodated into the knowledge structure would not necessarily be the same for different knowledge structures, given the same information, I. This means that different people (*i.e.* different knowledge structures) will accommodate different amounts of the same given information.

Brookes' equation also clearly supports Piaget's primary learning mechanisms of assimilation and accommodation of new information:

> *...Assimilation is the process by which new information is interpreted in the light of existing cognitive structures; accommodation is the process by which cognitive structures change in the light of new information.* (McShane, 1991:41)
> *... the mechanisms of assimilation and accommodation serve as a filter between cognitive structures and new information. They act continually over time to modify existing cognitive structures.* (*ibid.*:42)
>
> *Brookes' equation presents a dynamic picture of a person's knowledge undergoing change. It is a conceptualization of the fundamental transformation*

> *that characterizes information and its effect in the mind. It is an expression of what happens in the mind when people are exposed to information and do something with this information.* (Todd, 1999)

As Brookes (1975) stated, "it will take a long time" to understand the equation. This is because there are no consistent definitions of the variables, nor can these variables be measured in any way.

In the next section, Brookes' equation and the concepts of assimilating and accommodating information is discussed in more detail to show their relationship to learning.

2.2.B Assimilating and accommodating information: learning

As mentioned in the previous section, Brookes' equation states that not all information received is processed (Brookes, 1980). Furthermore, a piece of information may be interpreted differently, depending on the current state of the recipient (or the context in which the information is received), resulting in different changes to his or her knowledge structure (Ingwersen, 1996). Also, as no two people can have the same knowledge structures, they will interpret new information differently and so assimilate different amounts (ΔI from the Brookes equation) of the new information. People are continually constructing or interpreting new experiences and by so doing are transforming their prior knowledge into new knowledge (Crebbin, 1999). This processing of information to construct new knowledge is **learning** (Gagné & Glaser, 1987).

According to Mayer, Steinhoff, Bower and Mars (1995) as well as Harp and Mayer (1998), in order for a learner to construct *a coherent mental representation* (knowledge) from information presented, s/he must use the processes *selecting*, *organising* and *integrating* to evaluate the information.

- *Selecting*: relevant information is extracted;
- *Organising*: links are made between the selected pieces of information;
- *Integrating*: links are made between the new information and prior knowledge.

Only once this process has been completed can it be said that knowledge has been created and learning has taken place.

In order to create knowledge, people need to do more than passively access information, they need to do something with the information (Alexander, 1995). Ingwersen (1992:33) feels that by interacting with information, a person may become aware of a lack of knowledge[1] and thus be forced into searching for new information to overcome this deficiency. Information is thus something which affects and transforms the recipient's state of knowledge when perceived (Ingwersen, 1996).

In the next section, the use (and misuse) of the words information and knowledge will be discussed.

2.2.C Information and knowledge: synonymity

From the previous arguments it can be seen that while most authors accept that information is not, in itself, knowledge, information is required to extend existing knowledge. According to Brookes (1975) "knowledge is the summation of many bits of information which have been organised into some sort of coherent entity". Some authors, however, seem to regard the terms as being interchangeable:

> *...Think of a teacher writing Pythagoras's theorem on a blackboard and asking the students to copy it down. This is using the blackboard for knowledge. The teacher could as easily have got the students to turn to a page in their textbook that contains the same knowledge.* (Tiffin & Rajasingham, 1995:62)

What the students are looking at here is not knowledge, but information. Their brains need to do something with this information (in this case Pythagoras's theorem) so that it can be added to their existing knowledge structures. Ingwersen (1996) sums this up well:

> *The author's text, including titles, captions, headings or cited works are representations of cognitive structures* [of that author] *intended to be communicated as information objects.*

Unfortunately, the interchangeability of the terms *information* and *knowledge* is exacerbated by dictionary definitions. (See, for instance, the Online-Dictionary.) A more pertinent dictionary definition for information is *facts or news* (Collins Plain English Dictionary, 1996:329).

Belkin (1975) discusses the difficulty in defining information and states that it depends strongly on the context in which the word is used. Saracevic (1999) in his essay on Information Science asks the question "What is 'Information' in Information Science?" and answers it by saying "We don't know". He goes on to say

> *Information is a basic phenomenon. For all basic phenomena - energy or gravity in physics, life in biology, justice in jurisprudence - the same "we-don't-know" answer applies.*

---

[1] Also referred to as an *anomalous state of knowledge* (Dervan & Nilan, 1986; Ingwersen, 1996)

He believes that Information Science is the communication of "human knowledge records", where a knowledge record is a "content bearing object".

Perkins on the other hand states categorically "What is knowledge? Knowledge is information..." (Perkins, 1986: 2). This is the opposite view to that discussed above, and, in the opinion of the author, just as incorrect. Knowledge is created from information, but to create information from knowledge requires a verbal articulation of that knowledge *by the person in possession of the knowledge.* Crebbin (1995) takes this even further in saying that "it is not always possible for someone to interpret and reconstruct knowledge into a form which can be understood by others" (*i.e.* it is not always possible for someone to recreate information from the knowledge s/he may possess). Shulman (1987) has similar views to Crebbin from his work with teachers, "teachers themselves have difficulty in articulating what they know and how they know it".

Crebbin (1995 and 1999), in developing a definition of knowledge from constructivist learning theories, states that "knowledge does not exist outside people". She feels that the belief that knowledge exists and has meaning beyond human construction, needs to be challenged (Crebbin, 1995).

2.2.D Information and knowledge in the computer industry

The use of the words information and knowledge in the computer industry is widespread. A term such as *Information Technology Department* is used to describe people doing hardware, software and network support. Generally, these people have nothing to do with information other than to provide the medium on which it is digitally stored or transported. However, the *technology* in *information technology* is the key concept and most of the work that the technology does, revolves around information (capture, storage, retrieval and transmission). Thus, using *information technology* as a global description for the computer industry is perfectly legitimate. According to Tanner (1992), the current usage of the term *information technology* implies the electronic handling of information, whether that information is numbers, pictures, sounds or other forms as well as a mixture of these. However, Davenport (1997:24-26), from an Information Science perspective, feels that the people in these fields are more concerned with technology and have very little to do with information. He feels that even corporate librarians are becoming more concerned with technology than the information which they are expected to deliver.

A term used incorrectly in the computer industry is *Knowledge Engineering*. In trying to find a definition for this term, the author did a search using the Google search engine (http://www.google.com) and came up with more than 30 000 hits. Of the more than 50 sites visited, only the Coventry University's Knowledge Engineering Management Centre (KEMC) tried to define *Knowledge Engineering*:

> *What is Knowledge-Based Engineering (KBE)?*
>
> *We haven't seen a perfect definition yet, but here's the best we've found, "A computer system that stores and processes knowledge related to and based upon a constructed computerised product model".* (KEMC, Coventry University 1999).

On the same page, they define *Knowledge Management*:

> *What is Knowledge Management?*
>
> *The systematic process of finding, selecting, organizing, distilling and presenting information in a way that improves an employee's comprehension in a specific area of interest. Knowledge management helps an organization to gain insight and understanding from its own experience. Specific knowledge management activities help focus the organization on acquiring, storing and utilizing knowledge for such things as problem solving, dynamic learning, strategic planning and decision making. It also protects intellectual assets from decay, adds to firm intelligence and provides increased flexibility.* (*ibid.)*

Reading these two definitions, in the light of the earlier discussion, it should be clear that *information* should be the descriptive noun used in these subjects, rather than *knowledge*. Unfortunately, *Knowledge Engineering* is widely accepted in the computer industry, so it is highly unlikely that a semantic argument against its use is going to change matters. Ingwersen (2000b) sums up the source of this semantic error by noting that knowledge engineering is an abbreviated form of knowledge **representation** engineering, where the "representation" element has, unfortunately, disappeared. This is supported by Bunderson and Inouye (1987) who state that "Knowledge technology includes those methods and mechanisms that mankind has evolved for the *acquisition* of knowledge or expertise from one or more human masters, and the *representation* of that knowledge in appropriately usable form." [italics in original].

Another example, stemming from the concept *Knowledge Engineering*, where knowledge is used instead of information

> *...She admitted that it prevented her from making recreational use of the Web while at work, but noted that the slow speed really did get in the way of doing her job, which was becoming increasingly knowledge- and research- based.*
>
> *...*
>
> *Expectations will rise, and need to be matched by the company system if the culture of the true knowledge worker is to be successfully nurtured. ...* (Honeyball, 2000).

The use of the word knowledge instead of information by academic institutions, publications and dictionaries, unfortunately lends legitimacy to the concept that information is knowledge. Martin (1998) sees a shift in the term "knowledge worker" to "information worker" since the publication of Parat's report (1977 as cited in Martin 1998) on *The Information Economy* for the US Department of Commerce.

It would appear that the confusion between knowledge and information in the computer industry is a result of Machlup's book *The Production and Distribution of Knowledge in the United States* (1962). In both this book and the 1980 follow-up, he maintains that knowledge is a marketable commodity in that it can be produced and sold. He defines "knowledge as anything that is known by **somebody** and the production of knowledge by which **someone** learns something **he** or **she** has not known before, even if **others** have". (Machlup, 1980: 7). In keeping with the view given in a preceding paragraph, emphasis has been placed on words in Machlup's own definition which shows that knowledge is something personal. Machlup goes on to include *disseminating* and *communicating* in his definition of knowledge production (*ibid.)*. Machlup does allude to the difference between information and knowledge (*ibid*: 8), but refuses to accept these differences. He states that "...in these ordinary uses of the word, all information is knowledge" (*ibid*: 9).

2.2.E Philosophical views on information and knowledge

According to Popper (1968:4) neither observation nor reason can be described as a source of knowledge. This statement cannot go unchallenged. Without observing (not only visually) the information (in all forms) with which we are bombarded each day, we cannot add to our existing knowledge. Similarly, without thinking and reasoning about that information, links to our existing knowledge **cannot** be made. Thus, observation and reasoning are fundamental to increasing our existing knowledge. Popper does, however, state that knowledge cannot start from nothing, but is advanced by the modification of earlier knowledge (*ibid*:28). Yet how is this modification of knowledge achieved? It **must** come from some external stimulus.

De Lange (2000) has looked into the roots of the words information and knowledge in order to extract the historical meanings. Interestingly enough, those meanings are as relevant today as they were centuries ago. He goes on to define knowledge as "the whole of all acts of conscious thinking" and information as "a collection of abstract forms represented (carried, coded) by any artifact outside the human mind" (*ibid.)*.

Gorman defines knowledge as "Distinctions and connections organized for purposes within context" (Gorman, 1999, 2001a). He breaks knowledge into three parts: facts, skill and understandings (Gorman, 2001b) and clarifies these as follows:

- Facts or distinctions are the building blocks for knowing something. These need to be memorized as they usually cannot be deduced. They are retrieved exactly as they were stored. By themselves, they only reflect the past (Gorman 2001c).
- Skills are required to know how to do something
- Connections or understandings are how the facts and/or skills relate to each other within a specific context. These become the models which enable a person to apply "old" knowledge to new situations (Gorman 2001c).

Davenport (1997:5) believes there are three levels of "information" in Information Science, with each successive level becoming more complex. These levels are data, information and knowledge. Davenport's summary of the definitions of data, information and knowledge is most succinct.

Table 2.2.e.1 *Data, Information and Knowledge* (from Davenport, 1997:9)

Data	Information	Knowledge
Simple observations of states of the world • Easily structured • Easily captured on machines. • Often quantified • Easily transferred	Data endowed with relevance and purpose • Requires unit of analysis • Need [*sic*] consensus on meaning • Human mediation necessary	Valuable information from the human mind. Includes reflection, synthesis and context • Hard to structure • Difficult to capture on machines • Often tacit • Hard to transfer

In the light of the above definitions, Davenport has a rather tongue-in-cheek view of the concept knowledge management:

> *For years, people have referred to data as "information"; now they have to resort to the high-minded "knowledge" to discuss information - hence the current boom in "knowledge management".* (Davenport, 1997:8).

In spite of this and saying that "data, information and knowledge are not interchangeable concepts" (Davenport, 1998:1), Davenport misuses the word *knowledge* in discussing knowledge transfer:

> *Knowledge transfer involves two actions: transmission (sending or presenting knowledge* [information][1] *to a potential recipient) and absorption by that person or group. If knowledge* [information] *is not absorbed, it has not been*

[1] The author has included [information] in the quotation to signify where he feels that Davenport has used *knowledge* incorrectly.

> *transferred. Merely making knowledge* [information] *available is not* [knowledge] *transfer.* (Davenport, 1998:101).[1]

Davenport goes on to say:

> *Even the transmission and absorption together have no useful value if the new knowledge does not lead to some change in behaviour, or the development of some new idea that leads to new behaviour.* (*ibid.*).

2.2.F Working definitions of information and knowledge

The following table sums up the preceding arguments. These definitions will be used, to qualify the terms given, in the rest of this document. From *knowledge* and *information*, working definitions for *learning* and *teaching* are also proposed.

Table 2.2.f.1 *Working definitions*

Knowledge[2]	• Skills which enable a person to solve problems. • Stored facts which allow a person to understand a problem or situation.
Information	The medium by which knowledge is transferred between people. It may be verbal, written, an action to be copied or a combination of these.
Learning	Making links between information presented and existing knowledge to create new knowledge.
Teaching	Assisting a learner in creating new knowledge from information presented.

It should be noted that Bloom *et al* (1956) have a far more complex structure for knowledge. They also separate intellectual abilities and skills from knowledge, which conflicts with the preceding arguments. In this study, intellectual abilities and skills are considered as part of knowledge.

From the definitions given in table 2.2.f.1, information requirements for Web-based teaching can be developed.

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[1] This quotation is nothing other than a reformulation of the Brookes equation (section 2.2.A).

[2] This definition of knowledge are loosely based on Gorman's views (2001a).

2.3 Information requirements for Web-based teaching

> *When authors advocate a particular approach to teaching (or learning), only rarely do they make explicit their view of what constitutes valid knowledge, of how it is created, shared or reproduced.* (Candy 1991:262).

Before the requirements for Web-based teaching can be addressed, it is necessary to define the role of the teacher and the role of the learner in the teaching/learning process.

2.3.A The role of the teacher

> *Teaching can be thought of as events, external to the learner, designed to support internal learning processes* (Gagné, 1987).

The teacher should be a subject expert, and being a subject expert means that the teacher would have converted information on the subject into usable knowledge. In teaching that subject, the teacher presents his or her knowledge to the learner. However, to the learner, this is not knowledge, but information[1]. A good teacher will realise this and try to facilitate making the required links between the learner's existing knowledge and the new information presented (Gagné & Glaser, 1987; Copley, 1992 as cited in Tam, 2000). Most of the theories of learning revolve around making these links (*e.g.* Bloom's Taxonomy of Learning[2] and Gagné's Learning Events[3]). Unfortunately, in most tertiary[4] teaching situations, the teacher has even less regard for the process by which the learner is expected to accommodate new information with his or her existing knowledge. These tertiary level teachers have usually forgotten what is difficult and what is easy for students (Bransford *et al*, 1999:32). A teacher's subject knowledge needs to be tempered with pedagogical knowledge as well (Shulman, 1987; Bransford *et al*, 1999:33).

More often than not, the learner is coached, by the teacher, to pass an examination (Fox, 1983; de Bono, 2000: 6; Johnston, 2000; Kantrowitz & McGinn, 2000; Schank, 2000; Shea, 2000). In cases such as these, the learner gains no knowledge, and the information that had been absorbed during the coaching/cramming session is soon lost. (equation 2 in section 2.2.A). Assessments usually measure factual knowledge which seldom asks the student when, where and why that knowledge should be used (Bransford *et al*, 1999:37).

Further, in attempting to use software to disseminate [educational] information, the software developer seldom does a needs analysis of the user, nor, in fact, is any kind of detailed analysis of the user done. This usually results in the failure of the software to

---

[1] contrary to the view expressed by Tiffin & Rajasingham (1995) discussed in a previous section

[2] Bloom *et al* (1956)

[3] Gagné (1965)

[4] Tertiary education refers to higher or post-secondary education.

facilitate learning (Draper, 2000). The failure is often as a result of the software being driven by technology rather than the educational needs of the student (Draper, 1998). In order to develop successful educational software, the teacher needs to work closely with the developer. This is to make sure that not only are the subject requirements met, but also those of the user. Needless to say, the teacher **must** also understand the needs of his or her students (Galusha, 1997) and should also have a good grasp of the capabilities (and limitations) of the technology to be used (Kaufmann & Thiagarajan, 1987).

In order for a teacher to develop a successful Web-based learning environment, her or she needs to critically examine his or her teaching practice and develop it accordingly. (Saarenkunnas *et al*, 1999). Web-based teaching does not rely on Web-based instruction only, it also needs the more traditional forms of contact teaching (*ibid.)*. The teacher should also take the views of the learners, about the role of Web-based teaching, into account when designing courses. This could prevent "cultural insensitivity"[1] to, as well as "misempowerment"[2] of, the learners (Lê & Lê, 1999).

To analyse his or her teaching practice, a teacher needs a set of guidelines on which to base his or her analysis. Such a set of guidelines from Shulman (1987) is given in Table 1.3.1. Shulman bases his model on classroom evaluations of successful teachers.

Table 2.3.A.1 *A model for pedagogical reasoning and action* (Shulman, 1987)

Comprehension	Of purposes, subject matter structures, ideas within and outside the discipline
Transformation	• Preparation: critical interpretation of texts, structuring and segmenting, development of a curricular repertoire, and clarification of purpose • Representation: use of a representational repertoire which included analogies, metaphors, examples, demonstrations, explanations, and so forth • Selection: choice from among an instructional repertoire which includes modes of teaching, organizing, managing, and arranging • Adaptation and tailoring to student characteristics: consideration of conceptions, preconceptions, misconceptions and difficulties, language, culture, and motivations, social class, gender, age, ability, aptitude, interests, self concepts, and attention
Instruction	Management, presentations, interactions, group work, discipline, humour, questioning and other aspects of active teaching, discovery or inquiry instruction, and the observable forms of classroom teaching
Evaluation	• Checking for student understanding during interactive teaching • Testing student understanding at the end of lessons or units • Evaluating one's own performance, and adjusting for experiences
Reflection	Reviewing, reconstructing, reenacting and critically analyzing one's own and the class's performance, and grounding explanations in evidence
New comprehensions	• Of purposes, subject matter, students, teaching and self • Consolidation of new understandings, and learnings from experience

[1] This could be racial or economic factors preventing the learner from successfully using the medium.
[2] The learner might not want to use the medium.

Before looking at the role of the learner, consider these words in closing this section on the role of the teacher,

> *...But what must concern the academic teacher is not so much the information retrieved by the student, but the use of that information - the transformation wrought by the student to render it as knowledge.* (Laurillard, 1993:126).

2.3.B The role of the learner

Students need to seek meaning and understanding from the information they interact with in order to gain knowledge (deep learning) rather than merely memorising facts for later recall in an examination (shallow learning) (Alexander, 1995).

The majority of students are unable to make connections between what they are learning and how knowledge they gain will be used. This is because of the way in which they process information (Anon., 2001b). Students need to learn when, where and why to use information received as well as how to recognise meaningful patterns in the information in order to develop an understanding (knowledge) of the subject matter (Bransford *et al*, 1999:38).

The learner needs to apply some form of cognitive strategy in order to solve given problems. If applied successfully, the cognitive strategy should lead to mastery of the subject matter (Fleming, 1987). Learners need to think about and discuss their own approach to learning, and be willing to explore alternatives (Candy, 1991:296). However, many learners regard this as

- a waste of time,
- the teacher avoiding his or her responsibility,
- not what they had come to learn (Baird & Mitchell, 1986 as cited in Candy, 1991:297).

Nonetheless, for learners to be able expand their knowledge, they need to become autonomous, and to become autonomous learners, they need to think about learning itself (Candy, 1991:298,299). A common misconception is that a person becomes autonomous on becoming an adult. This is rarely the case, as discussed by Steyn (1998). The student needs to be convinced that he or she needs to become an independent lifelong learner (Forsyth, 1998:20).

As the teacher usually sets specific deadlines for tasks in Web-based courses, students are responsible ensuring that they complete their tasks within these deadlines (Passerini & Granger, 2000). Learners need to take control over their learning rather than having a teacher control it for them. Figure 2.3.b.1 shows a hypothetical continuum showing how teacher/learner control of learning varies. On the left is teacher dominated control, with very little scope for learner control, as is found in a school classroom. On the right a point is reached where the learner controls almost everything which he or she wishes to learn. This point would be reached by a person truly capable of independent study (Candy, 1991:8-19). This point is seldom achieved, but for Web-based learning, one would hope that the learner falls at least into the right half of the continuum.

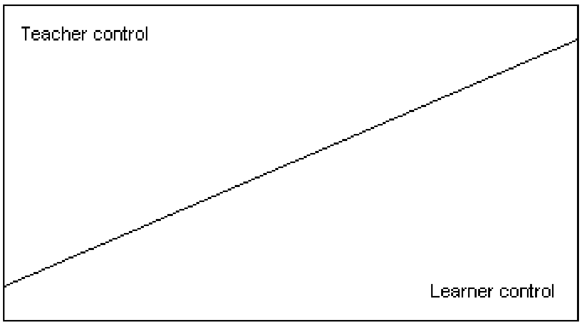

Figure 2.3.b.1 *Hypothetical teacher/learner control continuum* (after Candy, 1991:10)

The figure also shows that as the teacher surrenders control over what is being learned, the learner must accept a corresponding amount of control of his or her own learning (Candy, 1991:9). This seldom occurs with undergraduate students. Steyn (1998) feels that undergraduate students should be treated as developing learners rather than adult learners. However, with Internet-based learning, the learner **must** take more control of his or her learning (Forsyth, 1998:32). A further problem often found is that undergraduate learners lack the motivation for on-line coursework found in adult learners (Irani, 2000). This lack of motivation for on-line learning is usually caused by the learning expectations ingrained in the student by the passive manner in which information is received in the school classroom (Åkerlind & Trevitt, 1995).

To sum up this section on the role of the learner, consider the following from MacFarlane (1995):

> *Students will have to learn how to manage their own learning processes to an unprecedented degree... to swim in a sea of information, to use the rich resources of a supportive learning environment, to self pace and self structure their own programmes of learning* (MacFarlane, 1995 as cited in Ward & Newlands, 1998).

2.3.C The role of the medium of delivery

Technology-based teaching procedures must take into account characteristics of the learner, such as maturity and knowledge status (Gagné, 1987) as learning is highly dependent on the prior knowledge of the learner (Reigeluth, 1983 as cited in Fleming, 1987). It should also try to match the learner's cognitive strategies with the task at hand by

- assuming the learner knows, and will use, the correct strategy,
- reminding the user of a known strategy,
- building a strategy into the teaching procedure (Fleming, 1987).

Much of the educational material available on the Web does not live up to expectations since most of this material is in the form of electronic page-turners or an electronic book with some search and indexing facilities (Cronjé, 1997; Forsyth, 1998:13). However, it is often easier and quicker to get an answer to a question by consulting a reference book than by using a search engine to scour the Web (Basch, 1999). Students often prefer the portability (and readability) of a book or printed notes over a network dependent computer terminal (Harmon & Jones, 1999). In spite of these misgivings, the Web does allow relatively easy access to information (Forsyth, 1998:13.).

Arnold (1997) prefers using the Web to deliver his course notes and references as it allows him the flexibility to make rapid changes to the course content and reference material in the light of students' responses to preceding lectures and assignments. All the students then have immediate access to the changes without having to wait for a reprint of the updated edition of the course guide.

In spite of its appeal as a delivery mechanism, the Web still contains many unknowns as a tool for learning, both in terms of the expectations of the learner and what can or cannot be done with the technology (Hill, 2001). As the Web is not appropriate in all situations in education, Harmon and Jones (1999) have proposed five levels of Web use for educators to use as a tool in deciding how, or indeed whether, to use the Web in their courses. Table 2.3.c.1 shows these levels with a short description of how Web usage varies in the different levels.

Table 2.3.c.1 *Levels of Web use in education* (after Harmon & Jones, 1999)

Level	**Web usage**
0	No Web use.
1	*Informational* Web use: usually administrative, including information such as the syllabus, course schedules and contact information. Frequent use of the Web is not necessary.
2	*Supplemental* Web use: provides an addendum to core content of a course, and usually includes course notes and handouts on the Web. Frequent, but not necessarily daily access to the Web is required.
3	*Essential* Web use: most of course content is placed on the Web. Students cannot successfully complete the course without accessing the Web.
4	*Communal* Web use: face-to-face and on-line interactions occur, with course content being provided in either medium. Students generate on-line course content themselves.
5	*Immersive* Web use: all course content and interactions occur on-line.

In addition to the levels of Web use outlined in Table 2.3.c.1, Harmon and Jones have also identified eleven factors that influence whether Web-based instruction should be used (*ibid.*). In Table 2.3.c.2 these factors are listed with a brief description of how each factor influences the choice of Web-based instruction.

Table 2.3.c.2 *Factors influencing the desirability of Web use in education* (after Harmon & Jones, 1999)

Factor	Description
Distance	This refers to the geographical proximity of the teacher and students. Under certain circumstances, teachers and students in close proximity can benefit from online instruction.
Stability of material	How often does the course material need to be updated? Web-based material can be rapidly updated and is immediately available.
Need for multimedia	If a course requires the use of multimedia, this can be easily incorporated into Web-based material, providing the student has sufficient bandwidth in his or her access to the Web.
Need for student tracking	Is it necessary to keep records of student interaction with and progress through the course? Web server-based software is available for record keeping.
Number of students	The higher the level of Web usage, the lower the number of students a teacher can manage. Using Web-based instruction to boost student numbers, when classroom space is at a premium, is a mistake.
Amount of interaction	Here, the interaction is amongst students and the teacher, not with the software. This becomes very important in Web use levels 4 and 5 in Table 2.3.c.1, where E-mail, chat rooms and bulletin boards would supply the interaction.
Social pressure to use Web	Although not really pedagogically valid, social pressure is one of the driving forces behind using the Web as an instructional tool. Educational institutions could lose credibility for not having Web-based offerings amongst their products.
Need for online reference	Reference sites, which are regularly updated, may be useful as an adjunct to course material.
Infrastructure	An institution must have the network capability and servers to supply a satisfactory data throughput. It also needs support personnel to maintain the technology.
Comfort levels	Students with no background in technology-based learning require significant amounts of training in order to cope with a Web-based course.
Access	This refers to whether the student has access to both the Internet and the necessary hardware.

Harmon and Jones have extended their arguments to show how the factors outlined in Table 2.3.c.2 affect the level of Web usage outlined in Table 2.3.c.1 (*ibid.*). The issue of "Number of students" has been examined by Irani (2000). She reported that many universities in the USA were looking to increase student numbers by 30-40% over the next ten years by offering on-line courses to relieve the pressure on campus facilities. She questions whether undergraduate students will be able to cope this medium of course delivery (*ibid.*).

According to Wijekumar (2001), creating an on-line course requires more than putting course notes on the Web. It requires time and effort from people with skills ranging from subject matter experts to instructional designers and programmers. She feels that currently, much of the material available being created is driven by tools built into "Web-based course and development systems" rather than educators with teaching and learning at heart (*ibid.*). Lê and Lê (1999) take this even further. They feel that the students themselves should be included in the design process when constructing on-line course material (*ibid.*, Saarenkunnas *et al*, 1999). Web-based courses seldom rely solely on the Web as the sole form of instruction. Traditional forms of teaching, such as lectures and tutorials, are also used (Saarenkunnas *et al*, 1999).

The so called Clark-Kozma debate (Clark, 1994; Kozma, 1994) centres around whether, in a learning activity, the delivery medium plays a role in any learning which takes place. An issue of the journal *Educational Technology Research and Development* was devoted to this debate (Ross, 1994). According to Clark, the learning activity (and learning) is independent of the delivery medium. To him, the teaching method is important. He uses an analogy of a truck delivering groceries. Regardless of what type of truck is used, the groceries will be delivered (Clark 1983 as cited in Clark, 1994 and Kozma, 1994). Kozma on the other hand feels that the medium of lesson delivery is important and does influence learning (Kozma, 1994). Depending on the topic, presentations in different media can influence the learning outcome. He cites two specific examples in which measured differences in learning outcomes were found, which could be directly attributable to the medium used. However, Russell (2002) has more than three hundred references in his "no significant difference" database. In these references researchers have found that technology-assisted teaching has not produced significantly different outcomes to classroom-based teaching.

"...the *learning activity* and not the technology or the medium in which it is used, is the key to improved outcomes..." (Housego and Freeman, 2000).

2.4 Web-based teaching as aid in disadvantaged communities

2.4.A Cultural and language issues

The failure of students to pass their grades in higher education can more often than not be ascribed to a mismatch between what students have learned in their home cultures and what is expected of them in the university culture (Bransford *et al*, 1999:225). In order for such students to create new knowledge, they need a great deal of assistance making links between their existing knowledge and the new information they receive on a daily basis (*ibid.*:224). This is of critical importance when technology-assisted teaching is being considered. A generic teaching method, such as found in Web-based courses, could fail by not taking into account cultural and language differences amongst learners (Lê & Lê, 1999).

2.4.B Political and economic issues

Education is a political and economic phenomenon and failure to take into account the financial constraints under which schools are forced to operate often lead to the downfall of new teaching practices (Morgan, 1987). A factor often overlooked when implementing such new practices, especially when technology is involved in the new practice, is maintenance (and the cost of the maintenance) of the new system (*ibid.*; Galusha, 1997). A limitation of the Internet is the increasing complexity of the technology required to access it. Implicit in this increasing complexity is an increase in the cost of being able to access the information available on the Internet (Forsyth, 1998:18). Before poor countries can capitalise on new technologies, they need to increase the number of people with the high-level skills required by these technologies (Elliot, 2001).

2.4.C The digital divide

Students need training in the technical issues of using computers and the Internet (Galusha, 1997). Students lacking these skills can be hampered in their efforts to complete a distance course. "If distance learning is to be successful, technical barriers must be made a non-issue" (*ibid.*) (see also "Comfort levels" in Table 2.3.c.2). On the other hand, if teachers are not motivated to use the technology then any Web-based teaching initiatives will not reach expected outcomes (Bohlin, 1999). Arnold (1997) asks whether it is always appropriate to compel students to commit themselves to technology-based learning as transformations of this nature are usually met with resistance. This resistance to technology-based learning is rarely acknowledged and even more rarely addressed by educators and education administrators (Åkerlind & Trevitt, 1995).

Furthermore, an aspect of the digital divide seldom discussed is the challenge of providing Internet access in all communities (Anderson, 2001). Generic services which supply only basic HTML Web services are inadequate to meet educational needs (*ibid.*). The cost involved in supplying (and receiving) high quality Internet services may be beyond the budget capabilities of many disadvantaged communities (*ibid.*).

2.4.D South African issues

One of the biggest problems in South African education is that of teacher skills. Many mathematics and science teachers in Black communities have not studied the subjects they teach beyond the senior school year (TELI, 1996; Pretorius, 2001a). In order to overcome this, in-service training programs for teachers have been implemented at many tertiary institutions.

However, there is very little motivation for teachers to improve their qualifications, nor for that matter is there any reason for university graduates to become teachers. A language teacher with a Masters degree (and more than 10 years appropriate experience) can, at best, expect to earn R80 000 per annum (with no fringe benefits), at one of the better schools in Pretoria (Nel, 2001). In the first three years that the BSecEd(Sci) (a course to train secondary school science teachers) was offered as a degree at the University of Pretoria, not a single Black student had enrolled (Nordhoff, 2001). With the poor return on investment on university studies for teachers, this is hardly surprising. O'Malley (2001) feels that some of the donations from the private sector and overseas sources, which are currently used for building new schools and repairing "old" ones, should be used for increasing the standards of teacher professionalism. However, without increasing the salaries of teachers, the standard of teaching will not improve. This problem is not unique to South Africa, as it has also been noted in the United States Government's Web-based Education Commission Report (WBEC, 2000: 6 & 7).

In 1996, the South African government compiled a report on using technology as a teaching and learning aid in education. This report, known as the Technology-Enhanced Learning Initiative (TELI), examined advantages and disadvantages of various forms of technological aids in teaching as well as how these aids could be implemented in South African education (TELI, 1996 &1997). An important finding was that the teacher remained the key to successful provision of education, regardless of the technological aid being used (TELI, 1996). Using technological aids in education is usually more expensive than in an equivalent face-to-face situation (*ibid.*). Schrecker (1998) concurs with this and goes on to say that technology does not save money by lessening the need for teachers and classrooms. It requires a high capital investment as hardware, software and support staff have a built-in obsolescence which needs to be continually upgraded.

In 1997, the TELI team gave themselves five years in which to implement the initiative (TELI, 1997). At the time of writing (November, 2001), no noticeable progress in its implementation has been seen (as can be deduced from the writings of Pretorius in the *Sunday Times* during 2001), in spite of the R71 million budget requested in 1997 (TELI, 1997). This maybe an indication of the difficulty surrounding a project of this nature.

The Information and Communications Technology (ICT) report (Departments of Education and Communications, 2001) as well as the TELI discussion document (TELI, 1996) see the delivery of services, such as electricity, water and telephone connectivity, to the poorer communities as fundamental to the implementation of any technology-based teaching initiative. However, the introduction of technological aids to teaching may widen the gap between the urban and rural areas (TELI, 1996).

In closing this section on Web-based teaching in disadvantaged communities, consider the following:

> *Educational technology has not yet produced promised changes in our schools and our workplaces...* (Estes & Clark, 1999).

2.5 Conclusion

In this chapter working definitions of information, knowledge, learning and teaching have been developed from arguments in the literature as well as from the views of several academics. Information and knowledge are not synonymous, but rather, like teaching and learning, separate, related concepts.

From these working definitions, the information requirements for successful teaching via the Web have been developed. Web-based teaching requires more than merely converting course notes into Web pages. It needs more work than normal face-to-face lectures *in addition to* some face-to-face contact between the lecturer and the student. Using Web-based teaching to increase student numbers without increasing lecturing staff is also not feasible as these students require more attention (not less) than their classroom-based counterparts. Harmon & Jones (1999) tools for evaluating the desirability of Web use in education should be followed carefully before implementing Web-based modules.

Finally, issues concerning Web-based teaching in disadvantaged communities have been examined. These show that care should be taken in not further marginalising the disadvantaged communities with the introduction of technology that can be neither afforded by those communities nor supported within them.

Chapter 3 Methodology

Chapter guide

3 Methodology

3.1 The research problem

Table 1.3.1 and table 1.5.1 show the questions raised in this research. In order to answer these questions, the project outlined in this chapter was devised.

3.1.A The aim of the research

The aim of this project was to design, develop and implement a Web-based teaching resource for an undergraduate university course. This resource was then used as a vehicle for addressing the research questions outlined in chapter 1. By comparing the results obtained by students on the Web-based course with those obtained by students on the equivalent paper-based course, a measure of the efficacy of this method of teaching this course could be evaluated. By splitting the students in to groups according to their school background (resource disadvantaged *vs.* resource advantaged[1]) an indication can be obtained whether this method of teaching discriminated against either group.

3.1.B The objectives of the research

In order to meet the aim outlined in section 3.1.A, the following objectives had to be achieved.

Web-based course development

- Evaluate hardware and software requirements for a Web server;
- evaluate tools for Web page design and development;
- design Web-based course pages which met the same criteria as the equivalent paper-based course;
- develop the Web pages using suitable software and submit these to colleagues for peer review;
- change the Web pages according to peer review suggestions;
- implement the Web pages on the Web server and test the response of the Web server under heavy load; and
- grant students access to the course material.

[1] Resource advantaged (Ra) and resource disadvantaged (Rd) were defined in Table 1.4.2.

Web-based course evaluation

- Evaluate students' assignments;
- evaluate students' tests and examinations;
- evaluate students' time management skills;
- analyse and evaluate Web server logs; and
- develop, administer and evaluate a questionnaire which probed students' opinions about the Web-based course.

In sections 3.3 and 3.4 the objectives discussed above will be examined in more detail, but firstly, the Problem Solving Skills module of the Science Orientation Course, SCI 152, will be discussed in section 3.2.

3.2 A description of the Problem Solving Skills module of the Science Orientation course

The background to the Science Orientation course was discussed briefly in section 1.4, *Historical overview of the Science Orientation course*. In this section, more details of the course content, especially the Problem Solving Skills module (SCI 152), and the participants will be given.

Originally, the Science Orientation course was implemented to give students from disadvantaged communities skills, which they should have received at school, necessary to successfully complete degrees in the Sciences. Table 3.2.1 shows some of the skills covered in the Science Orientation course, with their current module numbers. Historically, all four modules ran concurrently over one academic year, with an examination being written at the end of that academic year. Currently, the modules SCI 152 and SCI 153 run in the first semester and SCI 162 and SCI 163 in the second semester. An examination terminates the modules at the end of the respective semesters.

Table 3.2.1 Study skills covered in the Science Orientation course

Module	**Module name**	**Brief description**
SCI 152	Linear Problem Solving Skills	Includes elementary computer literacy, mathematical word-processing skills, Internet awareness and mathematical problem solving skills.
SCI 153	Academic Proficiency	Includes study skills, learning styles, time management and solving personal problems.
SCI 162	Non-linear Problem Solving Skills	The use of system dynamics to define and solve non-linear, multi-variable problems.
SCI 163	Basic Research Skills	Includes using the library, using books and journals, plagiarism and referencing and research methods used in science.

More information on these modules can be found at http://goldilux.up.ac.za/goldlab

In this study, only the section of the SCI 152 course, dealing with the Problem Solving Skills, will be examined. The Problem Solving Skills component of the SCI 152 lends itself to a student's first contact with Internet delivery of lesson material, in that most of the knowledge required to solve the problems, should be part of his or her background from school mathematics. In addition, the students already had some exposure to the Internet and the Web in the Internet awareness assignment in the SCI 152 module.

The next section deals with the type of student taking the Science Orientation course.

3.2.A Target population

As mentioned in the previous section, the course was originally limited to students, from communities disadvantaged by the apartheid education policies, who were interested in careers in science. These students were chosen on the basis of their scholastic achievements as well as selection tests and interviews, where their aptitude for science studies was measured. As mentioned in section 1.4, the original course was part of a bridging year between school and university, where the idea behind the bridging year was to improve the students' academic ability in the sciences. This was done in order to allow these students to perform at the same level in their first year, as students whose scholastic achievements were at the level required by the University of Pretoria. This objective was largely achieved, as a number of students from the bridging program obtained degrees in fields such as medicine and engineering.

During 1995, the management of the University of Pretoria decided to terminate the bridging program in the Faculty of Science, and in its place introduce an "extended B.Sc.". The idea behind the extended B.Sc. was that the first year was to be split over two years to allow academically weaker students a chance to acclimatise to the pace of university teaching. An advantage of the extended B.Sc. over the bridging program was that the students could accumulate credits toward their degrees in the first year. With the bridging program, no credits were awarded for subjects passed. The Science Orientation course was absorbed into the main stream of the University's academic activities (and some of its content was also included in academic offerings in other faculties) to become a credit bearing course. Although the extended B.Sc. was still aimed largely at students from disadvantaged communities, students from advantaged communities also began applying for this method of study in order to try and obtain access to faculties with more rigorous entrance requirements (such as medicine, engineering and veterinary science). The course was compulsory for these academically weaker students.

From 1998, Science Education students, doing the Bachelor of Secondary Education (Science) degree, had to include the modules SCI 152, SCI 153 and SCI 163 as part of their degree program. The SCI 152 module was included as the Director of the Centre for Science Education felt that Science teachers should have exposure to alternative uses for computers in education (Braun, 2000). These prospective teachers should additionally be trained in deliberate problem solving processes which involve the simplification of a problem into small steps, before recombination into the larger solution (*ibid*. See also section 3.2.B Aims and objectives of the module). SCI 153, which focuses on study methods and study self management, is intended to benefit the student teachers personally, and in their future professional role as study facilitators (*ibid*.). The presence of these student teachers had a stimulating effect on the SCI 152 student group as a whole, as they tended to readily offer assistance to academically weaker students.

With the modularisation of the Science Orientation course in 2000, and the addition of compulsory computer and information literacy to the University of Pretoria curriculum, further changes to the composition of students taking the SCI 152 module was noted. Several top students started taking the SCI 152 module voluntarily, as they felt this would pose more of a challenge than the generic computer and information literacy modules of the University.

Starting in 1999, lecturers at the University of Pretoria began experimenting with Web-delivery of course and lecture notes as well as assignment material, in undergraduate courses. The reasoning was that this method of teaching

- had been successfully used in several post-graduate courses (*e.g.* Cronjé 1997; Cronjé & Clarke 1998);
- was "cheaper" in that duplicating costs were avoided;
- was driven by a directive from the management of the University for lecturers to implement some form of technology-based teaching in their courses (van Harmelen 1997).

The author decided to use this method of delivery for the Problem Solving component of the SCI 152 course in 2000, for further reasons

- lecture space was unavailable for the larger student group taking the course;
- no definitive research was available on how successful this method of lesson delivery was for academically weaker students, with little or no computer background.

Table 1.4.2 (repeated below) shows how students were grouped for the purposes of this study. This grouping was necessary in order to see the effect of scholastic background on the students' ability to cope with this different method of teaching.

Table 1.4.2 Group definitions used in this study

Group name	Group abbreviation	Definition
Resource advantaged learners	Ra	Learners from schools with resource centres, who have had to use the resources, with minimum input from the teachers, to complete tasks.
Resource disadvantaged learners	Rd	Learners from disadvantaged schools without resource centres. In these cases, learners have to rely solely on teachers as a source of information.

In assigning students to these groups, the author first used the apartheid education system divisions: those from the former white provincial education departments and those from the former Department of Education and Training (DET). However, extensive interviews with students showed that those from Coloured and Asian communities (who fell under the former DET) were actually Ra learners in that their schools were better equipped than those in the Black communities. From the interviews with the students, it is interesting to note is that in spite of government funds being taken away from Ra schools, no corresponding improvement in the resource capabilities of Rd schools has been seen since the change of government in 1994. An advantage of using this categorisation is that Black scholars attending Ra schools could be included in the Ra category. However, during the period of the Internet delivery of lesson material in this study (2000 and 2001), no students on the course, from Black communities attended Ra schools. The severe disadvantage that students from Rd schools were at was seen during "open book" tests on the paper-based course (1997-1999). These students had no idea how to find information from a textbook. The index to the book was as foreign to them as the content of the book.

3.2.B Aims and objectives of the module

The aim of the Problem Solving Skills component of the SCI 152 module is to teach the students how to analyse and solve scientific problems.

The objectives of the Problem Solving Skills component of the SCI 152 module is for the students to

- analyse a geometry problem;
- break the problem down in to sub-problems;
- solve the sub-problems; and
- synthesise the solutions of the sub-problems to obtain the solution to the main problem.

Emphasis is placed on the use of algebra, trigonometry and Euclidean geometry in solving the problems. The mathematical concepts covered are extremely important in physics, but the general strategies followed can be adapted to any scientific field. The course was designed to use, and build on, the students' existing knowledge of mathematics, by carefully providing the information necessary for the students to develop the required problem solving skills.

3.2.C Module content

The paper-based course consisted of a weekly 40 minute lecture followed by a four hour practical in which the computer language Logo was used as an aid in solving mathematical problems. The lecture was a discussion of the previous week's problems, new Logo commands (if any) and hints on solving the current week's problems.

In creating a Web-based resource for the course, care had to be taken that sufficient information was available to the students so that the lecture could be omitted. Thus, the Web-based resource had to contain detailed solutions to earlier problems, which included the mathematics behind the problem, as well as well-structured examples to assist the students in solving new problems.

The table below outlines the content of each assignment.

Table 3.2.c.1 *SCI 152 assignments*

Assignment no.	Assignment title	Brief description
1	Introduction to Logo	Introduces the student to the Logo environment and basic Logo commands.
2	Using colour & Regular polygons	Exercises in using commands to draw in colour are given as these are necessary for the Church Project. This is followed by questions to guide the student in discovering geometrical properties of regular polygons.
3	Using REPEAT & Rotating regular figures	REPEAT is used as a tool in generating regular polygons by repeating simple commands. Nested REPEATs allow complex figures to be produced. The generation of complex figures by nesting commands is the foundation for synthesising the solution to a problem from component solutions.
4	"Circles"	Many-sided regular polygons give the illusion of circles. However, the line segments in these regular polygons results in more complex geometry than that of simple circles.
5	Procedures	Procedures give students a means to generate their own Logo commands from basic Logo commands. Procedures simplify the synthesis of solutions to complex problems.
6	Procedures and variables	Manipulation of variables allows procedures to be re-used when drawing figures of different sizes.

The problems in each of these assignments may be viewed with an Internet browser on the attached CD under the folder "SCI152 Web pages". A solutions page for each assignment is linked to the relevant assignment page.

The final assignment for the course is for each student to draw a church using Logo. The objectives behind this are threefold:

- to test whether the student could use the problem solving strategies provided by the course, independently of the other students;
- to force the student to analyse a problem **before** attempting to solve it (*i.e.* recognise the component problems); and
- to synthesise a solution from the analysis of the problem.

It must be stressed that programming in Logo is not the aim of the course. Logo is merely a tool used to test solutions to the mathematical problems. Out of the more than 300 basic Logo commands only 18 are used in the course and very few students experimented with other commands.

3.2.D Method

The practical sessions of the Problem Solving Skills module (SCI 152) took place in the Gold Fields Computer Centre at the University of Pretoria. This centre is open from 07:30 to 20:00 each weekday during the academic year. Students registered to use the centre were able to do so at any time during these hours, provided that the centre had not been reserved for other activities. Figure 3.2.d.1 shows the layout of the Gold Fields Computer Centre. Each X on the diagram represents a computer. The author's office is one of those shown in the figure, giving an idea of the close proximity to the students. This has both advantages and disadvantages:

- one advantage is that help for the students was always close at hand;
- a disadvantage is that the students found it easier to ask for assistance rather than try to puzzle through any problem on their own. This problem was exacerbated by the fact that the author's office has a window facing into the computer centre (which can be seen in the second photograph in figure 3.2.d.2).

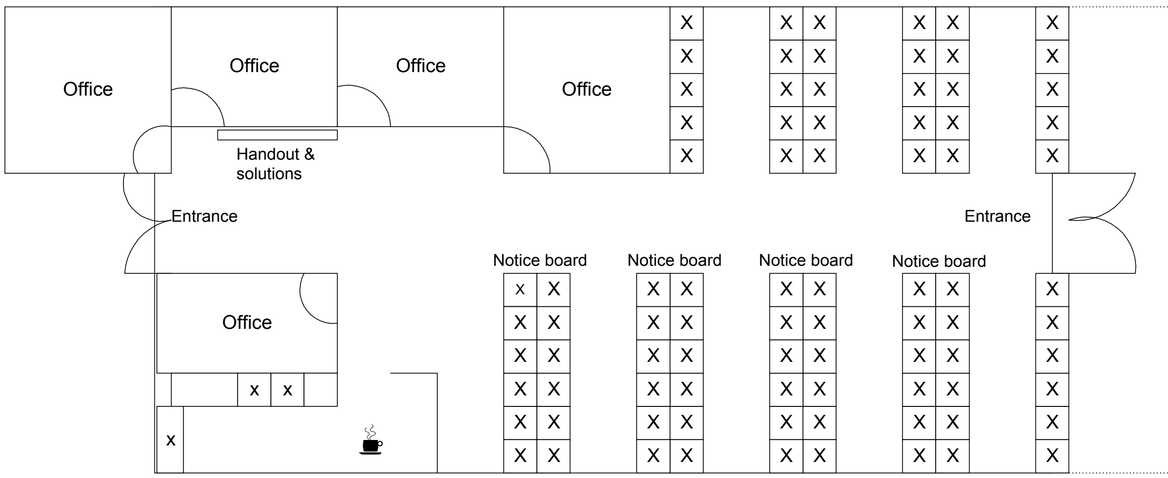

Figure 3.2.d.1 The layout of the Gold Fields Computer Centre (from Steyn, 1998)

Early in 2002, the Gold Fields Computer Centre moved to new premises on the University of Pretoria campus. Although the dimensions of the new Centre was not the same as the old one, the layout remained similar in that the same benches and cubicles were used in the new Centre. The photographs in figure 3.2.d.2 show SCI 152 students working on their assignments in the new Centre. (Views of the old Centre can be seen in the video clips on the attached CD as well as from photographs in Steyn, 1998.)

As mentioned in section 3.2.C, the paper-based course consisted of a 40 minute lecture followed by a four hour practical session each Wednesday of the semester. During the practical session, the lecturer and tutors (one tutor per 12 students) were present to assist the students in creating their solutions to the problems. The student-student and student-tutor interactions (as well as student-lecturer interactions) shown in the photographs and in the video clips on the CD, took place throughout the pratical session. Most of the students managed to finish their assignments within the practical period, but those who did not, were allowed to finish it in their own time before the deadline on the Friday following the practical session. In this case, it was normally the weaker students of both the Ra and Rd groups who required the extra time to complete their assignments. These students normally tried to finish their assignments in free periods, but had to rely heavily on the lecturer for assistance in completing these.

	A photograph showing mixed race and gender SCI 152 students working on an assignment...
	...the author's office on the right of the photograph showing the window looking out into the Centre...
	...two tutors (both standing) giving advice to students.

Figure 3.2.d.2 Photographs of students working in the Gold Fields Computer Centre

With the Web-based course, students were free to work on their assignments at any time, however, the tutors were only available during the normal practical period on Wednesday.

In both years that the Web-based resource was used, most of the students of the Rd group were present during the practical period, whereas students of the Ra group were inclined to skip the practical session and then cram to complete the assignment before the deadline. Of the entire group, only a few students of the Ra group tried to work ahead, in spite of the need to gain time to complete the Church Project satisfactorily.

3.3 Web-based course development

3.3.A The Web server

The Web server used in this study was built by the author from spare parts for the student workstations in the Gold Fields Computer Centre at the University of Pretoria. It has the following specifications:

- 100MHz Pentium 1 processor;
- 32MB main memory;
- 6GB IDE hard disk;
- 10Mbit/s ethernet card.

Linux (http://www.linux.org) was used as an operating system for the Web server. The only other option considered was Microsoft NT. This was precluded because of its rather excessive hardware requirements. Furthermore, Linux is available at no cost, as is the Web server software, Apache (http://www.apache.org).

[For the record, the Web server has been running continuously since December 1999, with two stoppages. One due to a power failure and the second when the Gold Fields Computer Centre moved to another building on the campus of the University of Pretoria. No malfunctions were experienced during the periods when the course was active and there was never any noticeable delay in downloading the pages, even at times when all the students were active.]

3.3.B Web page design tools

Several WYSIWYG Web page design tools were evaluated for use in developing the Web course pages. These were:

- Microsoft Frontpage;
- Microsoft Frontpage Express;
- Netobjects Fusion.

Microsoft Frontpage Express was chosen as it was available at no charge as part of Microsoft Internet Explorer 4. Frontpage Express also had the advantage over the other two products in that its HTML editor was far less limited in that special HTML codes used by WYSIWYG controls were not hidden.

3.3.C Design and development of the Web pages

A great deal of care had to be taken in designing the Web pages to ensure that sufficient information was available for the students to complete the course successfully. The pages had to fall into at least Level 3 of Harmon and Jones Levels of Web usage (Harmon & Jones, 1999) as the students were expected to obtain most of the course content from the Web. However, several factors influencing Web-based instruction on Level 3 that Harmon and Jones identified (Harmon & Jones, 1999), did not apply to the SCI 152 course. Table 3.3.c.1 shows the Harmon & Jones Level 3 factors influencing Web-based instruction, and those that applied to the SCI 152 course.

Table 3.3.c.1 *Factors influencing the SCI 152 course on Harmon and Jones Level 3 Web usage (after Harmon & Jones, 1999).*

Factors	**Harmon & Jones Level 3**	**SCI 152**
Distance	Medium	Low
Stability of material	Dynamic	High
Need for multimedia	High	Low
Need for student tracking	High	Medium
Number of students	Large	Large
Amount of interaction	Low	Medium
Social pressure to use Web	Medium	Medium
Need for off-line reference	High	Medium
Infrastructure	Moderate	High
Comfort levels	Medium	Medium
Access	Moderate	High

In the table, the "stability of material" had to be high in order to make comparisons with the paper-based course. By "amount of interaction", Harmon and Jones referred specifically to email, chat rooms and bulletin boards, in other words, peer interaction rather than interaction with software. This electronic interaction was not necessary on the SCI 152 course as most of the students completed their assignments in the Gold Fields Computer Centre, which meant students could interact directly with each other when necessary.

As most of the interaction was not with the Web pages, but rather with the PC Logo software, the design of the SCI 152 Web-based course falls into the category of page-based Web instruction (Barron, 1998). The advantage of page-based Web instruction is that it makes use of standard HTML code which can be read in any browser (Barron, 1998). Including non-standard interaction on the Web page would require the use of browser plug-ins[1]. These plug-ins are not always compatible with all browsers (see, for example Jones *et al*, 2000).

In designing the Web pages, the author followed the recommendations of Nielsen (2000) in keeping the interface as simple as possible. This was in order to keep the students' attention focused on the academic information contained in the pages. Figure 3.3.c.1 shows the simplicity of the Index page.

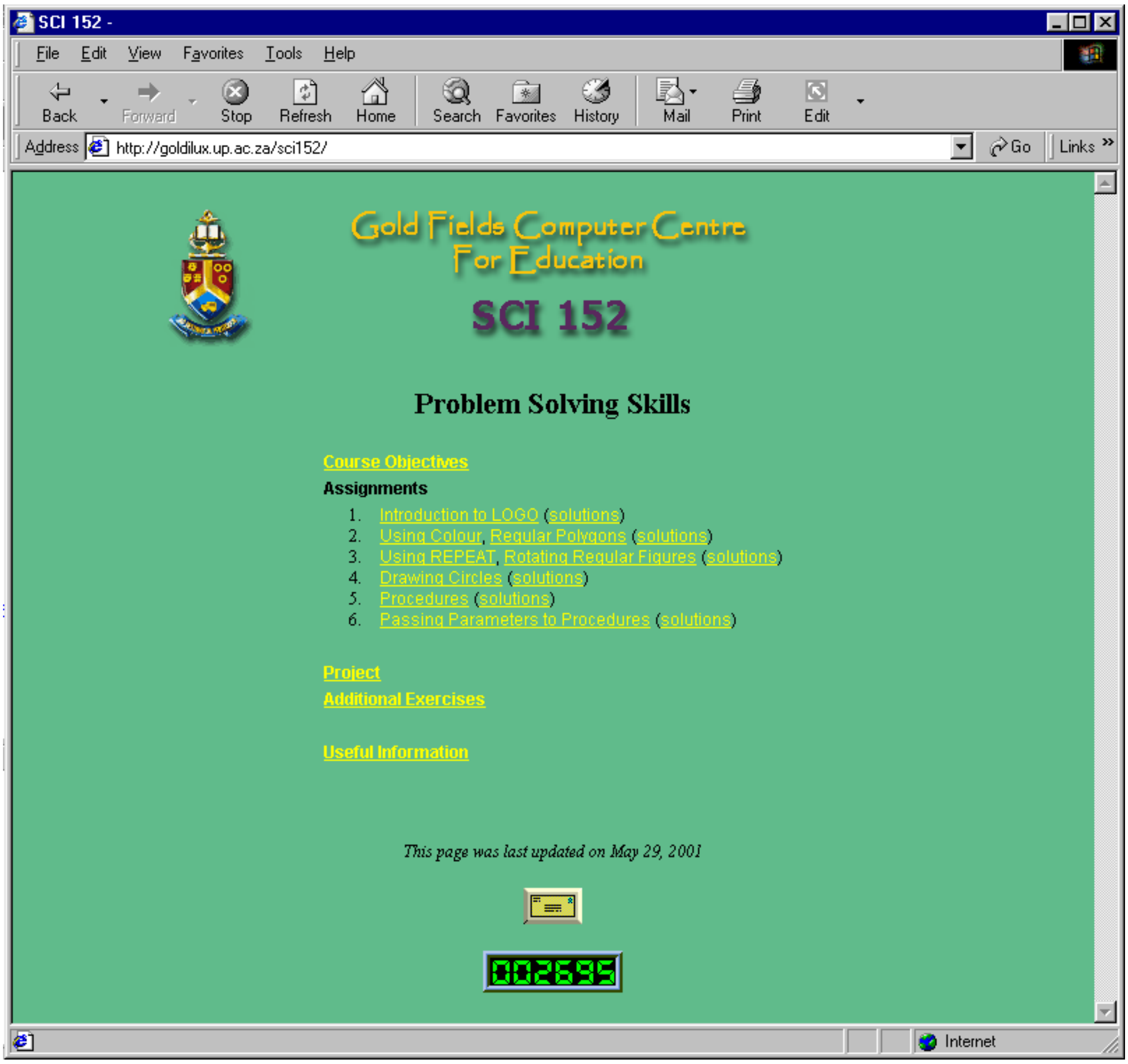

Figure 3.3.c.1 *The Index page of the SCI 152 Web-based course*

[1] A plug-in is a software module which has to be loaded onto the workstation, in order to obtain the effect envisaged by the Web page developer.

Web pages need to download quickly in order to maintain the user's interest (Nielsen, 2000:46). Excessive use of pictures increases the download time of the page. As diagrams were important in describing the assignments in the rest of the course, the first page was designed with a minimum of images so as to download quickly. This was to ensure that the users could interact with the information as fast as possible (Nielsen, 2000:50). There are only three image links on the Index page:

- the University of Pretoria emblem, which links to the University of Pretoria homepage;
- an image iconifying the name of the Gold Fields Computer Centre which links to the homepage of the Centre;
- an envelope icon which links to the author's email address.

Using pictures as metaphors to site navigation are sometimes useful, but these are often overused leaving the visitor to a Web site uncertain as to what should be done (Nielsen, 2000:180). A literal design of links usually makes the Web page easier to use (Nielsen, 2000:182-187). Certain icons could also be offensive to users from different cultural backgrounds, so the imagery behind the icon should be thoroughly researched before being used (Nielsen, 2000:315). In this study, students were from many different cultural and religious backgrounds so the use of icons as links was avoided as far as possible. Apart from those mentioned, only three further icons were used on other pages:

- a left arrow to move back to a previous assignment;
- a rectangle to move back to the Index page; and
- a right arrow to move forward to the next assignment.

Mouse flyovers were used to indicate the task assigned to these icons.

Other links shown on the Index page depicted in Figure 3.3.c.1:

- The course Objectives link, and the corresponding Objectives page, was included on the advice of one of the peer reviewers.
- The links to the solution pages were added to the Index page after the due date of each assignment. In 2000, the links to the solution pages were only available on corresponding assignment pages. As students appeared not to have used the solution pages, it was decided to add these links to the Index page as well, in order to make the existence of these pages more obvious.
- The Useful information page was included to act, amongst other things, as a bulletin board for important dates and announcements. (A similar idea to the "Notice Board" used by Ward & Newlands, 1998.)

In keeping with the guidelines given by Barron (1998), the pertinent information on the Index page can be viewed without having to use a scroll bar, even on monitors using a resolution of 640x480 pixels.

Figure 3.3.c.2 shows the introduction to the second part of Assignment 3, with guidelines that could be used in solving the problems that follow.

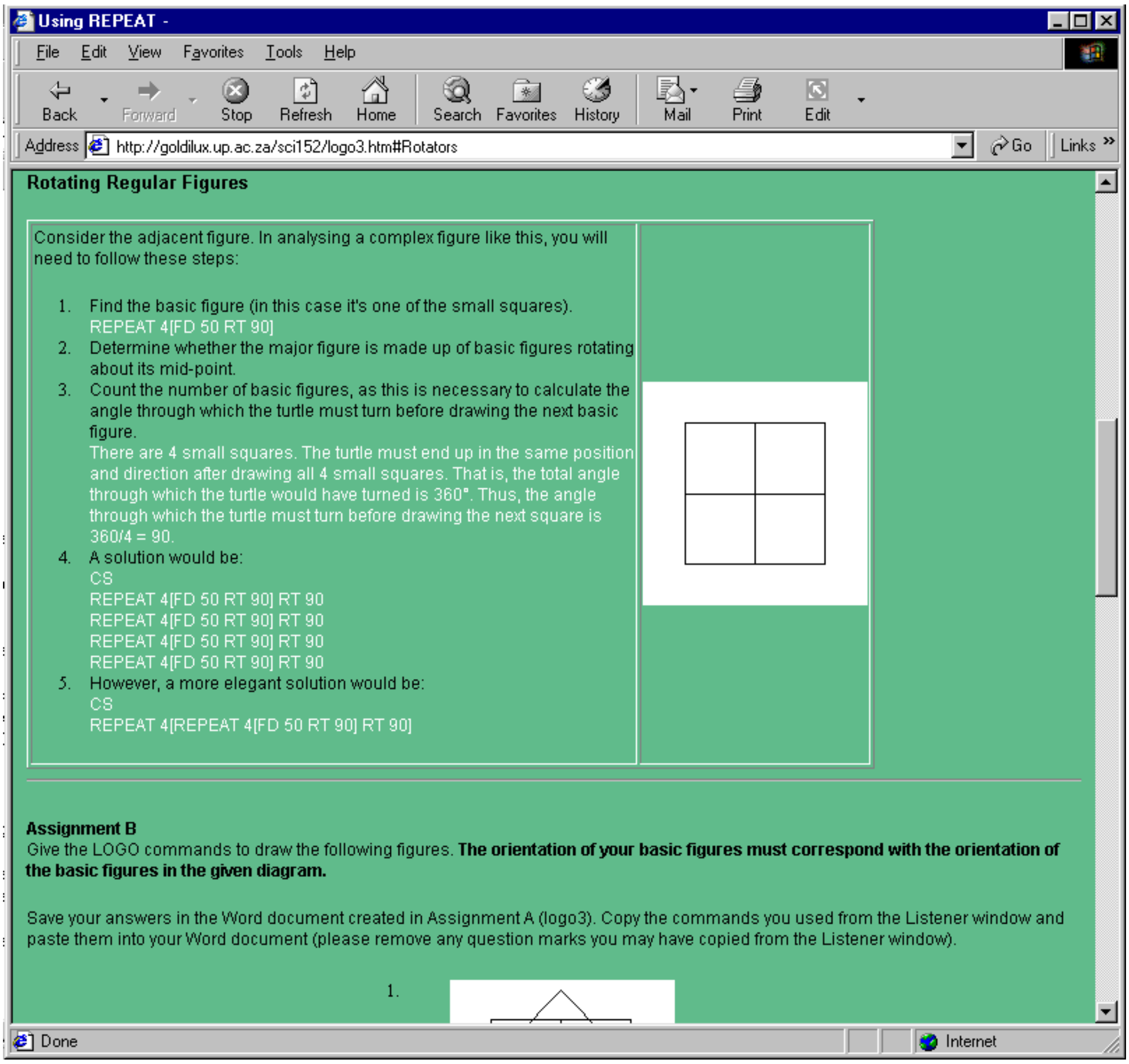

Figure 3.3.c.2 *Part of the Assignment 3 page*

In designing the pages, careful consideration was given to the use of colour (Barron, 1998; Nielsen, 2000:125). The green background was used specifically in that it provided sufficient contrast for both black and white text as well as the yellow used to indicate linked pages. The white text was used in an attempt to make it difficult for the pages to be printed. By default, Web browsers do not print the background colour, hence white text would not be visible on a white printed page. Normally, the first thing that students will do in attempting an assignment is to print the Web page (Ward & Newlands, 1998; Sheard *et al*, 2000). Students prefer the portability of a printed document (Harmon & Jones, 1999). The author found that he had to restrict student access to the printer in the Gold Fields Computer Centre as the students wasted large quantities of paper in repeated printing of assignment pages. According to De Villiers (2001a), the Department of

Telematic Learning and Education Innovation, who are responsible for Web-based teaching at the University of Pretoria, recommend that all Web pages used for teaching should be "printer friendly". However, in making this recommendation, they make no suggestions as to who should bear the cost of printing these pages. Furthermore, implicit in this recommendation is that students have access to a printer. This is certainly not the case as, before the author restricted access to the printer in the Gold Fields Computer Centre, students on the SCI 152 course often printed Web-based course pages for students on other courses.

Figure 3.3.c.3 shows part of the solution page to Assignment 3.

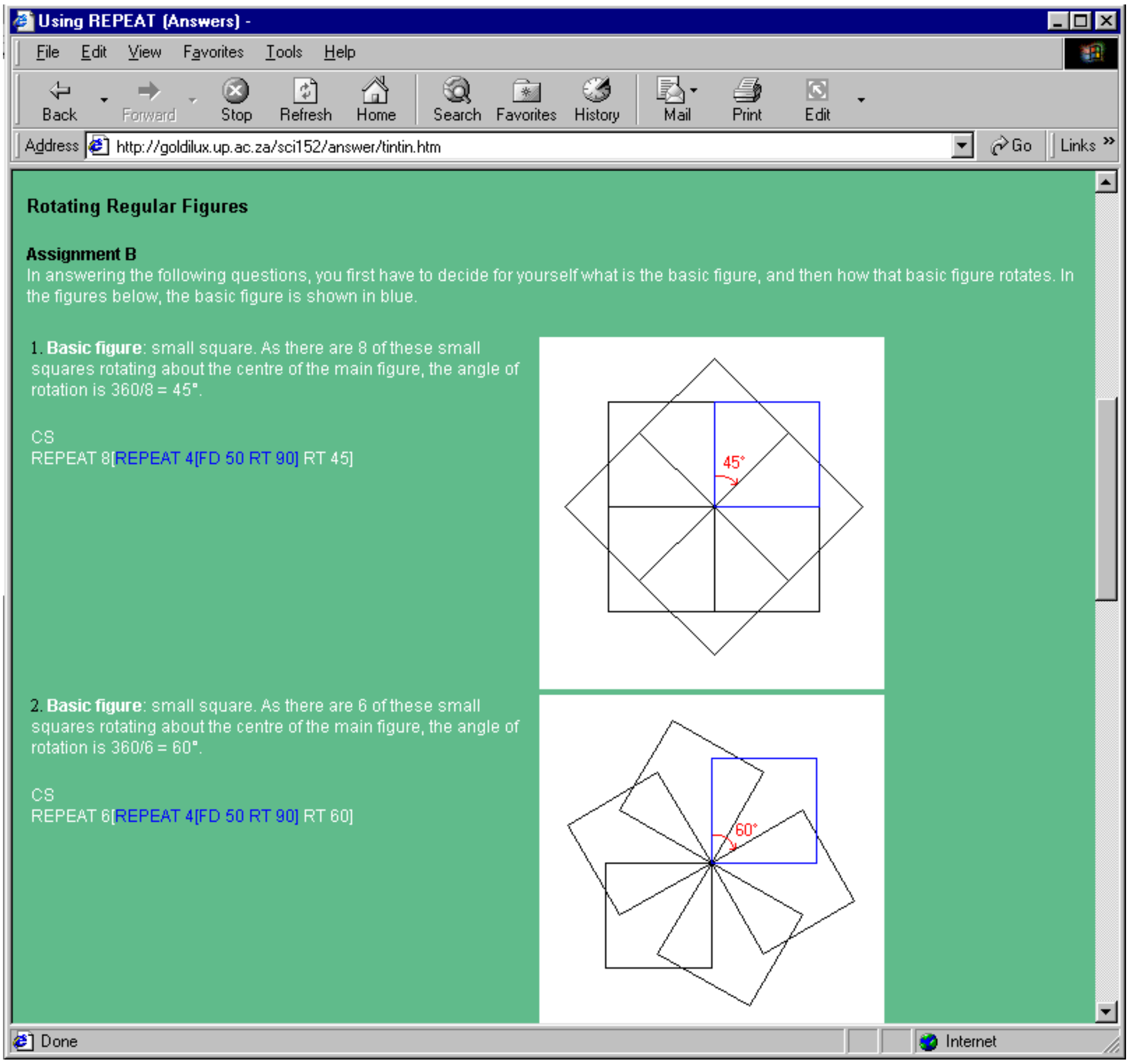

Figure 3.3.c.3 *Part of the solutions page for Assignment 3*

In making the diagrams, PC Logo was used to draw the initial image. This image was then edited in Microsoft Paint to show the important features in the diagram. The image was then converted to GIF format, for use on the Web, using Adobe Photoshop. The same procedure was used in creating the diagrams used in the assignments themselves, except that it was not necessary to edit the diagram in Microsoft Paint.

As the solution pages were available on the Web server at the start of the Web-based course, it was necessary to use an unconventional naming system to prevent students from guessing the names of these pages. Unrelated (and rather obscure) comic strip character names were used for these file names. The Web server software was set up in such a way that it was not possible to obtain a listing of the file names through a Web browser.

Once the Web pages were complete and the changes recommended by the reviewers were made, the students were granted access to the course material. The next section discusses how the course was evaluated, and the tools used in the evaluation. Students' results were used as a means of testing the effectiveness of the Web-based resource as a teaching aid.

3.4 Web-based course evaluation

In this study, descriptive quantitative statistics, supported by qualitative analysis, was used instead of descriptive quantitative statistics triangulated by inferential statistics. In order to assess the students' ability in converting the information from the Web pages into knowledge which could be used in solving problems of the type presented in the SCI 152 course, it was necessary to compare their results with those of students on the equivalent paper-based course. In analysing the results of students' assignments, tests and examinations, use was made of arithmetical means and graphs to compare results across years. The arithmetical mean was used as it is

- unbiased,
- efficient and
- consistent (Berenson & Levine, 1986: 274-276).

Standard deviations, although calculated, were not used in this study. Using a standard deviation to test the variance of the data implies that the data fits a Gaussian distribution. The students' results were not Gaussian, but skewed towards higher marks. Analysis of variance was not used for the same reason. According to Berenson & Levin (*ibid.*: 479), analysis of variance requires that the data

- be normally distributed;
- have homogeneous variance; and
- be independent of error.

If the distribution of the data is far removed from Gaussian, the analysis of variance F-test should be used. However, if the variance within each group is not homogenous, the

F-test will also be seriously affected (*ibid.*). As the data used in this study did not conform to the requirements for analysis of variance, this test was not used.

Estes and Clark (1999) recommend that both formative and summative evaluation be used in assessing the effectiveness of a technology-based course. While formal formative evaluation *of the students* was not undertaken, the results of the students on the paper-based course can be interpreted as formative evaluation *of the course*. Similarly, the results of the students on the Web-based course are a summative evaluation of the Web-based resource.

3.4.A Evaluation of students' assignments

In keeping with the recommendations of Cronjé (1997), the deadlines given for the completion of assignments on a Web-based course were strictly adhered to. On completing their assignments, students saved them on a fileserver in the Gold Fields Computer Centre. These assignments were then allocated to tutors who marked them according to a memorandum which had been used for all the years in which the content of the course had remained constant (1997 to 2001). The results of an assignment, together with feedback, were returned to the students, on the fileserver, within two days of the deadline for completion.

3.4.B Evaluation of students' tests and examinations

As uniqueness of the questions is a prerequisite for maintaining the standards of tests and examinations, careful consideration had to be given to the complexity of the questions throughout the study period. The author worked in close collaboration with the external examiner of the course in setting up the questions so as to ensure that the level of difficulty was maintained. In order to make the marks as representative and unbiased as possible, all tests and examinations were marked by the author and thoroughly moderated by the external examiner. The same external examiner was used throughout the study period.

3.4.C Evaluation of students' time management skills

As mentioned in section 3.4.A, students saved their completed assignments on a fileserver in the Gold Fields Computer Centre. When a file is saved, the operating system includes a date and time stamp of when this task was performed. Analysis of these dates yielded an idea of how each student managed his or her time in completing the assignments.

3.4.D Analysis and evaluation of Web server logs

The Web server software used in this study, Apache, generated a record of each file downloaded from the Web server. These records include the IP[1] address of the computer requesting the download, the name of the file being downloaded and the date and time of the download request. [Note: the IP address of a computer is unique and is usually assigned by the ISP[2] when the computer connects to the ISP. In the Gold Fields Computer Centre, the IP addresses of the workstations were assigned by the author and fixed to the MAC[3] address of the ethernet card in the workstation.] However, one should be aware that the Web server was not only used for the SCI 152 course, but also for other Web sites associated with the Gold Fields Computer Centre. All the traffic for these sites were also recorded in the log file. These extra records made the log file large and cumbersome to inspect and had to be removed manually before the course data could be evaluated.

The Web server logs were used to analyse the hits on the following pages of the SCI 152 course:

- Index
- Objectives
- PC Logo familiarisation
- Solutions
- Additional assignments
- Useful information.

In addition, the logs were used to track the pages accessed by students during the course of the examinations.

3.4.E Development and evaluation of a questionnaire

A questionnaire was developed in order to test the students' opinions about the Web-based course, as well as their computer literacy levels. The questionnaire is given in Appendix 2 and will be discussed in more detail in section 3.5.

3.5 Questionnaire

The questions used in the questionnaire were based on the author's experiences and close contact with the students during the paper-based-course and the early stages of the Web-based course. A research journal, video footage of the students and notes made during

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[1] Internet protocol. The IP address is an eight digit hexadecimal number, broken down into four groups of two digits. The leftmost four digits usually represents the Internet domain of the ISP.

[2] Internet service provider

[3] Media access control: a universally unique 12-digit hexadecimal number assigned to each ethernet card by the manufacturer.

interviews with them provided the author with a great deal of background information for a reflective study. These reflections were used in designing the questionnaire.

In setting up the questionnaire, the author used experience gained in computerising and analysing psychometric tests. These tests, especially interest and personality tests, often use several questions to test a single trait. In the questionnaire used in this study, two multi-question response sets were used to probe single concepts, although the individual questions also yielded interesting information. The two concepts were

- computer expertise and
- attitude towards Web-based teaching/learning.

In spite of the misgivings voiced by Fresen (1996), most of the questions required a binary response (yes/no). Binary responses give the subjects no leeway in their opinions on the question. This was useful when building the response sets for the composite questions mentioned above.

3.5.A Computer expertise

In order to determine the effect of exposure to computers, prior to starting the SCI 152 course, on the outcome of the course, a series of questions were asked to assess the level of computer expertise of the students. The questions used for this, together with the weighting assigned to each response, are given in Table 4.3.a.1. Increased weightings used were for increasing complexity of the computer skill being probed. The weighted results for each question were then added to build a composite skill level for each student.

The effect of prior exposure to computers on the results of the students is then determined by averaging the examination results of students falling into each of the skill categories and plotting these averages as a histogram.

3.5.B Students' attitudes towards the Web-based course

Since the students may have been influenced in their response to a direct question concerning their attitudes towards the Web-based course, four questions were used in drawing up a composite response to this question. These four questions, together with their responses, are given in Table 4.3.b.1. As these questions had binary responses, one point was added for each response given in Table 4.3.b.1, and zero for the other. No weightings were used. This resulted in five categories representing the students' views of the Web-based course.

The effect of the students' attitudes towards the Web-based course on their results is then determined by averaging the examination results of students falling into each of the categories and plotting these averages as a histogram.

3.5.C Use of supplementary pages

In order for students to gain maximum benefit from a Web-based course, it is necessary for them to make use of the supplementary pages on the course Web site, such as the course objectives and the solution pages. These supplementary pages were mentioned in section 3.3.C *Design and development of the Web pages* and in section 3.3.D *Analysis and evaluation of Web server logs*. Questions concerning the use of these pages were also included in the questionnaire. Responses to these questions were compared with the number of hits on the pages.

3.5.D Time management

Several questions were included relating to how the students managed their time without formal lectures and practicals. The responses were used as part of the assessment of the students' time management skills mentioned in section 3.4.C *Evaluation of students' time management skills*.

3.5.E Administering the questionnaire

Immediately prior to the examination in 2000, all students were asked to complete the questionnaire. This time was used as it was the only period when all students were present in the same locality after completing the Web-based course. The students were also asked to include their student number on the questionnaire for record purposes. This provided a direct comparison between responses to the questions and marks used to evaluate each student. In an attempt to prevent the students from giving responses which they might have thought would influence the author in marking the examination, they were told that the questionnaire would only be evaluated in the semester following the examination. All students were allowed extra time to complete their examination.

Unfortunately, the same technique could not be used in 2001, as several students had another examination immediately after the SCI 152 examination. Students on the SCI 162 course were asked to complete a shorter questionnaire on the day of their project presentation. However, this group was a subset of the SCI 152 group and five months had elapsed since the completion of the SCI 152 examination. The author is of the opinion that this affected the credibility of many of the responses, so only interesting responses from this group have been discussed in section 4.3.

3.5.F Evaluating the responses

Responses were entered into an *Excel*™ workbook. The responses to each question were then counted, firstly for the student group as a whole and then for the two racial groupings used in this study. Histograms of these results were then plotted to compare the results. These histograms were used to qualify other results (assignments and the examination) obtained by the students.

3.6 Summary

In this chapter, methods used to collect data, outlined in Table 1.8.2, were presented. In addition, components required to support the project, such as the Web server and designing the Web pages were also discussed. These components were the foundation on which the Web site was built, and without an effective Web site, the project would never have reached fruition.

In chapter 4 the data collected in this study will be analysed and discussed.

Chapter 4 Results and Discussion

Chapter guide

4. Results and Discussion

In this chapter, the data collection methods are grouped together rather than the research questions. This style was followed as many interesting observations and annotations would be lost if the question and answer format was strictly adhered to. These observations and annotations, which are scattered throughout the chapter, are important in building a profile of the students on the SCI 152 course.

In order to guide the reader as to which sections were primarily used to formulate answers to the research questions, the data collection matrix given in table 1.8.2 is repeated below, with the relevant sections in this chapter included in the table.

Table 4.1 *Data collection matrix for the research questions posed in Table 1.5.1, showing the sections in this chapter in which the questions are answered.*

	Course results	Questionnaire	Web-server logs	Assignment hand-in date	Observation & discussion
1. How did the students cope with the Web as a medium for lesson presentation?	4.1 4.3	4.3 4.4	4.2	4.4	4.1 4.2 4.4 4.5 4.6
• face-to-face contact	4.1.D 4.3.B	4.3.B 4.3.C			4.1.B 4.1.D
• sufficient information in Web pages	4.1	4.3.D			4.6
• successful time management strategies	4.1.A 4.1.B 4.1.C	4.3.E 4.4		4.4	4.1 4.4 4.5
• use of study-aid pages		4.3.D 4.3.E	4.2		4.2.B 4.2.E
2. What were students' attitudes towards Web-delivery of course material?	4.1	4.3		4.4	4.1 4.3
3. How did the digital divide affect the students' performance?	4.1 4.3 4.5	4.3		4.4 4.5	4.3 4.5
• prior exposure to computers	4.3.A	4.3.A			4.3.A 4.5
• successful completion of a solo computer-based project	4.1.C			4.4	4.1.C 4.5
• open internet access	4.5			4.5	4.5
4. Was there any difference in the ability of Ra and Rd students to complete the course successfully?	4.1	4.3 4.4			4.1 4.3 4.4

It can be seen from the table that there is much duplication in the methods which answer the different questions. The links between the various methods and answers will be discussed in chapter 5.

In this chapter, the distinction between Resource advantaged (Ra) and Resource disadvantaged (Rd) students set out in table 1.4.2 is used in discussing the results of the students on the SCI 152 course. This difference is examined to determine the effect of the different school systems in South Africa on a student's ability to deal with information presented via an electronic medium rather than in a classroom.

4.1 Comparison of assessment results

4.1.A Examinations

As the SCI 152 course is a credit-bearing course at the University of Pretoria, students have to be assessed by means of a moderated examination. The results of the examinations since 1997 can be compared because the course content has remained fairly constant since then.

Table 4.1.a.1 *The major differences between the Web-based course and the paper-based course.*

Paper based (1997-1999)	Web based (2000 & 2001)
Year course, with the June examination acting as a semester test.	Semester course, with the June examination finalising the course.
An "Academic Proficiency" component was included as part of the course and in the examination.	The "Computer Literacy and Problem Solving" course became a module on its own, separate from "Academic Proficiency".
Classroom based with assignments given weekly as paper handouts.	Web-based information delivery for the "Problem Solving" component of the course.
The course project could be completed within the first week of the second semester (after the June examination).	The course project had to be completed **before** the June examination.

In the data presented below, the results of the Academic Proficiency questions, from the June examination of the paper-based course, have been removed to make a more meaningful comparison. The numerical values used in drawing up these graphs are given in Appendix 1.

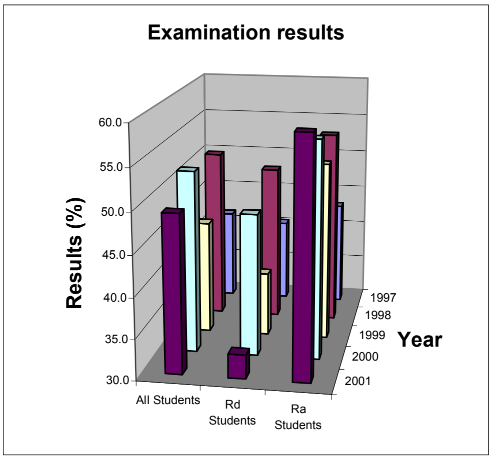


Figure 4.1.a.1 *The class averages for the examinations from 1997 to 2001.*

The apparent skewing of the data shown in Figure 4.1.a.1 towards better results for the Ra students from 1998 is due to the course becoming compulsory for BSecEd(Sci) students (secondary school science student teachers). These students were often in their second academic year, all in the Ra grouping and often had better University entrance prerequisites than the students for whom the course had originally been developed. The huge skewing seen towards the Ra students in 2001 is due to the presence of six Financial Mathematics students[1] in addition to the BSecEd(Sci) students. Five of these Financial Mathematics students achieved 80% or more for their SCI 152 examination. Their effect on the average mark of the class can be seen in the frequency distribution graph (Figure 4.1.a.2).

[1] The Financial Mathematics students took the course as the management of the University of Pretoria had decided that, from the 2001 academic year, all students would have to complete a computer literacy course. The SCI 152 module fulfils the requirements for the generic computer literacy modules CIL 171 and CIL 172. The Financial Mathematics students who took the SCI 152 course felt that it would pose more of a challenge than the generic courses.

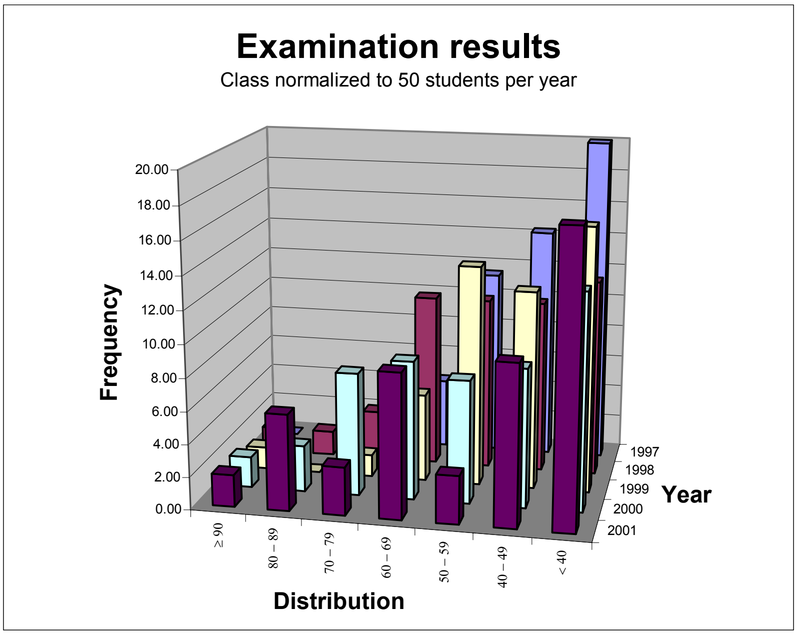


Figure 4.1.a.2 *The frequency-distribution of the students' examination marks. The class size for each year has been normalized to 50 students.*

Figure 4.1.a.2 shows a higher number of students in the grouping with more than 70% for the Web-based course (2000 and 2001) than the paper-based course (1997 to 1999). The number of students failing appears to have remained constant for both the Web- and paper-based courses (except for 1997, which was higher). One very pleasing point was that in 2000 a Rd student achieved more than 90% in the examination for the first time. In 2001, two Financial Mathematics students achieved more than 90% for the examination.

To obtain a better idea of how the Web-based course results compare with the paper-based course, the results shown in Figure 4.1.a.1 were averaged across the years 1997-1999 for the paper-based course and across 2000 and 2001 for the Web-based course. Although statistical significance cannot be claimed, the results provide good support for the trends shown. These results are shown in Table 4.1.a.2.

Table 4.1.a.2 *The difference in examination results for the Web-based and the paper-based courses.*

	Paper-based (number of students)	**Web-based (number of students)**	**Move**
All students	45.5% (105)	51.0% (104)	→ 5.5%
Rd students	42.6% (64)	41.3% (44)	← 1.3%
Ra students	50.0% (41)	58.1% (60)	→ 8.1%

This table shows that, overall, the results of the students doing the Web-based course were better than those doing the paper-based course. In the 2000 and 2001 examinations the Rd students fared marginally more poorly, while the Ra students fared appreciably better than the students who had done the paper-based course.

By doing a similar analysis on the data making up the frequency distribution graph in Figure 4.1.a.2, one can assess the effect of the Web-based course on the pass rate.

Table 4.1.a.3 *The difference in pass rate for the Web-based and the paper-based courses.*

	Paper-based %pass (%fail)	**Web-based %pass (%fail)**	**Move**
All students	42.9% (57.1%)	51.0% (49.0%)	→ 8.1%
Rd students	35.9% (64.1%)	31.8% (68.2%)	← 4.1%
Ra students	53.7% (46.3%)	65.0% (35.0%)	→ 11.3%

From Table 4.1.a.3 it can be seen that the Web-based course showed an overall improvement of 8.1% in the number of students passing their examination. However, 4.1% fewer Rd students passed the Web-based course than the paper-based course, whereas 11.3% more Ra students passed the Web-based course. This suggests that the Ra students were more at ease with the method of lesson delivery in the Web-based course than their Rd counterparts. However, as mentioned earlier, the skewing of results of the Ra students is more than likely due to the presence of the mathematically more capable Financial Mathematics students on the course in 2001.

To show the effect of the six Financial Mathematics students on the course averages, the data making up Table 4.1.a.3 has been recalculated without taking these students' results into account.

Table 4.1.a.4 *The difference in pass rate for the Web-based and the paper-based courses without the results of the Financial Mathematics students.*

	Paper-based %pass (%fail)	**Web-based %pass (%fail)**	**Move**
All students	42.9% (57.1%)	48.0% (52.0%)	→ 5.1%
Rd students	35.9% (64.1%)	31.8% (68.2%)	← 4.1%
Ra students	53.7% (46.3%)	61.1% (38.9%)	→ 7.4%

Although the table shows that the Ra students on the Web-based course still did better than their counterparts on the paper-based course, the difference is not nearly as dramatic after the exclusion of the Financial Mathematics students.

From the "no significant difference" phenomenon (Russell, 2002), one may have expected the results between the paper-based and Web-based courses to have been closer. However, the question should be asked as to **why** should there be no significant difference between assessment results of technology-based teaching and classroom-based teaching. The author feels, that regardless of how the information is presented, students have preconceived notions as to

- which information is relevant, and
- how to interpret this information.

These preconceived notions are based on their expectations as to what will be required in the assessment phase of the subject matter (see also Laurillard, 1993:211). [Draper (2001b) discusses similar matters under the headings "shallow learning" and "the hidden curriculum".] These expectations are a direct result of the coaching techniques used by teachers in preparing students for the assessment phase. As the assessment methods have not changed, one can hardly expect a change in results between classroom-based teaching and technology-based teaching.

4.1.B Assignments

From the preceding section, it appears that the students had gained sufficient knowledge from the information presented in the Web pages to fare better than the equivalent classroom/paper-based courses in their examinations. In order to assess more fully the students' interaction with the information on the Web pages, a comparison was made between the marks that had been allocated for the assignments over the years in which the study has run. With the paper-based course, the assignments were handed out after each lecture and these had to be completed within two days after the lecture. In the case of the Web-based course, the students had access to all the assignments and lecture notes from the beginning of the course. However, a weekly deadline for completing the assignments was still maintained.

Although the content of the assignments falls outside the scope of this document, it is nevertheless useful to be aware of this content in analysing the results of the assignments. In the following table (a shortened form of table 3.2.c.1), assignment numbers and the corresponding assignment titles are given. These titles will give the reader a quick review of the content of the assignments (the complete content is given on the enclosed CD under the directory "SCI152 Web pages").

Table 4.1.b.1 *SCI 152 assignments*

Assignment no.	Assignment title
1	Introduction to Logo
2	Using colour & Regular polygons
3	Using REPEAT & Rotating regular figures
4	"Circles"
5	Procedures
6	Procedures and variables

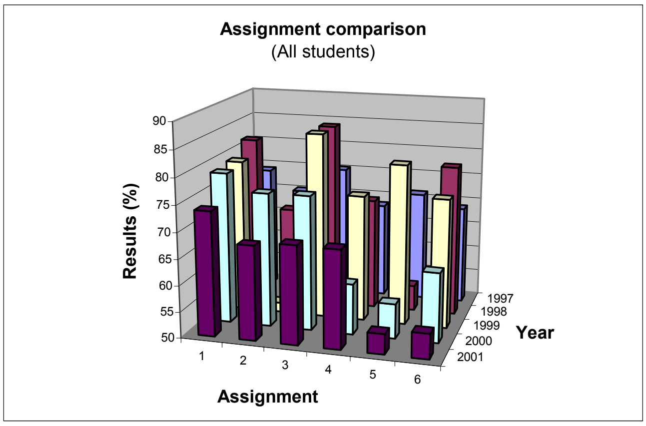


Figure 4.1.b.1 *Class averages for each of the assignments.*

Figure 4.1.b.1 shows little difference in the results over the years for the first three assignments (apart from assignment 2 in 1999). However, on the Web-based course, the results obtained for the fourth, fifth and sixth assignments were markedly worse than in preceding years. Another point of interest is that, in spite of faring extremely badly in their examinations, the 1997 group did not fare too differently to subsequent groups as far as their assignment results were concerned. Figures 4.1.b.2 and 4.1.b.3, depict a comparison of the assignment results for the Rd and Ra groups.

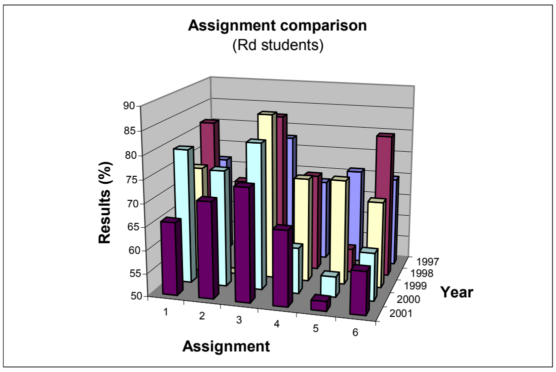


Figure 4.1.b.2 *Class averages for Rd students.*

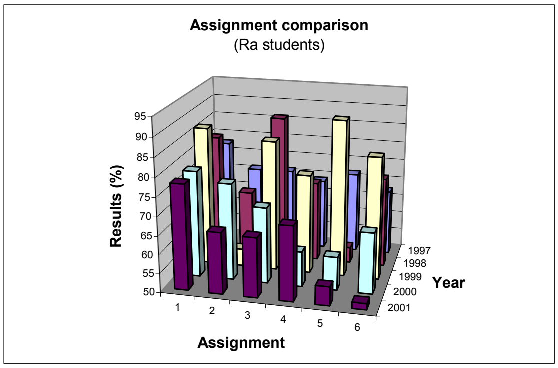


Figure 4.1.b.3 *Class averages for Ra students.*

From Figures 4.1.b.2 and 4.1.b.3, it can be seen that there appears to be very little difference in the results obtained by Rd and Ra students in most of the assignments across the years. In the Web-based course, Rd students did better in assignments 2, 3 and 6 than their Ra counterparts, whereas these students did better in the rest of the assignments. In the opinion of the author, the concepts addressed in assignments 4 to 6 were the most difficult to understand and master. In the following table, the assignment results for the paper-based and the Web-based courses are compared.

Table 4.1.b.2 *Average assignment results for the paper- and Web-based courses.*

Assignment	Paper-based (hand-ins)	Web-based (hand-ins)	Move
1	78.3% (107)	76.3% (103)	← 2.0%
2	63.2% (106)	72.0% (102)	→ 8.8%
3	81.9% (106)	72.4% (104)	← 9.5%
4	71.2% (106)	64.1% (102)	← 7.1%
5	69.3% (105)	55.2% (98)	← 14.1%
6	73.9% (104)	59.4% (92)	← 14.5%
Average	73.0%	66.6%	← 6.4%

From the above table it can be seen that, apart from assignment 2, the students on the paper-based course achieved better results for their assignments. This is a rather curious finding in the light of the examination results discussed in the previous section, where the students on the Web-based course had achieved higher results. The poorer results of the students on the Web-based course (especially in assignments 5 and 6) probably means that the information in the Web pages was insufficient to meet these students' requirements. Another possibility for the poorer assignment results is that student activity was not mainly confined to the practical period as had been the case with the paper-based course. Students had the freedom to work if and when they chose. This removed an important source of information from the group as a whole: communal activity. It became more difficult for students to rely on their peers for information and solutions to the problems. A phrase for this was coined by a tutor on the course from 1995-1998, namely, the "communal brain" (Horak, 1996). This communal brain frustrated the tutors as it led to widespread duplication of solutions. This is one of the reasons why the author is against groupwork. One is never sure of the origins of the insights presented. (According to Tam (2000), collaboration by students in solving problems is one of the tenets of constructivism.) It is also one of the reasons why the author is against examination exemption for students with high semester marks - one can never be certain whether their own work led to the results achieved. However, the independent activity of the students on the Web-based course was more than likely the main reason for their ability to solve the problems set in the examination, thereby accounting for their better results than those of students on the paper-based course.

Another point evident from the Table 4.1.b.2 is that the students on the paper-based course consistently handed in their assignments, whereas those on the Web-based course became more lax (recall that 105 students on the paper-based course and 104 students on the Web-based course wrote the examinations). One must assume that this laxity may be attributed to poor time management practises by the students. (See Section 4.4 *Time management*.)

4.1.C Church project

In order to show the students' ability to work independently, they were each required to produce a project program which drew a church. This project was worth 15% of the final grade for the SCI 152 course (whereas the examination was worth 40% of the final grade). As mentioned in Table 4.1.a.1, one major difference between the paper-based and Web-based courses was in this project: with the paper-based course, the students were allowed one week in the second semester to complete their project (*i.e.* after the examination), whereas the students on the Web-based course had to complete their projects within the first semester (*i.e.* before the examination).

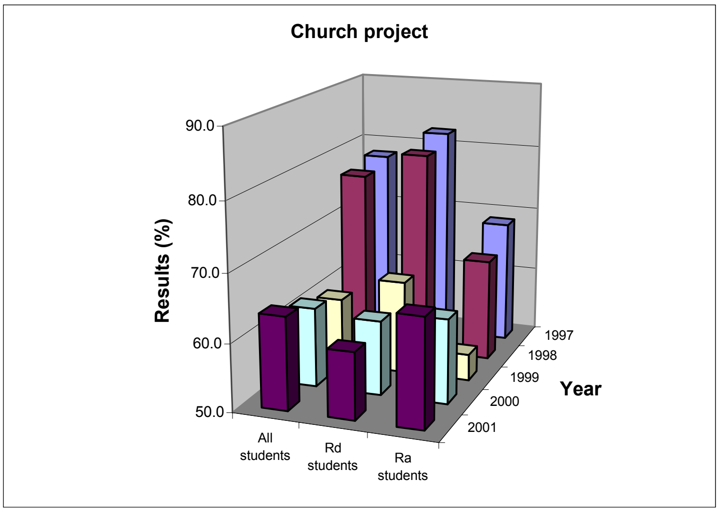


Figure 4.1.c.1 *Class averages for the church project.*

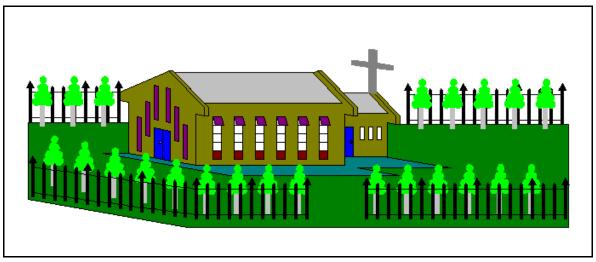
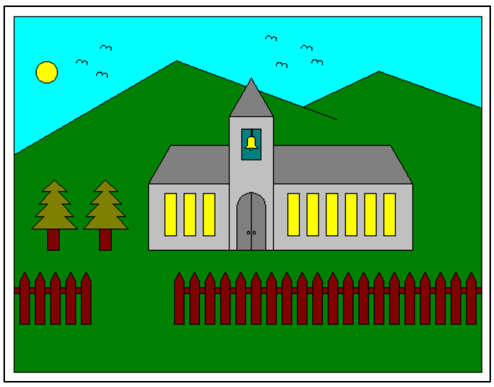
The figure shows that the Rd students in 1997 and 1998 put an exceptional effort into their projects.

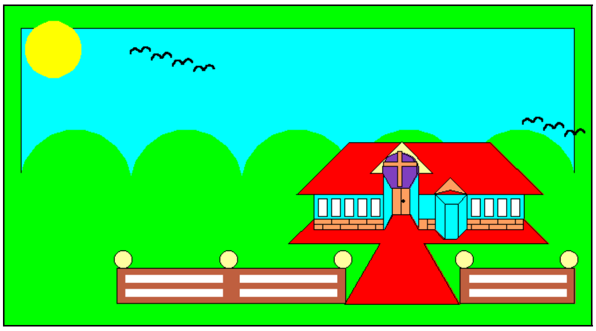
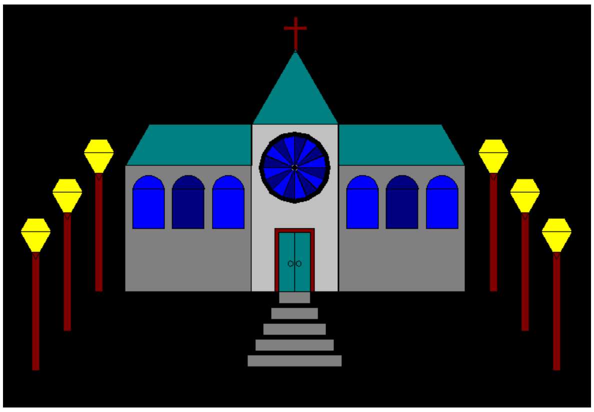
Table 4.1.c.1 *Average results for the church project for the paper- and Web-based courses.*

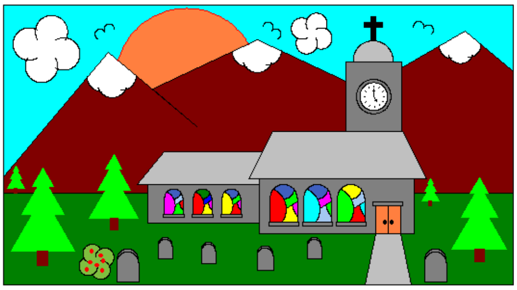
	Paper-based (hand-ins)	Web-based (hand-ins)	Move
All students	71.5% (92)	62.7% (104)	← 8.8%
Rd students	76.0% (63)	60.5% (44)	← 15.5%
Ra students	61.7% (29)	64.4% (60)	→ 2.6%

As can be seen from table 4.1.c.1, there was an extraordinary downward move in the results of the Rd students from the paper-based course to the Web-based course. The author feels that this difference is attributable to an attitude change on the part of the Rd students rather than to the extra time allowed to complete the project on the paper-based course (see table 4.1.a.1). This is evident from the fairly consistent results obtained by the Ra group over both the paper-based and the Web-based courses for their projects. The Rd students' results on the Web-based course fell more into line with that of the Ra students whose attitude was to complete the project with a minimum of effort.

A further interesting point from the table is that all the students on the Web-based course who wrote the examination completed their church project. This is in stark contrast with the assignment completions shown in Table 4.1.b.2. These students evidently felt that completing the church project was more important than completing their assignments. The opposite is true for the students on the paper-based course. Although these students completed all the assignments, many (most in the Ra grouping) decided that the church project was irrelevant. In spite of this, many excellent programs were produced. Some of the best churches are shown in the following figures.

	
1997	1998

	
1999	2000



2001

Figure 4.1.c.2. *A sample of churches produced by students on the paper-based and Web-based courses.*

4.1.D Supplementary examinations

The regulations of the University of Pretoria allow students who have done well during the semester, and who have nevertheless failed their examination, a chance to write a supplementary examination to boost their marks to 50%. In 2001, eleven students were given the opportunity to write the supplementary examination (nine Rd and two Ra students). Of these students, five (four Rd and one Ra) approached the author for assistance prior to the supplementary examination. The author was shocked to find, that these students had only a vague idea as to what a Logo procedure was, and no idea whatsoever about manipulating variables within a procedure. These concepts should have been mastered in the last two assignments (see Table 4.1.b.1). To deal with this shortcoming, the author discussed, in detail, an approach to solving the examination problem (which they had failed) as well as a similar problem taken from assignment 5. On seeing the logic behind this approach, the Rd students, of their own accord, tried several variations to these problems. The Ra student only made a half-hearted attempt at doing the examination problem. In the supplementary examination, three of the four Rd students achieved full marks, the third obtained almost 90% while the Ra student got 56%. The rest of the students again failed dismally. The author feels that it goes without saying that the students who failed, both the examination and the supplementary examination, had the same lack of knowledge as did the students discussed earlier.

The author learned a valuable lesson from his interaction with these students. For a student to learn problem solving skills he or she needs to **see** the process in action in order to be able to **emulate** it. By talking and asking questions while simultaneously doing the problem the teacher definitely gives the student more insight into the problem solving process than the student would derive from a static medium, such as a book or a Web page (see also Tam, 2000). Of course, a major advantage of working with individuals or small groups is that the students feel more at ease and less afraid to ask questions of the teacher. Unfortunately, with the asynchronous nature of Web-based learning, the student is not always able to ask a question at the right moment. Also, he or she has no way of learning what is the **right question** to ask, without observing a role model. The author feels that regardless of how sophisticated computer software may be, it can never be a role model.

4.2 Analysis of student activity on the Web pages

The Web server software used, Apache, generates a detailed log file of all files downloaded as each page is accessed. The data includes

- the IP address of the computer requesting the file,
- the date and the time of the request, and
- the name of the file being downloaded.

There are, however, two unfortunate omissions to the data in the log files:

- although an IP address signifies a specific computer, there is no way of knowing who is at the computer and
- if the browser's back button is used, the browser uses information retained in its own cache and does not request that page from the Web server, which means that no record is kept of that particular request.

From July 2000, the Web server was also used to host the pages of the Gold Fields Computer Centre, the personal pages of several staff members as well as test pages for external work done by staff members. This had the unfortunate side effect of generating a great deal of extra information in the log files, both from hits on these pages and from Web spiders tracking hits on Web servers. This made it much more difficult to extract the data for hits on the SCI 152 pages from the log file in 2001 as more than 65000 requests were registered on the Web server. In analysing this data, hits from Web spiders, ISPs outside South Africa and the author's computer have been excluded.

Table 4.2.1 *Requests on http://goldilux.up.ac.za/sci152*

Course dates	Home page requests	Average home page requests per student (no. of students)
22 March 2000 - 29 May 2000	1236	23.3 (53)
16 March 2001 - 1 June 2001	1226	24.0 (51)

(The numbers of students given in the above table are those who wrote the respective examinations.)

4.2.A Objectives

As the Objectives page was linked from the Index page, using a browser's back button from the Objectives page would result in the user returning to the Index page, without a record being made in the Web log files. To access another page, the user would have to click on a new link on the Index page. This new link would then be registered in the Web log file. So, providing that the user remained on the course pages, an estimate of the time spent on the Objectives page could be obtained by considering the time the Objectives page was opened to the time the next page was opened.

In the tables below, the total number of hits with the average time spent on the Objectives page is given in the first data column. In the following data columns this figure is broken down to those students who spent 60 or more seconds on the page; those who spent between 30 and 60 seconds on the page; and finally, those who spent less than 30 seconds on the page.

Table 4.2.a.1 *Time (in seconds) spent on the Objectives page in 2000.*

	Total	$t \geq 60$	$30 \leq t < 60$	$t < 30$
Number of hits	25	6	12	7
Average time spent on page	49.60	102.00	45.00	12.57

Table 4.2.a.2 *Time (in seconds) spent on the* Objectives *page in 2001.*

	Total	$t \geq 60$	$30 \leq t < 60$	$t < 30$
Number of hits	24	6	6	12
Average time spent on page	44.67	106.83	47.67	12.08

What is interesting to note is that the number of hits on the Objectives page was very similar in both years. However, in 2000 more students[1] spent more than 30s on the page than in 2001 (18 as opposed to 12) from which one could deduce that the 2000 students tried harder to make sense of the course than in 2001. This is further borne out by the fact that of the 12 students in 2001 who had spent fewer than 30s on the page, 11 spent less than 20s there!

In trying to set a time standard for reading this page, the author had an English-speaking person read the complete page aloud while timing her with a stopwatch. It took her 52s to read the complete page. One would thus assume, given that the majority of students on the course were **not** first language English speakers, and that they should have been trying to extract meaningful information from the Objectives page, they should have taken more than 52s to read **and** understand the page. This means that only those students who spent more than 60s on the page made an effort to understand where the course was heading. In 2000, 53 and in 2001, 51 students wrote the final examination, which means in both years, fewer than 12% of the students read the page meticulously.

This supports the author's view that course objectives are irrelevant to most students. These students see the objective of most courses as completing the assignments as quickly as possible (Carr, 2001a).

The issue of objectives in instructional design was hotly debated on ITForum[2] in February 2001[3]. The discussion was started by Jones (2001) wanting to know where, in a CBT lesson, one should place the objectives of a lesson. The debate centred around whether they should be included (JRI, 2001; Morrison, 2001), whether they should be hidden (for the instructor's use only) (Draper, 2001a), or whether they should be set out in a watered-down form in a language that students could understand (Buckner, 2001; Clark, 2001; Draper, 2001a). Flanagan (2001) raised a novel concept in having the students formulate the objectives themselves, after completing the lesson. Cronjé (2001) feels that the title "Objectives" should be avoided. In his view a phrase such as "possible examination questions" should be used to attract the student's attention to this section of the lesson.

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[1] In using this data, the author makes the [unverifiable] assumption that no student visited the page more than once. This assumption is used throughout this section.

[2] ITForum is a discussion group devoted to matters relating to instructional technology. More information can be found at http://itech1.coe.uga.edu/itforum/home.html

[3] The discussion can accessed in the searchable archives of the ITForum listserver at http://www.listserv.uga.edu/archives/itforum.html

4.2.B Naming of parts

To try to familiarise the students with the PC Logo environment, a page showing the major windows used by the software was linked to the first assignment page. As this page also included a discussion of the Logo co-ordinate system, it was important that the students should have accessed this information before attempting the assignments. Unfortunately, as this page was linked to the Assignment 1 page, most students used the back button of the browser to exit from it. This meant that it is not possible to estimate the time students spent on the page.

Table 4.2.b.1 *Hits on the page which discussed the PC Logo environment.*

Year	Number of hits	Percentage of students who submitted Assignment 1 (no. of students)
2000	34	65% (52)
2001	44	86% (51)

As can be seen from Table 4.2.b.1, many students submitted Assignment 1 without looking at the layout of the PC Logo windows. This could mean the that

- students were capable of exploring the PC Logo environment without outside assistance;
- students relied on their colleagues and tutors to explain the PC Logo environment;
- students submitted copies of their peers' work.

Ideally, the hope would be that the first point is the correct assumption, but the author feels that the second and third points were more likely to be correct.

It should be noted that very few further hits were made on this page after the due date for assignment 1, in 2000 as well as 2001.

4.2.C Solutions

One of the most important aspects of a Web-based course (or distance-based course) is the need for self reflection by the student. After an assignment is completed, it is necessary for the student to compare and evaluate his or her submission with a model answer delivered by the course presenter. In the present course, a set of model answers for each assignment was posted to the Web site on the due date for the submission of the particular assignment.

In preparing the following table, hits on the day of the examination have been excluded. These will be discussed separately in Section 4.2.F *The search for inspiration.*

Table 4.2.c.1 *Hits on the solution pages.*

Year	A1	A2	A3	A4	A5	A6
2000	47	53	51	17	15	26
2001	40	42	40	56	49	28

In 2000, the solution pages could only be accessed from the assignment pages. In 2001, to make it easier for the students to access these pages, a link was included on the home page. As can be seen from the above table, the students in 2001 appeared to show even less interest in these pages than in 2000 (apart from the solutions to assignments 4 and 5).

One very interesting conclusion that can be drawn from this table is that, in spite of the poor results achieved for assignments 4 and 5 in 2000 (see Figure 4.1.b.1), the students had largely disregarded the solution pages for these assignments. As mentioned previously, the students from 2001 appeared to see more value in these particular pages.

4.2.D Additional assignments

This page was created to offer the students stimulating challenges over and above the exercises given in the weekly assignments.

In many cases, students ended their browsing of the SCI 152 site on this page, so no time measurement (as in paragraph 4.2.A. *Objectives*) could be made. In the table below, hits on the examination day have been excluded. These will be discussed in Section 4.2.F. *The search for inspiration.*

Table 4.2.d.1 *Hits on the* Additional assignments *page.*

Year	Page requests	Average page requests per student (no. of students)
2000	115	2.17 (53)
2001	74	1.45 (51)

Table 4.2.d.1 shows that students exhibited very little interest in these pages. The students of 2000 appear to have been more conscientious than those in 2001, in spite of the tutors in 2001 warning students that an examination question from 2000 had come from these pages.

In neither 2000 nor 2001 did students approach the author for assistance in solving the problems on this page, so the assumption must be made that, although many students looked at the page, none tried the exercises. The following figure shows one of the exercises, which the author had used in the final assignment prior to 1997. This exercise was removed, as even the most competent of students could not solve it without a great deal of coaching. The author feels that this problem, at least, should have generated questions from the students had it been attempted.

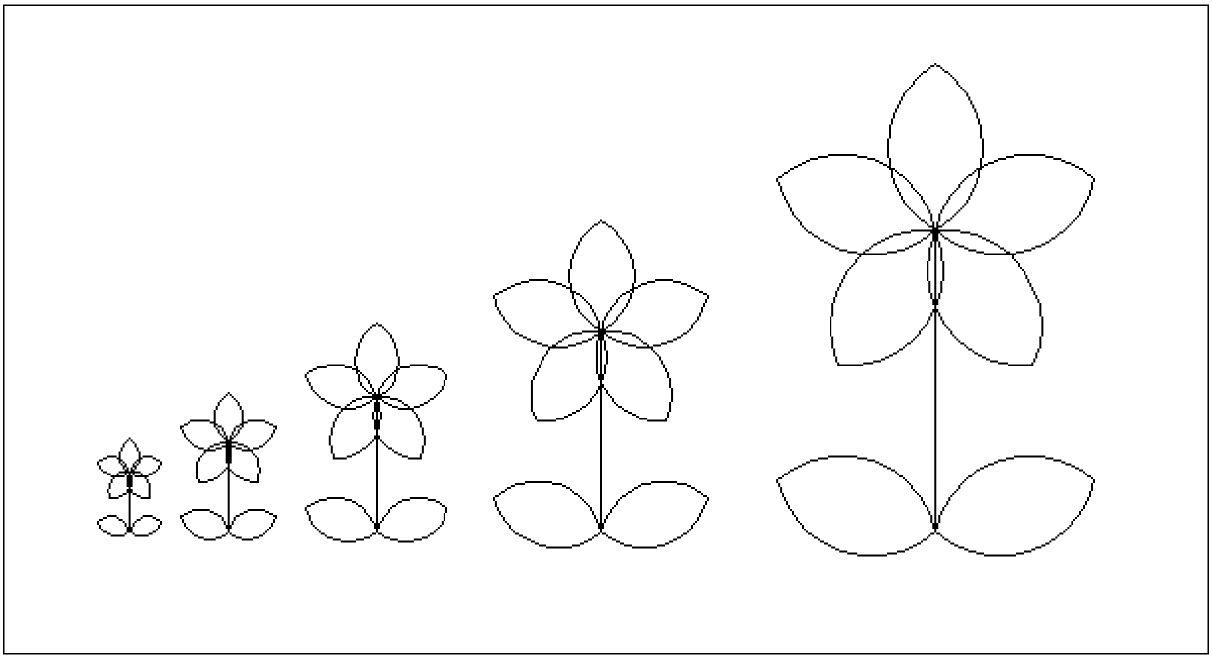

Figure 4.2.d.1 *One of the exercises from the* Additional assignments *page*

In the paper-based course, the additional assignments were included in the SCI 101 course workbook (SCI 101 was the precursor to the Science Orientation course). Only one student discussed those exercises with the author. In discussions with other students, none realised that additional exercises had been included in the workbook. So, in defence of the students taking the Web-based course, the students on the paper-based course were no more conscientious than their counterparts on the Web-based course.

4.2.E Useful information

The author had hoped that the *Useful information* page could be used to give the students hints on how to schedule their time in the absence of lectures.

Table 4.2.e.1 *Hits on the* Useful Information *page*

Year	Page requests	Average page requests per student (no. of students)
2000	141	2.66 (53)
2001	92	1.80 (51)

Although more interest was shown in this page than in the *Additional assignments* page, it was still lower than the author had expected. Again, as with the *Additional assignments* page, the 2000 students showed more interest in this page than the 2001 students.

One of the objectives of the *Useful information* page was to inform students of important dates in their course calendar. To have achieved this aim, one would have expected at least one visit per week per student. However, the students seemed to prefer receiving such information by word of mouth from the author, the tutors or other students.

4.2.F The search for inspiration

During the examination, the students had full access to the Internet, including the course Web pages and solutions. In this section an attempt is made to track the students in their search for inspiration while trying to solve the examination problem. Although it is not possible to identify particular students, it is possible to track their activities through the IP address of each computer which was used to access the course Web pages. Students sat at the same computers throughout the examination.

Table 4.2.f.1 *Number of students accessing the SCI 152 pages during the course of the examinations (The second number is the number of students who wrote the examination.)*

	No. of students
2000	49/51
2001	27/53

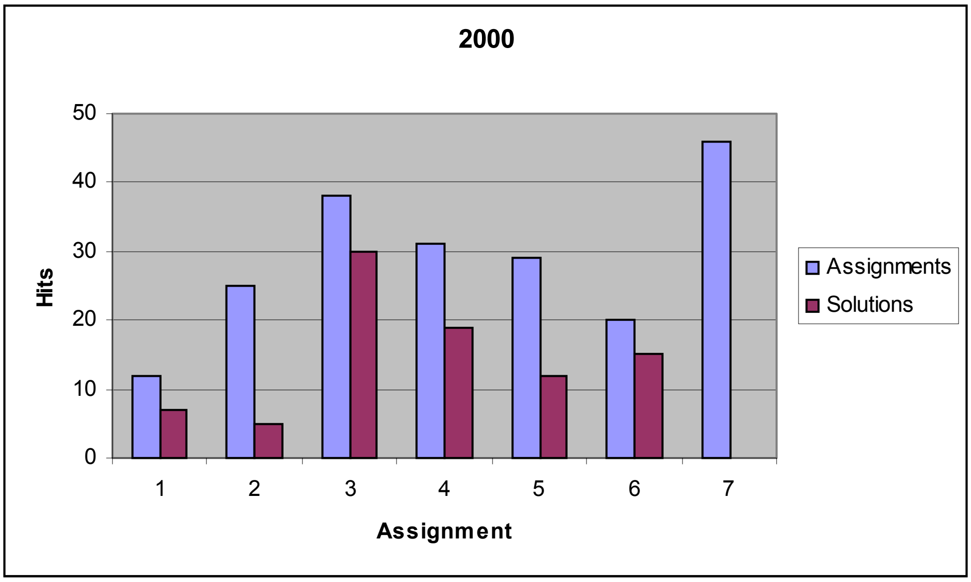

Figure 4.2.f.1 *Hits on the SCI 152 pages during the course of the 2000 examination*

In Figure 4.2.f.1 (and Figure 4.2.f.3) Assignment 7 is the *Additional assignments* page.

In 2000, the high number of hits on the *Additional assignments* page was due to the author mentioning, during the course of the examination, that an examination question had been taken from that page. Many students would thus have looked at this page in search of a solution (or inspiration!). Of the 49 students who accessed the SCI 152 site during the examination, eight only looked at the *Additional assignments* page, and one student only looked at the *Index* page. Pages which may have been useful in assisting the students in answering the examination question were:

- the solution page to Assignment 3;
- the solution page to Assignment 6; and
- Assignment 2 or its solution page (the examination question required the use of colour).

As can be seen from Figure 4.2.f.1, the highest number of hits (apart from the *Additional assignments* page) was on the Assignment 3 page followed by the Assignment 4 page. Apart from the solutions to Assignment 3, the students appeared to regard the solution pages as being of negligible value. Figure 4.2.f.2 shows the paths followed by four students in moving through the SCI 152 Web pages during the 2000 examination.

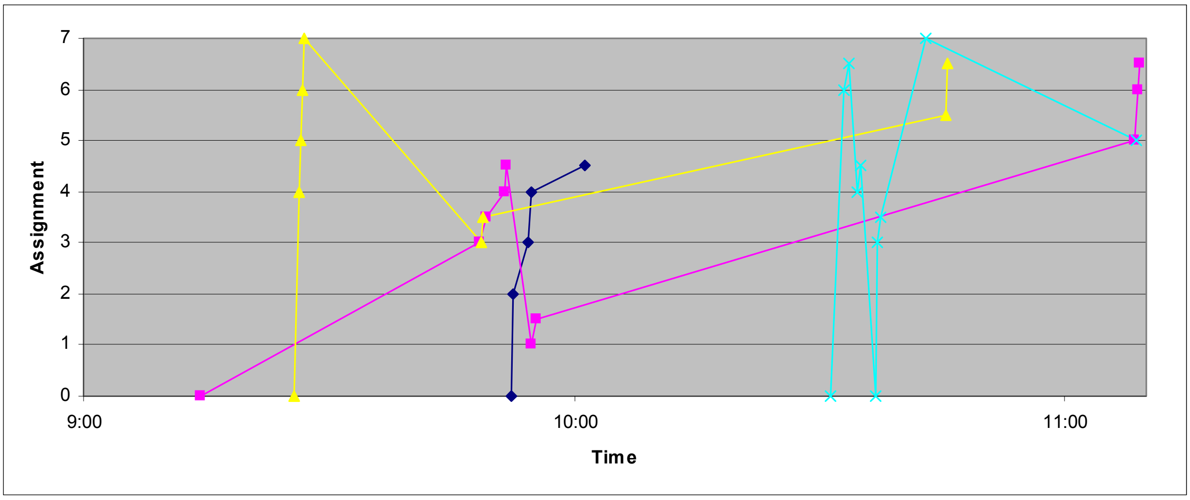

Figure 4.2.f.2 *Paths followed by four students in moving through the SCI 152 Web pages during the 2000 examination*

In the above figure (and Figure 4.2.f.4), Assignment 0 is the home page and Assignment 7 the *Additional assignments* page. The half values indicate the respective solution pages (*i.e.* 1.5 would signify the solution page to Assignment 1).

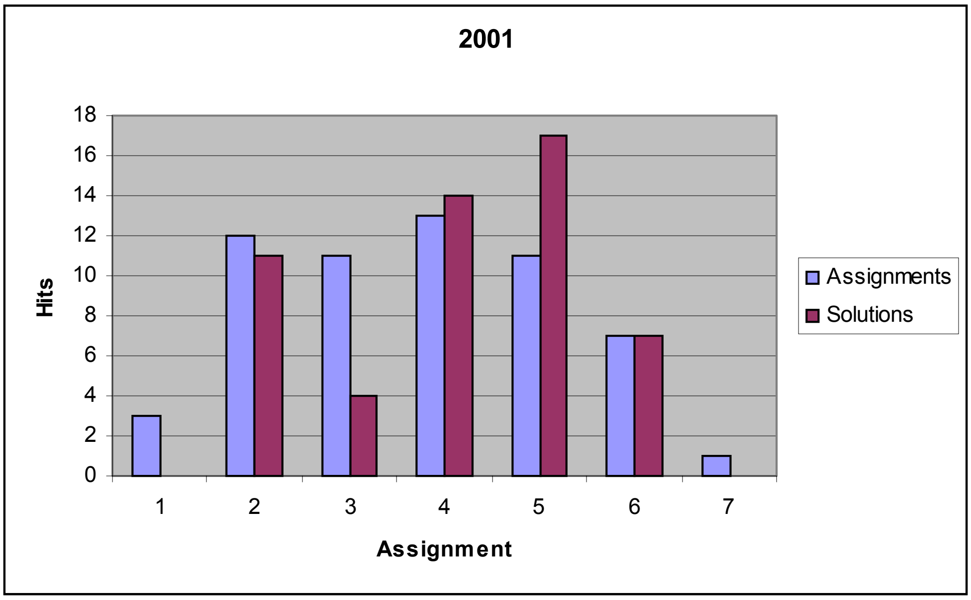

Figure 4.2.f.3 *Hits on the SCI 152 pages during the course of the 2001 examination*

In 2001, of the 27 students who used the SCI 152 pages during the examination, one visited only the solutions to Assignment 2, one only the solutions to Assignment 4 and two only the solutions to Assignment 5. Pages which may have been useful in answering the examination question were:

- the solution page to Assignment 5;
- the solution page to Assignment 4; and
- the solution page to Assignment 6 (if a student did not understand how to use variables).

Figure 4.2.f.3 clearly shows that the highest number of hits were on the solution pages to Assignments 4 and 5. The author can think of no valid reason why the number of hits on Assignment 2 and its solutions was so high. What is also of interest from Table 4.2.f.1 is that, apparently, almost half the class had decided that nothing could be gained from looking at the course Web pages during the examination.

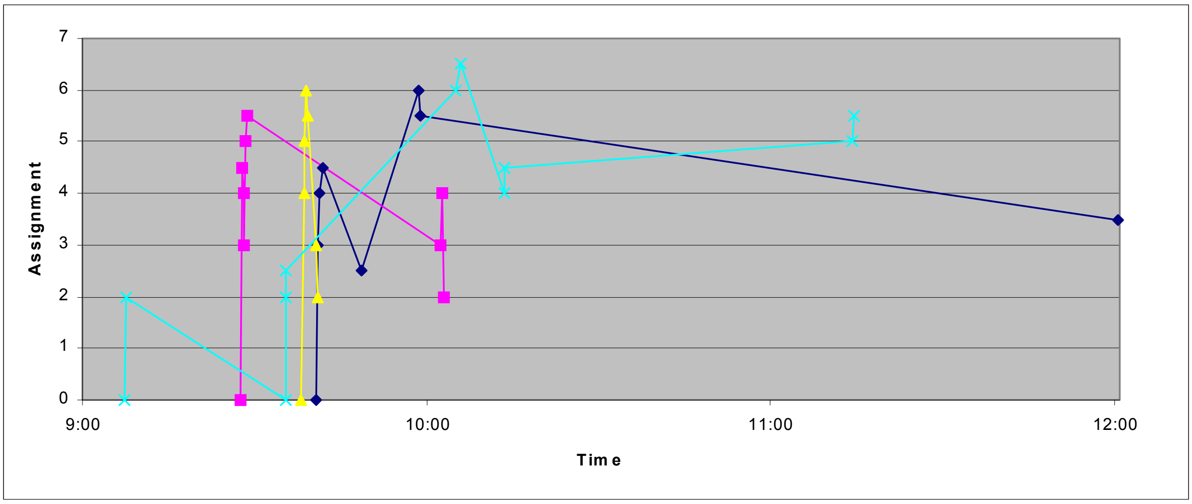

Figure 4.2.f.4 *Paths followed by four students in moving through the SCI 152 Web pages during the 2001 examination*

The light blue path is the really interesting one in Figure 4.2.f.4. This student seemed to think there was something in Assignment 2 which could help him or her, then gave up and did something else. Around 09:30 this student returned to Assignment 2 and its solutions, thought about it for 30 minutes then went to Assignment 6 and its solutions, thought about that for five minutes and went on to Assignment 4 and its solutions. After an hour of trying, the student then proceeded to Assignment 5 and its solutions. While it is unclear whether this student found the information he or she needed, he or she did eventually follow a path that would have offered the most assistance in his or her search for a solution.

4.3 Student assessment of the Web-based course

Students in 2000 completed a questionnaire covering aspects of the Web-based course. Selected questions from the questionnaire, given in Appendix 2, have been analysed to show the students' opinion, as well as to test the validity of their answers by correlating these with results given in previous sections.

4.3.A Computer literacy

A series of questions required students to rate their computer literacy. The responses to four of these questions have been used to generate a computer literacy profile of the students[1].

[1] The ratings used in generating the computer literacy profiles are based on the author's experiences in teaching computer literacy to students for more than 10 years.

In Question 1, students were asked to rate their computer expertise before enrolling at the University of Pretoria.

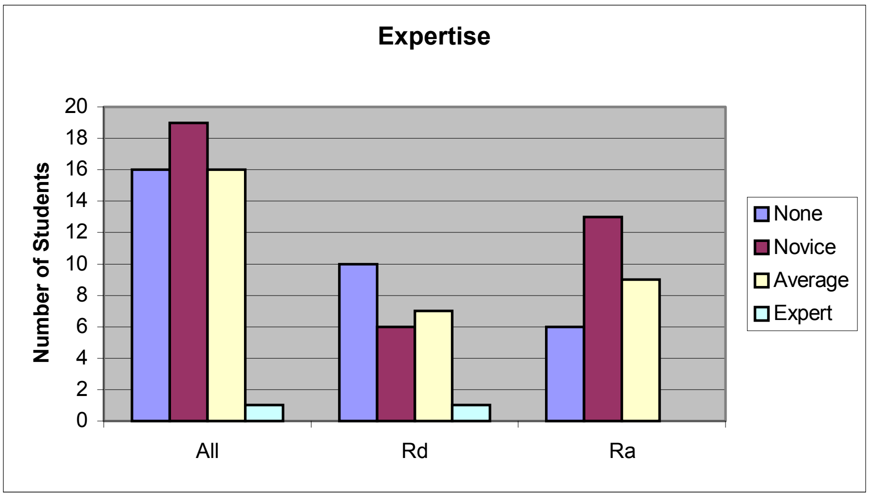

Figure 4.3.a.1 *Students' own rating of their computer expertise*

The author feels that the student who rated himself as being an expert was being facetious. This student had not used the Internet before; nor had he completed the game King's Quest (Question 6). Often, young people regard themselves as computer experts if they have played computer games, which was not the case with this student. A student who had both the "Microsoft Driver's License" and the "A+" certification viewed her expertise as Average. From Figure 4.3.1.a it can be seen that just over 60% of the class regarded themselves as having little or no computer skills.

In Question 2, students were asked whether they had access to a computer at home.

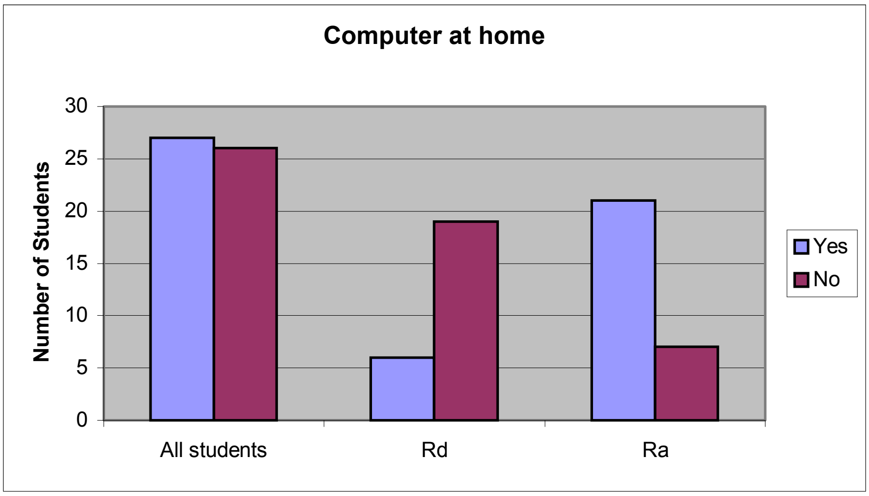

Figure 4.3.a.2 *Students' access to a home computer*

Quite a high premium can be put on access to a home computer on the level of expertise of a user. These students are often not scared to experiment with the technology. As can be seen from the graph, there was little difference in the numbers of students who had and who did not have access to a home computer. However, an expected difference between access and non-access by the privileged and non-privileged groupings is shown in the graph.

In Question 4, students were asked whether they had used a word processor before. Word processing can be regarded as a high-level computer skill.

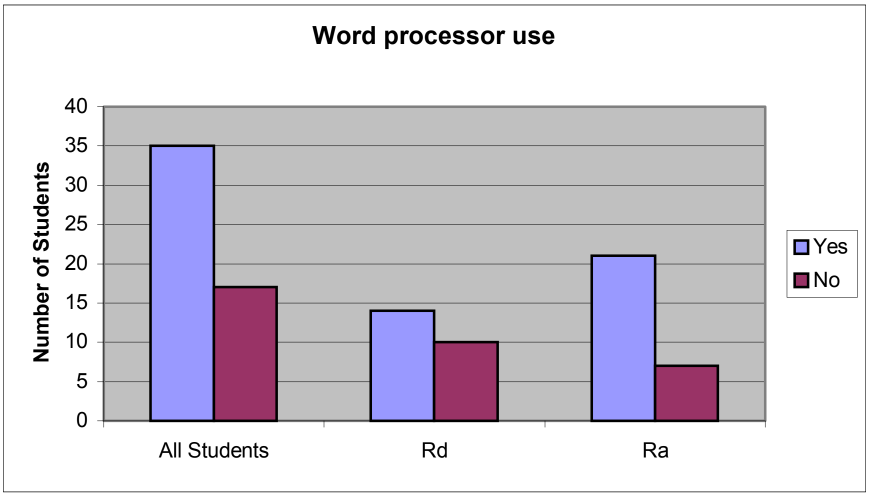

Figure 4.3.a.3 *Word processor usage by the students*

The non-use of a word processor shows a strong correlation with the students' own ratings of themselves as first-time computer users (see Figure 4.3.a.1).

In Question 7, students were asked whether they had used the Internet before. Internet usage can be regarded as a very high-level computer skill.

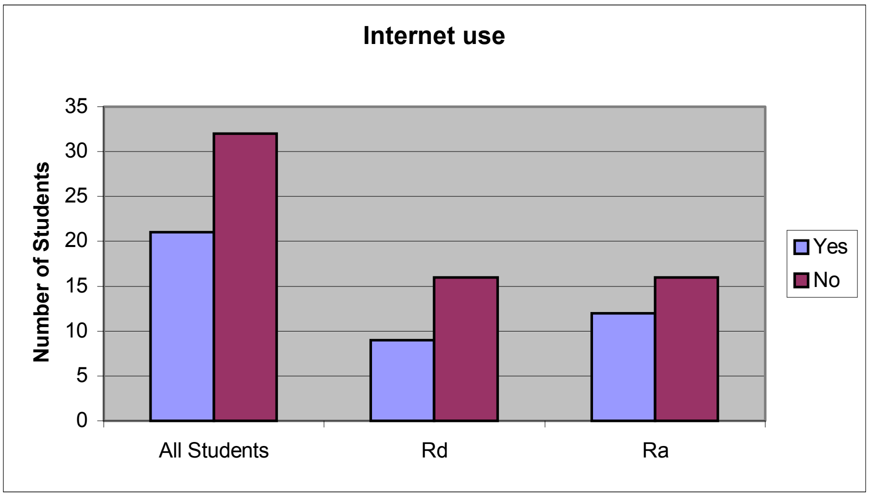

Figure 4.3.a.4 *Internet usage by the students*

The above graph is interesting, showing that more than 60% of the class had not used the Internet before, with slightly more of the privileged group having had access than the non-privileged group.

Figure 4.3.a.5 was generated from the data comprising Figures 4.3.a.1 to 4.3.a.4 by adding weighting factors to the students' responses to those questions. The weighting factors and the responses used are given in the following table.

Table 4.3.a.1 *Weighting factors used in generating Figure 4.3.a.5*

Question	Response	Weight
1. Own expertise rating	Novice	1
	Average	2
	Expert	1
2. Access to a home computer	Yes	2
4. Used a word processor	Yes	3
7. Used the Internet	Yes	4

From Table 4.3.a.1, it can be seen that the student who rated himself as an expert was viewed as novice[1] in compiling the scores used to draw up Figure 4.3.a.5:

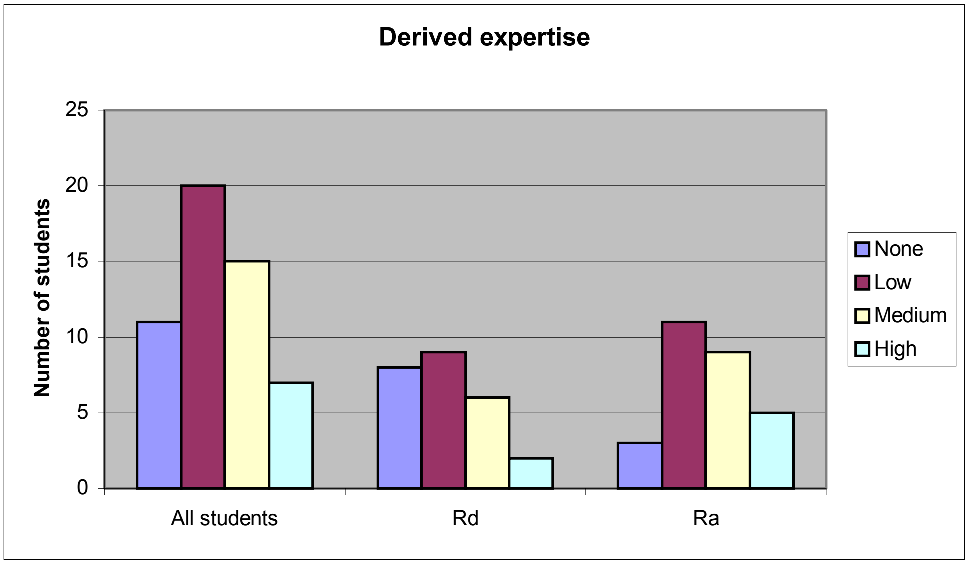

Figure 4.3.a.5 *Derived computer literacy levels*

What is interesting when comparing the above graph to Figure 4.3.a.1, is that some students who regarded themselves as having no expertise, had in fact used computers before.

The overall shapes of the clusters in this graph are very similar, apart from the first time users, where more are in the non-privileged group. It should again be noted that this graph shows that almost 60% of the class had little or no computer skills at the beginning of the course. This is important in analysing their responses to other questions in the questionnaire.

[1] This was discussed earlier, below figure 4.3.a.1.

Figure 4.3.a.5 can be extended to see if the students' computer literacy levels influenced their examination marks. In Figure 4.3.a.6, the marks of the students whose responses made up the categories in Figure 4.3.a.5, have been averaged.

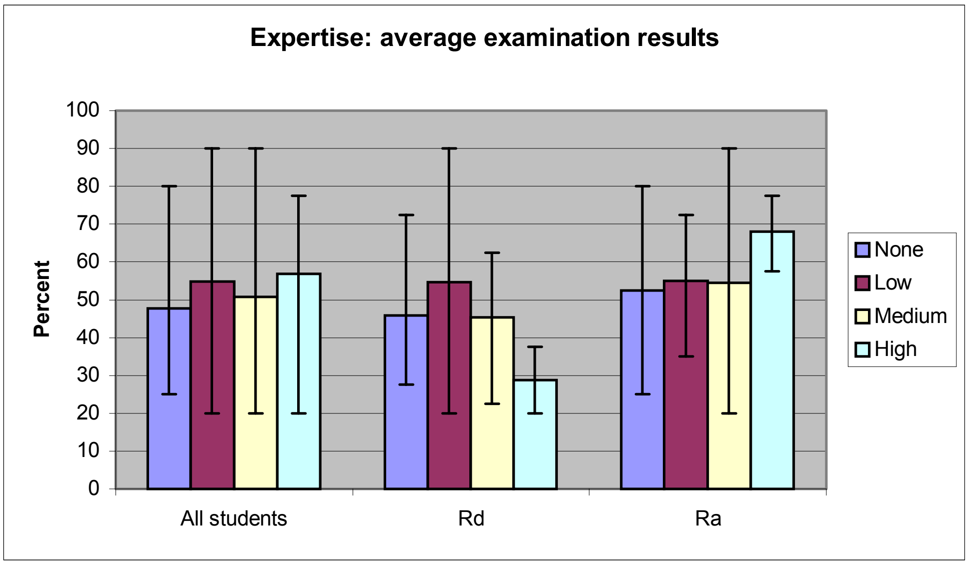

Figure 4.3.a.6 *Average examination marks achieved by students who responded as shown in the different categories in Figure 4.3.a.5.*

In Figure 4.3.a.6, error bars have been used to show the maximum and minimum examination marks achieved by the students in the different categories. The scatter in the average marks of the group "All students" shows that computer literacy played an insignificant role in the students' examination performance. However, in considering the groupings, it is evident that Rd students with high computer literacy levels performed very poorly, whereas those in the Ra group performed much better than the other categories in the group. What is also of interest is that the best-performing Rd students were in the lower categories of computer literacy, whereas with the Ra group, the top-performing students were spread through all the categories.

4.3.B Using the Web pages of the SCI 152 course

The questions discussed in this section were intended to test the students' opinions on a course without formal lectures.

Question 32 asks whether the students had coped with the course without lectures.

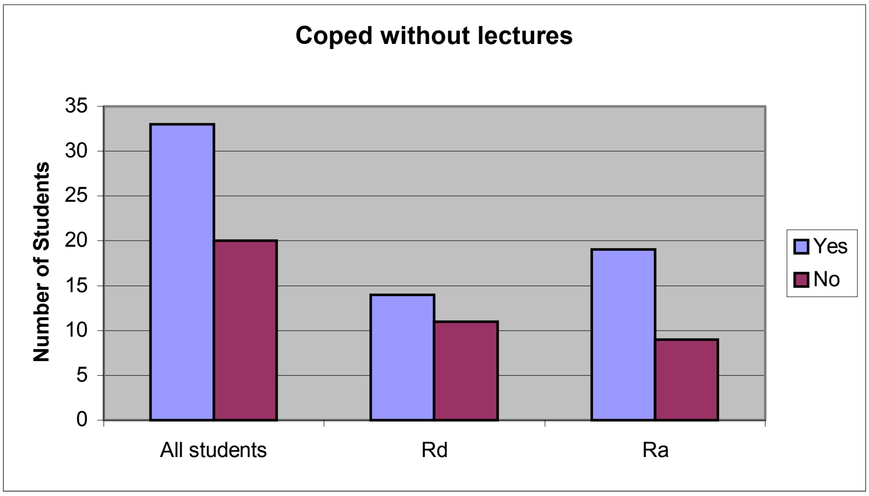

Figure 4.3.b.1 *Did students cope with the course without lectures?*

62% of the students felt that they had coped with the course well enough not to warrant lectures. However, a rather high percentage (38%) of the students felt that they had not coped with the Web presentation. This is to be expected when students are faced with a new method of learning (Åkerlind & Trevitt 1995).

Question 35 asks whether the students found sufficient information in the Web pages to complete the assignments.

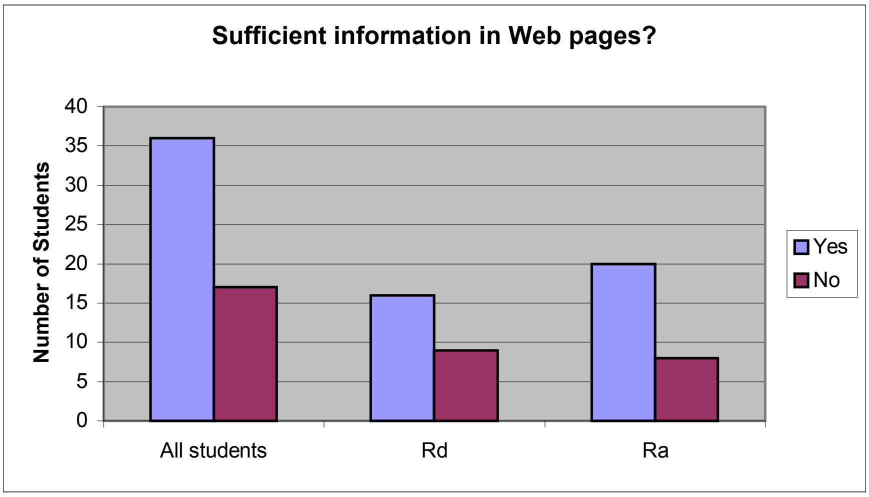

Figure 4.3.b.2 *Was there sufficient information in the Web pages to complete the assignments?*

68% of the students felt that the Web pages had provided them with sufficient information to complete the assignments. However, a high percentage felt that they needed more information. If one looks back at Figure 4.1.b.1, it is evident that students did not fare too well in Assignments 4 to 6. An explanation may be that, in spite of the positive feeling amongst these students, insufficient information had been available. This is further borne out by the data shown in Table 4.1.b.2, where the students on the paper-based course fared consistently better in their assignments than those on the Web-based course.

In Question 33, students were asked whether they would have liked to have had some lectures.

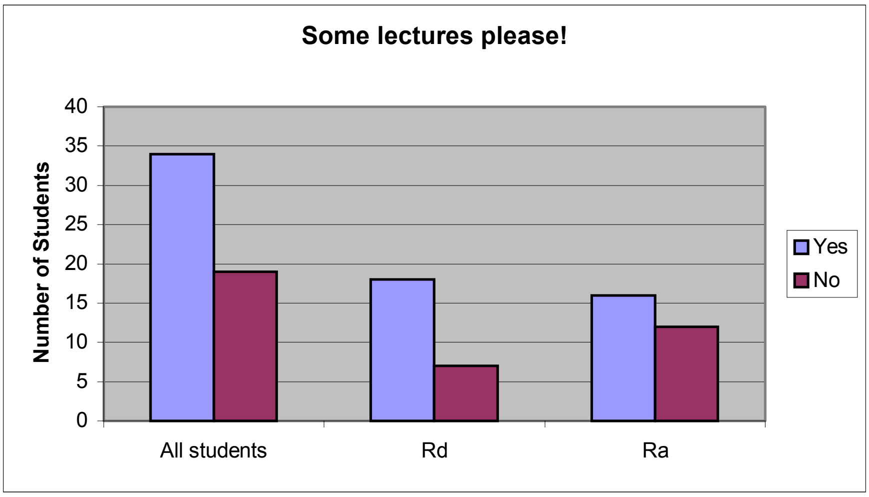

Figure 4.3.b.3 *Would the students have liked to have had some lectures?*

In spite of Figure 4.3.b.1 showing that the majority of students were satisfied with their ability to cope without lectures, 64% indicated that they would have liked to have had some lectures. This means that 26% of those who felt that they had indeed coped would still have appreciated some lectures.

Question 34 queries whether the students could have completed the assignments without the presence of the lecturer and the tutors.

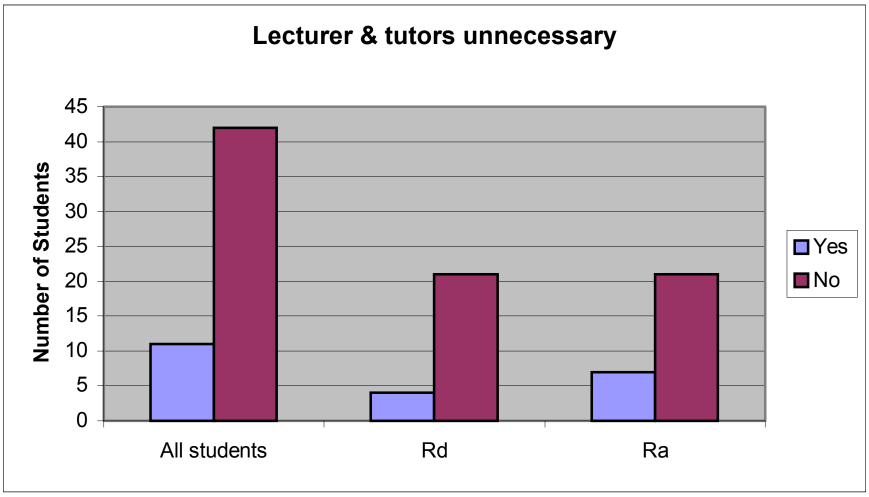

Figure 4.3.b.4 *Could the students have completed the assignments without the lecturer and the tutors?*

An overwhelming 80% of the students felt that they would not have been able to complete the assignments without the presence of the lecturer and the tutors.

The results shown in Figures 4.3.b.3 and 4.3.b.4 are in accordance with the findings of De Villiers (2001b), that undergraduate students still feel the need for face-to-face contact with the lecturer and tutors. Web-based course material should thus be used as a supplement to classroom activities only.

In order to asses the students' feelings about the Web-based course, the data making up Figures 4.3.b.1 to 4.3.b.4 has been summed for each student according to the following table, with one point for the response shown and zero for the response not shown. This would put each student in a category ranging from zero to four.

Table 4.3.b.1 *Responses used in generating Figure 4.3.b.5*

Question	Response
32. Did you cope without lectures?	Yes
33. Would you have liked some lectures?	No
34. Could you have completed the assignments without the lecturer and tutors?	Yes
35. Was there sufficient information in the Web pages for you to complete the assignments?	Yes

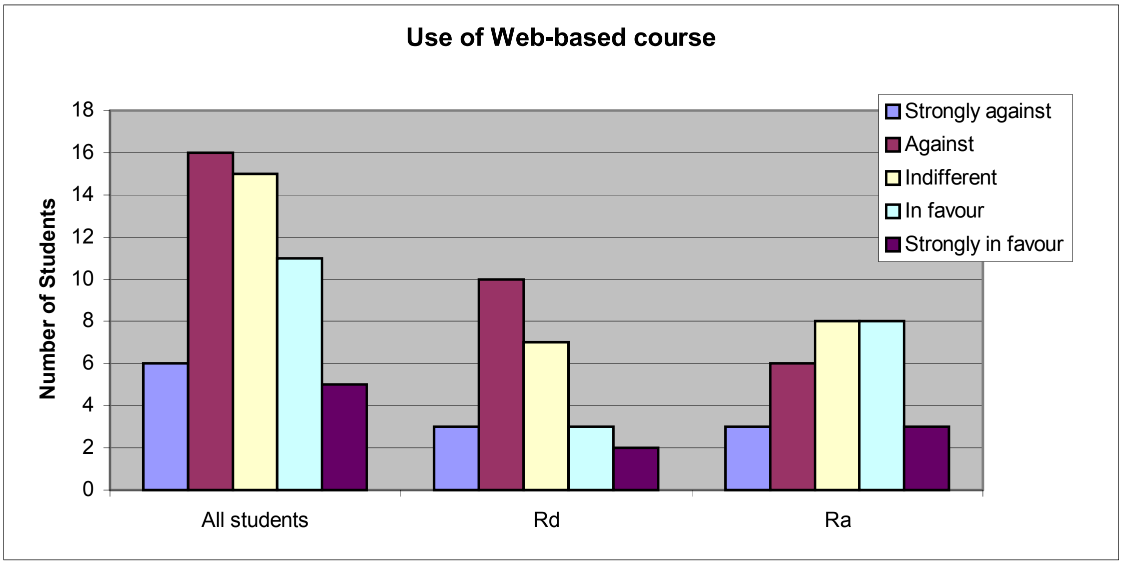

Figure 4.3.b.5 *Students' overall view of the Web-based course*

From the above figure it is evident that 42% of the students were against the Web-based course, while 30% were in favour of it, with the rest being indifferent. More Rd students than Ra students were against the Web-based course (13 *vs* 9), while twice as many Ra students as Rd students were in favour (11 *vs* 5). McIntyre and Wolff (1998) found that 75% of their students felt that a Web-based course should not be used as a total replacement for a classroom-based course. This is in keeping with the findings of Hart and Gilding (1997). Their students missed the interaction between the lecturer and other students found in a classroom setting.

Figure 4.3.b.5 can be extended to take into account the examination marks achieved by the students in each of the categories.

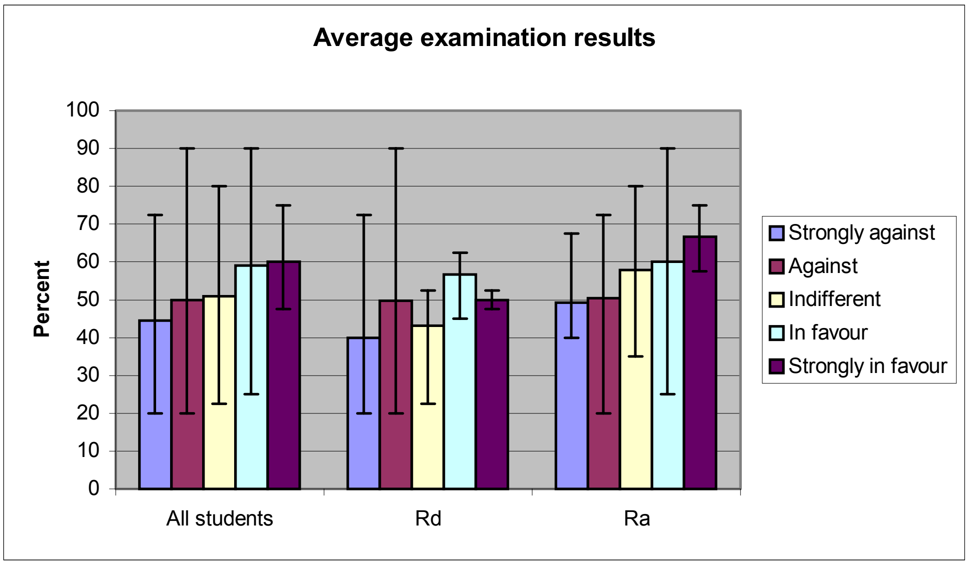

Figure 4.3.b.6 *Average examination marks achieved by students who responded as shown in the different categories in Figure 4.3.b.5*

Error bars have been used in Figure 4.3.b.6 to indicate the maximum and minimum marks achieved by students in each of the categories. The trend shown by the group "All students" is expected, where students "in favour" of the course should have done better than those "against" the Web-based course. Of special interest in this figure, however, is that the top-scoring Rd students were against the Web-based course. The top-scoring Ra students were either indifferent to the Web-based course or merely "in favour" of it. Note that the scatter of marks in the "strongly in favour" category is small in both the Rd and Ra groups.

4.3.C Could other courses be run from the Web?

Students were asked in Question 10 whether they felt if any of their other courses could be run from the Web.

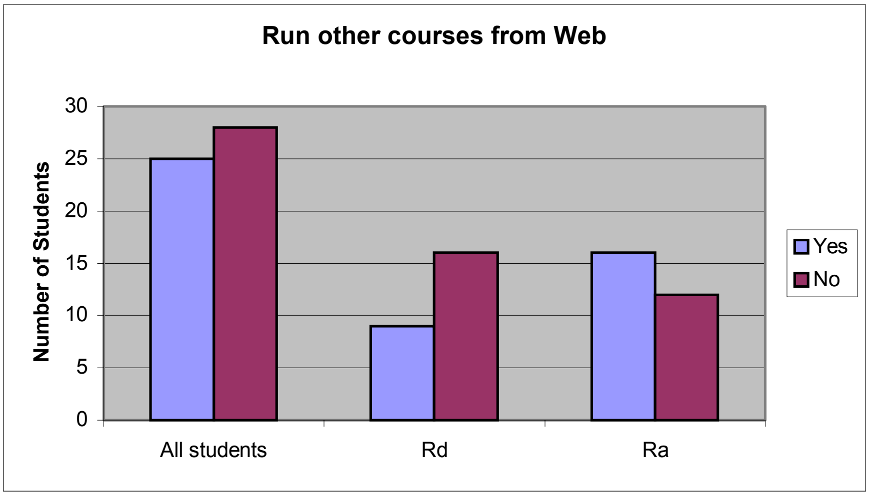

Figure 4.3.c.1 *Students' view as to whether any of their other courses could be run from the Web.*

Students' views were fairly evenly split on this question (25 in favour, 28 against). However, more Ra students were in favour of Web-based method of lesson delivery, with the shape of the responses for the racial groups being symmetrically opposed (64% of Ra students against and 57% of Rd students in favour). This is in keeping with the findings shown in Figure 4.3.b.5, where more Rd students were against the Web presentation of the SCI 152 course, and more Ra students in favour.

4.3.D Solution pages

As mentioned in section 4.2.C, one of the most important activities of a Web-based course is comparing model answers from the course presenter with one's own. In Question 27, students were asked if they had compared their answers with those on the solution pages.

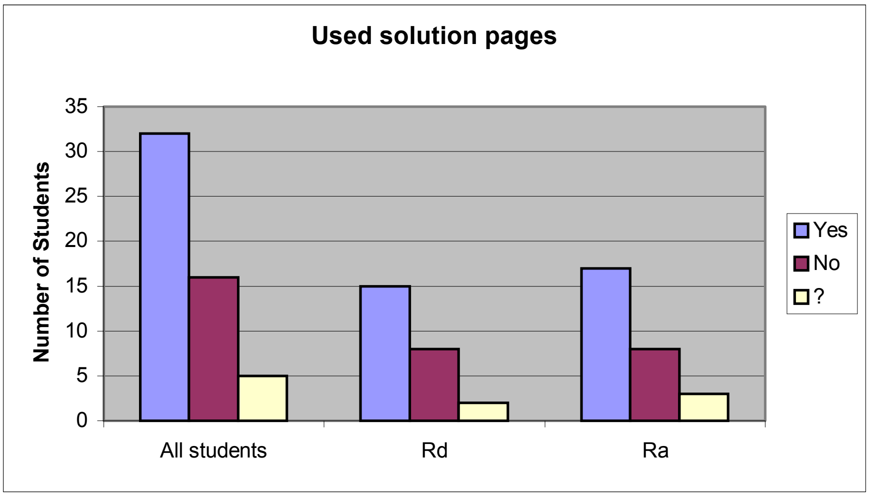

Figure 4.3.d.1 *Students' response to whether they had compared their answers to the solution pages.*

60% of the students said they had indeed compared their answers with those on the solution pages, but the statistics regarding the hits on the solution pages, given in Table 4.2.c.1, show that while students were fairly conscientious in the first half of the course, they were extremely lax in the second half. Unfortunately, the students seemed to misinterpret Question 28, "Which solution pages have you looked at?" by considering instead the **number** of solution pages they had looked at. Answering this question correctly could have given some insight into Table 4.2.c.1.

The worrying aspect in Figure 4.3.d.1 is that 5 students (almost 10% of the class), had not found the solution pages, which means they had never gone back to the assignment pages after receiving their marks (furthermore, they did not go back to these pages in revising for the examination). As mentioned in section 4.2.C, a link to each solution page was put on the home page in 2001 to make the existence of these pages more obvious to the students (see Figure 3.2.c.1). In spite of this, four out of the 26 students who completed a questionnaire in 2001, also did not find the solution pages.

In an attempt to find the students' main problem areas regarding the solution pages, Question 29 asked which solution pages gave insufficient information.

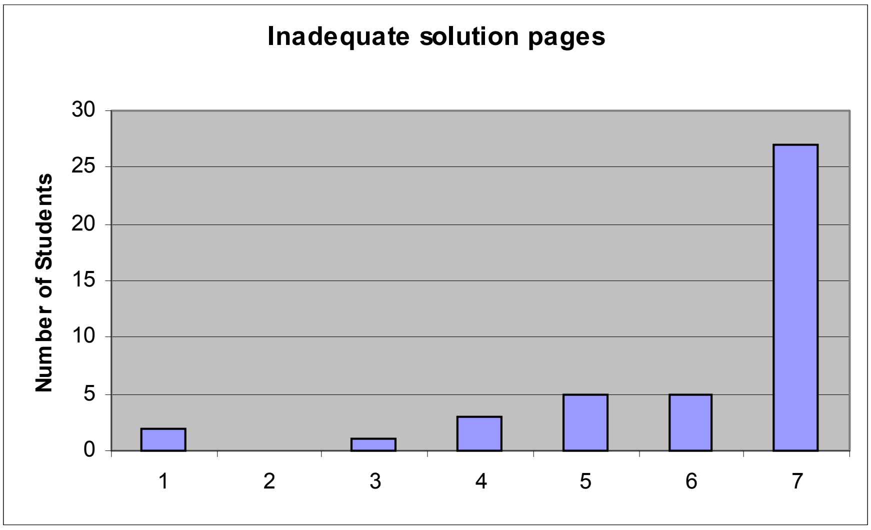

Figure 4.3.d.2 *Students' response to which solution pages were inadequate (In the figure, 7 refers to the response* "All were adequate".)

From the above figure, 51% of the class felt that the solution pages **that they had looked at** were adequate. However, what is interesting about this figure, is that although Table 4.2.c.1 shows a lower number of hits for the solution pages of Assignments 4 to 6 than those of Assignments 1 to 3, more students were unhappy with solution pages 4 to 6. In some ways, the response that there were problems with the solution pages was somewhat of a surprise. Although the students frequently discussed their problems regarding the assignments, in both years that the Web-based course was run, there were never any queries nor comments on the solution pages.

4.3.E Honesty in answering the questionnaire

In preparing and analysing a questionnaire of this nature, one implicitly assumes that the respondents are being honest in answering the questions. The issue of honesty with this questionnaire can be tested with Question 25: "Did you read the course objectives?".

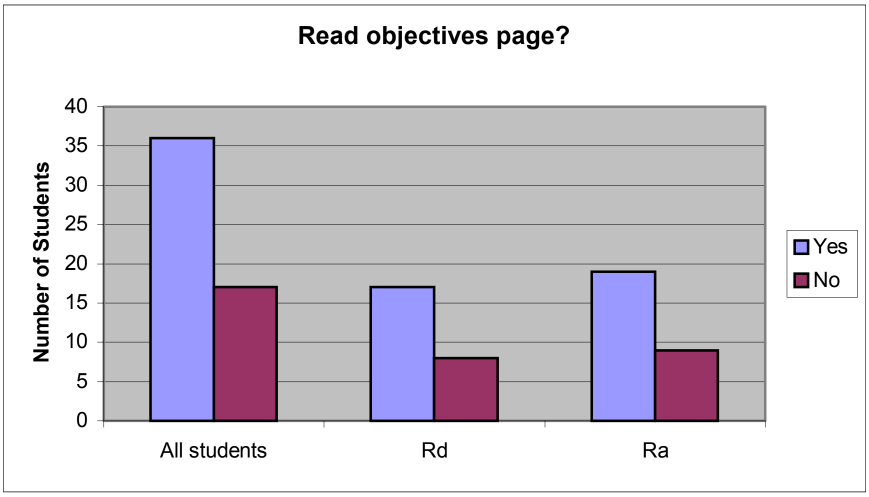

Figure 4.3.e.1 *Students' response to whether they had read the Objectives page.*

From this figure, 36 students (68% of the class) claimed that they had read the Objectives page. However, from Table 4.2.a.1, it can be seen that there were only 25 hits on the Objectives page prior to the examination. From the reasoning given in section 4.2.A, the author feels that only six students could actually have **read** this page, which means 30 students were not answering the question honestly. Even if the students had equated *read* with *looked at* it still means that at least 11 students were not answering the question honestly. As it is not possible to find out who had answered the question honestly, from those who answered *Yes*, only those who answered *No* were completely honest in answering the questionnaire.

If the data making up Figure 4.3.b.5, which gives the students' view of the Web-based course, is recalculated using only the results of the "honest" students, the following table is obtained.

Table 4.3.e.1 *A comparison of students' views of the Web-based course between the whole class and the "honest" students*

	All students (53)	**"Honest" students (17)**
Against	42%	29%
Indifferent	28%	42%
In favour	30%	29%

From the table, it can be seen that the "honest" students are split evenly between being in favour and being against the Web-based course. However, more of this group of students were indifferent to the Web-based course when compared with the whole class. This is not unexpected if one considers the question which generated these "honest" students ("Did you read the course objectives?"). What is probably being measured here is not their indifference to the Web-based course, but rather these students' indifference to the course as a whole.

4.4 Time management

An important aspect of a Web-based (or any distance-based) course is the students' ability to manage their time effectively (*e.g.* Sherry, 1996). In the absence of formal lectures, time must be set aside to complete assignments within the deadlines set by the lecturer. By monitoring the dates on which the students saved their assignments, a measure of the effectiveness of the students' time management strategies was obtained. Just-in-time completion of assignments would not suffice as a measure of good time management as the students had to work ahead in order to "gain time" for their Church Project.

4.4.A 2000

In the questionnaire completed by the students in 2000, Question 20 asks whether they had scheduled time to complete the assignments. 83% of the students responded that they had used some form of time management. Yet, the dates on which the assignments were submitted show that only two students had worked ahead consistently. These two students completed their assignments a full month ahead of schedule, and their Church Project a week ahead of schedule. A further two students had completed Assignment 5 a month ahead of schedule, but finished Assignment 6 just before the due date.

45% of the students were more than a week ahead by the time the fourth assignment was due to be submitted, but by the end of the course had slipped back to the due date for submission. This was probably due to a disruption in academic activities caused by two short vacations in April 2000 (10 days at the beginning of April and 12 days at the end). Laurillard (1993: 219) finds, in situations such as this, that students lose contact with the issues being studied. She prefers block teaching rather than distributed teaching (*ibid*: 220).

In spite of five hours being allocated to the course on the University timetable, students seemed to view this as free time, since there were no formal lectures. Thus, they regarded using the Gold Fields Computer Centre during practical times as "having to manage their time".

4.4.B 2001

Students in 2001 used a completely different time management technique to the students in 2000. Several of these students would complete two assignments in a single session, and then would wait until the assignment following these two was due before completing another two assignments.

Only one student completed his Church Project ahead of schedule and a further six completed their assignments a week ahead of schedule. As with the students in 2000, the rest of the students in 2001 did not try to work ahead at all.

4.4.C Assistance with time management

The students in 2000 felt that a Web page on "Time Management in the SCI 152 course" would have been useful.

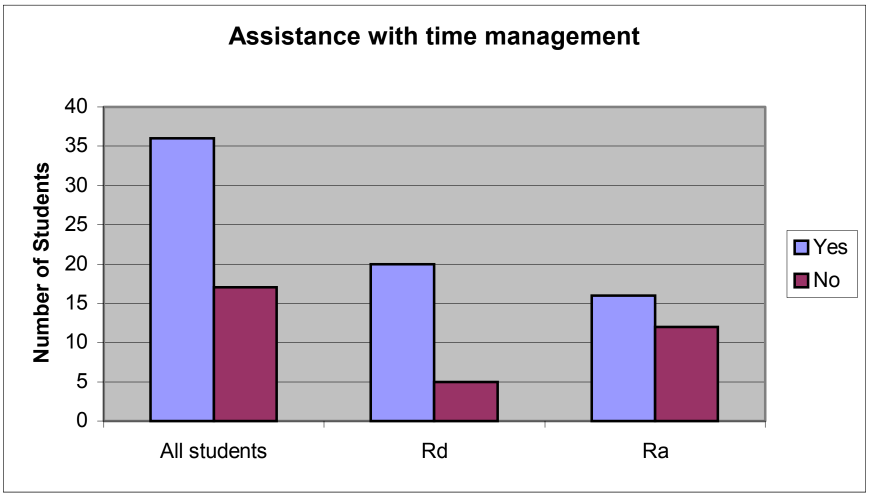

Figure 4.4.c.1 *Response to Question 22 of the questionnaire:* "Do you think a Web page on 'how you could possibly manage your time on this course' would have helped you?"

From the above figure it is clear that 80% of the Rd students felt that they needed some kind of assistance with time management, whereas only 57% of Ra students felt that this may have been of some benefit. This result is in stark contrast to constructivist approaches to learning, where students are expected to decide for themselves on how to study (Sing 1999).

It should be noted that all the students on the course in 2000 were also enrolled on the SCI 153 course (Academic Skills). One of the topics covered on this course is time management, so it is evident that students have difficulty in transferring skills learned in one subject to another.

4.4.D Reading ahead

One of the major advantages of a Web-based course is that all the course material (apart from the solutions to the assignments) is available at the start of the course. Students were encouraged to read and work ahead as far as possible so that they would have sufficient time to complete their Church Project.

While the Web logs do show many hits on assignment pages before they were due, there is no way of knowing whether these hits represent a cursory glance or an in-depth preview of the page. The students in 2000 responded positively as to whether they had read ahead.

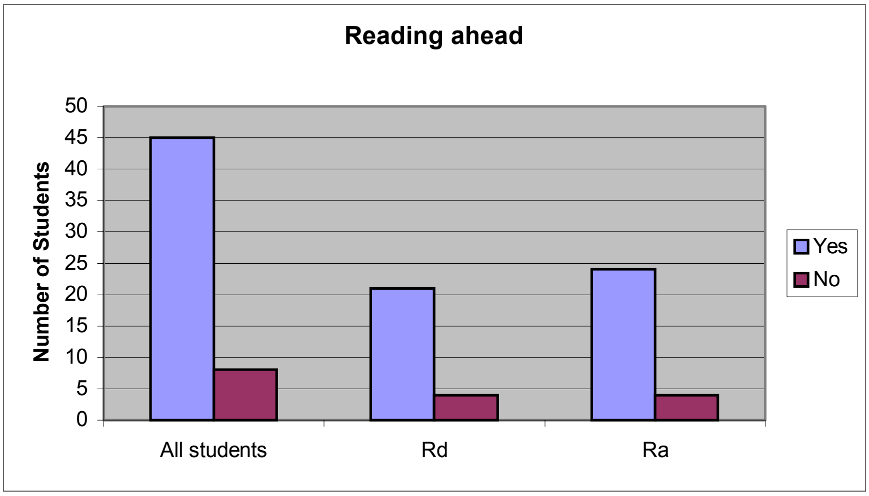

Figure 4.4.d.1 *Response to Question 18 of the questionnaire:* "Did you, at any stage, read assignments that were not yet due?"

An overwhelming 85% of the students in 2000 claimed that they had read assignments which were not yet due. However, as discussed in section 4.4.A, this reading ahead was not translated into working ahead.

It is important to note that the ideal learning situation is where a student can choose his or her own path through the study material (Candy, 1991:50-73). In the two years that the Web-course has run, only four students tried exercises from assignments out of sequence (in all cases the exercises were from Assignment 6 before Assignment 5 was completed). The rest of the students followed a linear path in completing the assignments.

4.5 Off-task activities

In 2000, students only had access to the Internet during the course of their Internet awareness practical. After that they were restricted to the Intranet of the University of Pretoria. In 2001, students had unrestricted access to the Internet after their Internet awareness practical. According to Nortje (2001), this was an oversight on the part of network management at the University of Pretoria, as open access to the Internet from computer laboratories is restricted to the hours 18:00 to 22:00 on weekdays. Normally, special permission has to be obtained for open access outside of these times.

Observations of the students in 2001, while they were active on the Internet in the Gold Fields Computer Centre, showed that most had obtained Web-based email addresses by the end of the course. As the author had given no instructions in this regard, the more experienced Internet users amongst the students must have exposed novice users to this technology. Another favoured activity was the search for lyrics to popular songs. There is no doubt that the free Internet access led to self-empowerment amongst the novice users, in that they had learned to use the Internet as an aid in finding information. This is best illustrated by the way in which most students approached a task in which they had to draw a map of the King's Quest world. (King's Quest is a computer game used in the computer literacy component of the SCI 152 course to expose novice users to the idea of using the computer as a source of entertainment.) In previous years, this map was often copied (with errors) from colleagues who had completed the game. In 2001, the map was "discovered" in various forms on the Internet, and so, as in the past, students were able to submit a map without playing the game. [Plagiarism of Web-based information by students in collecting information for assignments is a serious problem (Carr, 2001b; Cronjé, 2001). Tapscott (2001) maintains that the Web encourages users to become critical thinkers by forcing them to use their judgement in evaluating the information they find. The author disagrees with this as his observations have shown that the majority of students copy information from Web pages without even bothering to read it (Carr, 2001b). Meintjies (2001) has a further problem in that information, when found, is often dated. Do students have the ability to discern the relevance of the information?]

The high novelty value of Internet activities for the novice computer users led to misuse of the available tools. The most overused was Internet-based SMS to mobile phones of friends within the Centre. The incessant beeping of these phones gave the author the impression that very little academic work was being done by these students, especially closer to the examinations. In a similar vein, sending emails to peers in the Centre was another big time waster. Interestingly enough, the author received no emails from the students, but did receive an SMS from one student thanking him for assistance with a problem.

Figure 4.1.b.1 and Table 4.1.b.2 clearly show a decrease not only in marks for the assignments, but also a decrease in the number of assignments being handed in as the semester progressed. Although the data was not presented in this document, the decrease in the number of assignments handed in, shown in Table 4.1.b.2, was found mainly

amongst the 2001 students. Distractions, caused by unrestricted Internet access, is the most likely cause of this laxness.

Although the data presented in this section is somewhat subjective, it shows that unrestricted access to the Internet could have had a detrimental effect on the students' academic performance.

4.6 Interaction

Prior to the Web-based SCI 152 Logo course going live on 22 March 2000, the author asked several friends and colleagues to check the pages for spelling, grammar and logic errors that may have been overlooked. However, most of these people commented on interaction. Brown (2000) and Erasmus (2000) felt that some form of interactivity should be built into the pages to make sure that students had grasped the concept that they were required to work with. Vermaak (M, 2000) and von Glehn (2000), on the other hand, would both have liked to have had Logo software to try the exercises. Both mentioned being frustrated at not being able to follow the arguments being developed without the Logo software.

The author, agrees with Cronjé (1997) about the static nature of Web pages. These pages are nothing more than a vehicle for presenting the information. In order to create the necessary knowledge to proceed with the course, the students had to interact with the Logo software **in conjunction** with the information on the Web pages. The author feels that this aim was achieved, as can be seen in the video clips taken of the students on the first day of the Logo course presented via the Web. These clips are in the directory VideoClips on the enclosed CD (see especially KATE.avi and NKOSI.avi).

Student interaction is discussed further in the chapter 6, *Future work*, under JavaLogo.

Interestingly enough, the Institute for Higher Education Policy's report on benchmarking Internet-based distance education emphasises the importance of interaction. However, the interaction they refer to is not with software, but rather interaction between students and the lecturer/tutors, and interaction between the students themselves (IHEP, 2000).

Chapter 5 Conclusions and Recommendations

Chapter guide

5 Conclusions and Recommendations

In this chapter, the results and discussions from the previous chapter will be used to answer the research questions posed in chapter one. Firstly, solutions to the questions pertaining to this project (from table 1.5.1) will be examined. Finally, possible answers to the major research questions (from table 1.3.1) will be derived from the project solutions and the literature.

5.1 Course design

How did the students cope with the Web as a medium for lesson presentation?

The majority of students polled in 2000 felt that they had successfully coped with the Web-based course (see section 4.3.B *Using the Web pages of the SCI 152 course*). This is supported by the examination results, where, overall, students on the Web-based course performed better than those on the paper-based course (see tables 4.1.a.2 and 4.1.a.3). However, several alarming factors are shown in tables 4.1.a.3 and 4.1.a.4

- more than half the class still failed the examination;
- the disadvantaged students were further disadvantaged by this medium of presentation in that their examination results were worse than those of the disadvantaged students on the paper-based course.

In order to improve the students' performance without lowering the standard of the course, several issues in the design of the course need to be addressed. These include

- face-to-face contact;
- design of assignment and solution pages;
- time management; and
- study aid pages

5.1.A Face-to-face contact

The majority of students in 2000 felt the need for some lectures (see figure 4.3.b.3). An even bigger majority felt that they would have been unable to complete the assignments without the assistance of the lecturer and the tutors (see figure 4.3.b.4). This implies one of two things

- a feeling of inadequacy amongst the students in not being able to complete their assignments without face-to-face assistance; or

- insufficient information on the Web pages for the students to complete the assignments on their own (this point will be dealt with in section 5.1.B *Assignment and solution pages*).

Students who wrote the supplementary examination in 2001 showed the benefit of having a single discussion session prior to the examination (see section 4.1.D *Supplementary examination*). This session was sufficient to boost these students over the mental barrier which had prevented them from passing their examinations the first time around. The need for face-to-face contact could also be the reason as to why the majority of students were not keen on having other courses run from the Web (see figure 4.3.c.1).

To ensure that students are not overawed by the Web presentation of academic material, regular **formal** discussion sessions should be held with the students. These discussion sessions should consist of fixed groups of not more than six students and the lecturer. In this way, any anxiety caused by a student's doubt in his or her capability to express him or herself in front of others can be minimised. With a small group, it is also easier for the lecturer to detect whether each student has grasped all the necessary concepts. The sessions should be held at fixed times each week and be made compulsory. Any student who feels he or she is coping with the material should show concrete evidence why he or she should not attend these sessions. Any student receiving permission not to attend would, however, remain part of a fixed group with the option to attend whenever they feel it necessary.

5.1.B Assignment and solution pages

As mentioned in the previous section, the students' apparent need for face-to-face support could be as a result of insufficient information on the Web pages. The poorer results achieved by students, on the Web-based course, in Assignments 5 and 6 show that there is a problem with these pages (see figures 4.1.b.1 to 4.1.b.3 and table 4.1.b.2). However, figure 4.3.b.2 shows that the majority of students in 2000 felt that there was sufficient information on the SCI 152 pages for them to complete their assignments. This feeling is reinforced by figure 4.3.d.2, where the majority of students who used the solution pages, felt that these were adequate. However, both figures 4.3.b.2 and 4.3.d.2 show that an appreciable number of students were not satisfied with the information given. figure 4.3.d.1 and table 4.2.c.1 show further, that students were not conscientious enough in using the solution pages, in spite of poor results achieved for the assignments (see table 4.1.b.2). Somehow, students must be taught how to read the pages more diligently. The best place to do this would be in the discussion sessions mentioned in the previous section.

All the assignment and solution pages should be re-evaluated in conjunction with students who have already completed the course. During the 2000 course, several pages were modified in this way with the help of the two students who were ahead of the rest of the class (see section 4.4.A *2000*).

5.1.C Time management

As many students felt that a time management page could be useful (see section 4.4.C *Assistance with time management*), such a page should be added to the Useful information page. This page should be developed in conjunction with the course presenter of the SCI 153 course (Academic Skills) to ensure that the time management principles covered in the SCI 153 course are reinforced for students taking both courses.

In order to make time management easier for the students, the number of assignments should be decreased from six to five. This should be feasible as several students in 2001 were able to complete two assignments in one session - see section 4.4.B *2001*. This would allow the students more time to work on their church projects. Whether this would result in better projects remains to be seen, as experience has shown that most students leave assignments and projects to the last possible moment before the due date (see sections 4.4.A *2000* and 4.4.B *2001*).

A generic time management page should also be developed for undergraduate students doing other Web-based courses at the University of Pretoria. It would be very surprising if these students were any different to the SCI 152 students in not needing assistance in managing their time.

5.1.D Study aid pages

5.1.D.1 Objectives As the students found the Objectives page irrelevant (see sections 4.2.A *Objectives* and 4.3.E *Honesty in answering the questionnaire*), the title and language used to describe the objectives of the course need to be changed to make the content more meaningful to the students (see, for example, Draper 2001b). Furthermore, the discussion at the end of section 4.2.A *Objectives*, shows that many leaders in the field of Instructional design feel that the objectives of a lesson or course are more important to the course designer than to the student. As the significance of course objectives in Instructional technology has diminished, it no longer warrants a major link, such as on the home page. The link should be moved from the home page to the Useful information page where interested students would still be able to find it.

5.1.D.2 Useful information As shown in table 4.2.e.1, students showed little interest in the Useful information page. This meant that it failed in its primary goal of acting as a bulletin board for the course presenter.

In order to make this page more obvious to the students, the link on the home page needs to emphasised, either by using a larger font or a small picture which depicts the contents (or changes) to the page. It may also be necessary to change the name of the page to something which attracts the students' attention. Currently, the link to the Useful information page is at the bottom of the home page (see figure 3.3.c.1). As pages are loaded in the same direction that people from western education systems read (left to right, top to bottom), before downloading is complete, people tend to

- scan the information
- click on an interesting link as soon as it is spotted
- click on the browser's back button if the information appears irrelevant.

So it is easy to see why the students' attention stops at the "important" information for them, the current assignment. Their scanning seldom reaches the link to the Useful information page. Because of the importance of the information in the Useful information page, the position of the link should be moved from the bottom of the home page to the position currently occupied by the link to the Objectives page near the top of the home page.

5.1.E Additional recommendations to course design

Several students wanted to be able to complete their assignments off campus. In order to allow them this opportunity, the current proprietary Logo package (PC Logo) would have to be changed to a non-proprietary package. Possibilities in this regard are

- a Java version of Logo (see section 6.3 *JavaLOGO*). A disadvantage of this is that the author of JavaLOGO wants a per download royalty paid, which puts this software back into the proprietary bracket.
- MSWLogo, a freeware version of Logo (Mills 2000). Students could download the software from the MSWLogo site to their home computer.

It would appear thus, that the only option is MSWLogo. Using this package would mean a complete redesign of the current course Web pages to take into account the differences between MSWLogo and PC Logo.

It should, however, be noted that allowing students to work off campus would favour the advantaged students. The disadvantaged students would still only be able to access their course material from computer laboratories on campus.

5.2 Web-delivery as a means of course presentation

What were the students' attitudes towards Web-delivery of course material?

Although attitude is difficult to measure, by looking at the responses to some of the direct questions in the questionnaire, as well as the students' approach to handling their assignments and projects attitudes can be gauged.

In 2000, the majority of the students on the SCI 152 course were against Web-delivery of course material (see figure 4.3.b.5). Equal numbers of students were either in favour or indifferent to this method of lesson delivery. The poll also clearly showed that the majority of disadvantaged students were against the Web-based delivery of course material. Although the majority of advantaged students were in favour of Web-based delivery of the course material, this majority is not as clear cut as with the disadvantaged students against Web-based delivery (see figure 4.3.b.5). Even the top-performing students from the disadvantaged group were against Web-delivery of the course material (see figure 4.3.b.6) while the top-performing advantaged students were marginally in favour or indifferent to this method of lesson delivery. As expected, most of the under-performing disadvantaged students were against Web-delivery, whereas the under-performing advantaged students were spread throughout the group (see figure 4.3.b.6). From table 4.3.e.1 it can be seen that the majority of "honest" students were indifferent or against Web delivery of course material.

A small majority of students in 2000 felt that other courses should not be run from the Web (see figure 4.3.c.1). In keeping with the findings on the Web-delivery of the SCI 152 course material discussed in the previous paragraph, the majority of disadvantaged students were against Web-delivery of other courses, while the majority of advantaged students were in favour of it.

As discussed in section 4.1.B *Assignments* students on the Web-based course faired far worse than their counterparts on the paper-based course as far as their assignments were concerned. Yet, as shown in table 4.2.c.1, the number of hits on the solution pages to the assignments was low (less than one hit per student in most cases). This would imply that the students were not interested in finding out where they had gone wrong.

As the disadvantaged students were against Web-delivery of course material, one feels that they are still uncomfortable with the use of technology as a supplement to a teacher. This is probably a mindset problem and could be changed with careful nurturing (see section 5.1.A *Face-to-face contact*). These students need to become more self-reliant and so gain belief in their own capabilities to solve problems without the assistance of others (see section 4.1.D *Supplementary examinations*).

5.3 The digital divide

How did the digital divide affect the students' performance?

In discussing the digital divide for students on the SCI 152 course, one must be aware that there are two aspects of digital technology which come into play:

- using Logo as a problem solving tool. This would have affected students on the paper-based course as well, but the problems found by students on the Web-based course would have been exacerbated by not having classroom activities to rely on; and
- using the Web as a lesson delivery mechanism.

As both of these are computer based, one would expect the digital divide to influence the outcome of any activities.

As mentioned in section 5.1 *Course Design*, examination results of disadvantaged students on the Web-based course were very much worse than those of the advantaged students (see figure 4.1.a.1). They were also worse than the disadvantaged students on the paper-based course (see tables 4.1.a.2 and 4.1.a.3). For these students, it would appear that Web-based delivery of lesson material had broadened the digital divide.

5.3.A Computer expertise

Figure 4.3.a.5 shows that the majority of students in 2000 had little or no prior computer experience. As expected, a higher percentage of the disadvantaged students had little or no prior computer experience, whereas the advantaged students were evenly split between little or no computer experience and medium to high levels of computer experience.

For the students overall, figure 4.3.a.6 shows an even spread of examination marks for all the categories of computer literacy. As expected, those advantaged students, with higher levels of computer expertise faired better in their examinations than the rest of the students on the course. However, the majority of disadvantaged students with a medium to high level of computer expertise failed their examination. For these students, having crossed the digital divide prior to starting their university careers, seems to have been a distinct disadvantage.

Section 4.1.D *Supplementary examinations*, showed that a single, formal face-to-face discussion with disadvantaged students gave them the confidence to rely on their own judgement, rather than the communal brain or a recipe, in solving the supplementary examination problems. Hopefully, these students have now, not only crossed the digital divide, but are also on the way to become self-sufficient life-long learners.

5.3.B Ability to complete a solo project

As a project of this nature entails competency with the Logo software, one would have expected that students who were more at ease with various software packages (*i.e.* those students with higher computer literacy levels) would have fared better with the project.

As discussed in section 4.1.C, the Church project was implemented to test the students' ingenuity in using the tools given to them in the Logo assignments. As each student had to produce his own church, the communal brain (discussed in section 4.1.B *Assignments*) would have minimal influence on the final product.

As shown in table 4.1.c.1, the disadvantaged students on the paper-based course excelled in their church projects. There marks were almost 15% better than their advantaged counterparts, and more than 15% better than the disadvantaged students on the Web-based course. By comparison, the advantaged students on the Web-based course were a mere 2.6% better than the advantaged students on the paper-based course and less than 3% better than the disadvantaged students on the Web-based course. As discussed in section 4.1.C *Church project*, the advantaged students on the paper-based course were very lax in their attitudes towards the church project, so one would assume that this influenced their marks. As both groups on the Web-based course performed much more poorly than the disadvantaged students on the paper-based course, the assumption must be made that the digital divide had no influence on the results of the church project.

5.3.C Open Internet access

The effect of the digital divide on first time Internet users is clearly shown by the very poor performance of the disadvantaged students in 2001 in their examinations (see figure 4.1.a.1). These poor results can largely be ascribed to excessive Internet surfing instead of academic pursuits (see section 4.5 *Off-task activities*). Open Internet access should thus be restricted, but not removed entirely, as these students deserve the chance to be able to explore the information available on the Web. The current Internet open time in computer laboratories at the University of Pretoria (18:00 to 22:00) should be re-evaluated as it discriminates against day students. A more realistic open time would be 15:00 to 22:00, which would allow day students some Internet time before having to leave in search of transport home. The 15:00 starting time would also allow overlap with the staff's working hours, which would still leave students time to ask questions, concerning aspects of Internet usage, of the staff.

5.4 The influence of the student's background

Was there any difference in the ability of students from disadvantaged and advantaged communities to successfully complete the Web-based course?

As discussed in the previous section on the digital divide, the effect of the divide on the performance of the SCI 152 students was not nearly as marked as expected. Hence, one must look further into a cause for the poor examination results of the students from disadvantaged communities. Something is clearly influencing these students' ability to handle a problem outside their current comfort zone[1]. This inability to inability to handle new problems can be directly attributable to the school system. Teachers, instead of teaching problem solving skills, rather teach recipes to solve a particular type of problem. These recipes prevent the students from adapting previously learnt skills to new situations. Coaching techniques for examinations lead students to expect a particular type of question (de Bono, 2000:6). This is not the fault of the teacher, but rather the education system in South Africa, as many mathematics and science teachers in Black communities have not studied the subjects they teach beyond the senior school year. Initiatives to assist teachers in improving their qualifications have been implemented at many tertiary education institutions.

However, if the lot of the teaching profession is not improved, teachers are not going to strive to improve themselves, and if the teachers do not improve, students will remain academic underperformers when they reach tertiary level. It was clearly shown in the previous section that students from the disadvantaged communities **do** have the ability to complete a course of this nature. Care, however, must be taken to ensure that the medium of lesson delivery does not become the stumbling block in the learning process. Students need to be taught to use resources, other than the teacher, in order to become successful life-long learners.

As Clark (1983 & 1994) stated, the medium of lesson delivery should play no role in the learning process, but one should be make sure that the student is capable of using that medium. To extend Clark's "grocery truck" metaphor (discussed in section 2.3.C *The medium of delivery*): the goods delivered are the same regardless of the vehicle, but we

[1] Comfort zone is a term used by Meyer (2000) to describe a person's current state of knowledge. A person is loath to work with issues outside his or her comfort zone, unless a perturbation caused by external factors (such as new information) forces the person to change the boundaries of his or her comfort zone. This

must make sure that the driver can drive the vehicle **and** knows the directions to his delivery point.

The hope has been expressed in education circles that by making Web-based academic material available to all, both students and teachers will be able to improve their performance levels. The feasibility of this concept will be discussed in the next section where an attempt will be made to answer the major research questions outlined in table 1.3.1.

5.5 Web-delivery of academic material as an aid to alleviating the educational shortfall in disadvantaged communities

To what extent can Web-delivery of lesson material be used to address the education shortfall in disadvantaged communities?

5.5.A Scholars as Web-learners

As shown by the results of the students on the SCI 152 course, much assistance and encouragement is required for students from the disadvantaged communities to make the transition from classroom-based learning to Web-based learning. Although this is mentioned in the original TELI discussion document (TELI, 1996), neither the subsequent document (TELI, 1997) nor the ICT document (Departments of Education and Communications, 2001) make any reference to it. Teachers, who are dedicated to both their subject and to the use of technology as an aid to their teaching are required as mentors for the students in making the transition. These teachers would also have to be more than familiar with the use of these technological tools to make TELI work.

5.5.B Teachers as Web-learners

The hope has been expressed that, by putting computers in schools and giving these schools Internet connectivity, upgrading of teacher skills could be carried out via the Web (Pretorius 2001b). These teachers, however, will suffer from the same problems found by students on the SCI 152 course: until they are proficient in the use of the technology, and acquire the unique skills required for Web-based learning, they will require face-to-face assistance. Ideally, this assistance would come from a competent IT teacher at the school. However, teachers with up-to-date IT skills are not easy to find (Pretorius 2001b) because of the high demand for IT skills in industry.

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perturbation is equivalent to the *anomalous state of knowledge* in Information Science (Dervan & Nilan, 1986; Ingwersen, 1996).

5.5.C Schools as centres of Web-based learning

According to Pretorius (2001c), the item highest on the wish-list of disadvantaged schools is a computer facility for the students. However, as mentioned repeatedly in the TELI discussion document (TELI, 1996), computers should only be placed in schools where they will serve a definite purpose in the teaching process. Merely placing computers in schools, without a strategy to use them, is a waste of time and money.

The delivery of services, such as electricity, water and telephone connectivity, to the poorer communities as fundamental to the implementation of any technology-based teaching initiative. While these are important, the infrastructure to support and maintain these services, as well as the computer hardware and software, are just as important. In rural areas, these support people are scarce because of the better salaries and living conditions found in the metropolitan areas.

A noteworthy objective of the ICT strategy (Departments of Education and Communications, 2001) is to make schools the centre of community life by allowing the community access to the computer facilities after school hours. However, no mention is made as to who is going to run these facilities after hours.

5.6 Knowledge and information

What is information and what is knowledge?

5.6.A Teaching and learning

In spite of the current trend to use these words interchangeably, they cannot be regarded as synonymous. From table 2.2.f.1,

- **Knowledge** is the skills which enable a person to solve problems. It is also the stored facts which allow a person to understand the problem or situation.
- **Information** is the medium by which knowledge is transferred between people.

Knowledge is something unique to a person, and each person increases his knowledge by creating links between his or her existing knowledge and new information he or she receives. From these definitions of knowledge and information, definitions for teaching and learning can be developed:

- **Learning** is when a person makes links between existing knowledge and information presented to create new knowledge.
- **Teaching** is assisting a potential learner in creating the links between his or her existing knowledge and new information presented. It is also the ability to assess whether the new information has been successfully assimilated by the learner *so as to create new knowledge.*

The highlighted point above is important in assessing whether deep or shallow learning has taken place. Another important attribute of a good teacher is knowing the size of the chunk of information which can be accommodated by the learner (ΔI in the Brookes equation).

5.6.B World Wide Web

The World Wide Web is a repository for massive amounts of information. However, it is not always possible to find pertinent information, nor is it possible to check the validity and accuracy of the information found. To be able to do this requires special skills and some knowledge of the subject matter being sought. Until these skills are learned, the novice user faces a daunting task in using the information available as a means of increasing his or her knowledge.

5.6.C The World Wide Web and teaching

A lecturer can make his or her course notes available on the Web. This has the advantage that students can prepare for a lecture by studying these notes prior to the lecture. However, students then tend to start skipping lectures as they feel they already have the necessary background material. Another advantage for the lecturer is that notes can be rapidly updated and deployed. A disadvantage for students is that they usually want a hardcopy of any lesson material, so access to a printer is required. Part of the lecturer's knowledge building exercises could be to have a page of subject related links, whereby the student could obtain the views of others, thus broadening his or her own view of the subject.

Many educators and education administrators see Web-delivery of lesson material as a means of overcoming the shortage of classroom space. By putting courses on the Web, students could study at any place and at any time. However, this presupposes that the students will have access to the Internet. As mentioned in earlier paragraphs, this is not the case, especially in the poorer communities. The education administrators also see Web-delivery of lesson material as a means of increasing the number of students that can be handled by a single lecturer. However, research has shown that off-campus students, who do not have face-to-face contact with the lecturer, require more of the lecturer's time in order to cope with the lesson material. The lecturer has to spend more time composing email messages and answering telephonic queries than would be the case in the equivalent face-to-face situation. Without spending this time on composing a reply, the lecturer cannot assist a learner at-a-distance in creating new knowledge.

In using the Web as a teaching mechanism, the teacher assumes that the learner is capable of independent study. With undergraduate students and scholars, this is seldom the case. These learners still require the physical presence of the teacher as a role model. They also need to develop skills such as time management and discipline in order to complete their courses. Discipline is also necessary to avoid being side-tracked by following off-topic links during on-line sessions.

The Web can be useful as a teaching mechanism. However, learners must be taught to use it in order to make successful knowledge gains.

5.7 Is the Web effective as a medium for teaching?

In closing this discussion, the question posed in the title of this document must be answered. For undergraduate and school students, using the Web to teach must be used with caution. The teacher must first make certain that the students can use the medium successfully. Care should also be taken that the important facet of role model, played by a teacher in helping students solve problems, is not removed before the students are capable of self-directed study. Students also need to be able to manage their time efficiently, in order to make a success of Web-based study.

For postgraduate students, as well as those students capable of self-directed learning, the Web can be used successfully as a medium for teaching.

5.8 Summary

The topics that have been discussed in this chapter are all tightly interwoven, and should not be viewed in isolation.

- What is clear is that many students do not have adequate background and skills to handle a Web-based course. It is unfair to impose technology-based teaching on these students without giving them some form of transitional training in moving from classroom-based learning to technology-based learning. (Prior computer skills amongst the disadvantaged students was of little assistance to them). Hopefully, the recommendations made above, especially the face-to-face discussion sessions (section 5.1.A *Face-to-face contact*), will help these students in making this transition. One would hope that this would help these students in achieving the academic improvement shown by the advantaged students.
- Web-based course presenters should monitor students' progress closely by examining, not only academic results, but also student activity on the Web pages. Problems found by students on Web pages should be rectified immediately.

- No form of telematic teaching should be allowed with undergraduate students, without first ensuring that they are capable of using the medium of lesson delivery.
- The school system in South Africa needs to be re-evaluated. The image of the teaching profession needs to be improved to attract highly qualified and motivated people, dedicated to transferring their skills to the students. Without this, students will never become lifelong learners, but remain followers of academic recipes.
- The current trend of pouring millions of rands, dollars and pounds into placing computers in schools (Pretorius, 2001b), with the hope that these will make-up for inadequate teaching practice, will never succeed without first giving the students the background to use technology. This, in turn, cannot be done without competent teachers who, themselves, are at ease with the technology.
- Students need to be taught the special skills required to convert information on the Web into usable knowledge.
- "The Internet is not a magic bullet that will solve rural poverty..." (Elliott, 2001).

6 Future Work

6.1 Email

As was shown in section 4.2.E, very few students looked at the page *Useful Information* (see Table4.2.e.1). Some students did not look at the page at all, as they went to the incorrect examination venue. The author had hoped that this page would act as a noticeboard for passing information to the students.

To make sure that **all** the students are informed of changes to the pages as well as class announcements, (and of course to promote discussions outside the practical period) an email listserver should be used. Up to now, the author has been wary of using email with undergraduate students because of its potential for misuse and the spread of viruses. Clarke (1998) has discussed the merits of email as a discussion tool amongst adult learners, but mentions that not all students participate equally (*ibid.*). The author (and others, *e.g.* Flanagan, 2000; Steyn, 2000) has found a similar lack of discussion from the bulk of the members of the GUIDE group of postgraduate Information Science students at the University of Pretoria. The author thus feels that if there is a lack of discussion amongst senior postgraduate students, first year students (who are mainly first time Internet users) will be even less inclined to make use of this medium for problem solving (this scenario has been documented by Draper, 1997 and Marsh, 2000). Email to the listserver will then devolve into one-way traffic, with the course presenter using it for administrative issues. The author had similar experiences with a group of prospective engineering students from the South African Airforce during the second half of 2000, in that they failed to use their listserver for anything other than administrative issues. Hart and Gilding (1997) found the same problem, but were happy to use the listserver for posting global notices to all the students.

Arnold (1997) found that students regarded participation in email discussion groups not as an aid to, or part of, the course, but rather as something extra.

6.2 Web Access Logs

The Apache Web Server logs yielded good information for this study (section 4.2), but it was extremely time consuming extracting this information. Unfortunately, only the IP address of the workstation was logged when each page was accessed. This gives no information as to the identity of the user of the pages. A more formal student login to the site may be required as the course is a credit bearing one at the University of Pretoria. A cross correlation between the Apache logs and the login logs could yield a far more precise measure of how each student used the Web pages.

The formal login could also help in shifting students' attitudes when they realise their progress is being monitored.

6.3 JavaLOGO

Since 1995, the software *PC LOGO for Windows* (Terrapin, 2000) has been used for the course. This is a limitation, as the assignments can only be completed in the Gold Fields Computer Centre (which holds a multi-station license for *PC LOGO*), unless the student has a copy of this software. The author has looked at a very popular freeware version of LOGO, *MSWLogo* (Mills, 2000), but found the interface not as easy to work with as that of the commercial product from Terrapin. Furthermore, for a student to be able to use this software on a machine on which it was not installed, s/he would have to download it from the Internet (and then install it). This was beyond the capabilities SCI152 students in 2000. However, in 2001, several students of their own accord, downloaded and used *MSWLogo* in completing their assignments.

In an attempt to make LOGO software available, which would not entail downloading or installation, a Java version of LOGO is being developed (Vermaak, P. 2000). Using *JavaLOGO* means that the student will be able to complete the assignments from any workstation, with a Java enabled browser, connected to the Internet.

A further advantage of developing *JavaLOGO* is that some of the Java classes can be incorporated directly into the tutorial pages to provide a modicum of CBT interactivity for the student.

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Appendices

Appendix 1: Results at a glance

Table A1.1 Examination results

	1997	1998	1999	2000	2001		97-99	00-01			
All Students											
n	35	33	37	53	51		105	104			
Average	41.5	51.3	44.1	52.5	49.4		45.5	51.0			
Rd Students											
n	22	21	21	25	19		64	44			
Average	40.5	49.6	37.9	47.6	32.9		42.6	41.3			
Ra Students											
n	13	12	16	28	32		41	60			
Average	43.2	54.4	52.3	56.9	59.1		50.0	58.1			
All Students										**97-99**	**00-01**
≥ 90	0	1	1	2	2		2	4			
80 - 89	0	1	0	3	6		1	9			
70 - 79	0	2	1	8	3		3	11			
60 - 69	3	7	4	9	9		14	18			
50 - 59	8	7	10	8	3		25	11	**% Pass**	42.9	51.0
40 - 49	10	7	9	9	10		26	19	**% Fail**	57.1	49.0
< 40	14	8	12	14	18		34	32			
Rd Students											
≥ 90	0	0	0	1	0		0	1			
80 - 89	0	1	0	0	0		1	0			
70 - 79	0	1	0	4	0		1	4			
60 - 69	1	5	1	2	1		7	3			
50 - 59	5	3	6	5	1		14	6	**% Pass**	35.9	31.8
40 - 49	7	6	6	4	4		19	8	**% Fail**	64.1	68.2
< 40	9	5	8	9	13		22	22			
Ra Students											
≥ 90	0	1	1	1	2		2	3			
80 - 89	0	0	0	3	6		0	9			
70 - 79	0	1	1	4	3		2	7			
60 - 69	2	2	3	7	8		7	15			
50 - 59	3	4	4	3	2		11	5	**% Pass**	53.7	65.0
40 - 49	3	1	3	5	6		7	11	**% Fail**	46.3	35.0
< 40	5	3	4	5	5		12	10			

Table A1.2 Assignment results

	L1	L2	L3	L4	L5	L6	Av
n(97-99)	107	106	106	106	105	104	
97-99	78.3	63.2	81.9	71.2	69.3	73.9	73.0
n(00-01)	103	102	104	102	98	92	
00-01	76.3	72.0	72.4	64.1	55.2	59.4	66.6
Rd students							
n(97-99)	66	67	66	67	67	65	
97-99	75.8	63.2	82.5	70.6	66.2	73.3	71.9
n(00-01)	43	42	42	43	44	42	
00-01	73.6	73.5	78.9	62.4	53.4	59.9	67.0
Ra students							
n(97-99)	41	39	40	39	38	39	
97-99	82.4	63.3	80.9	72.4	74.9	75.0	74.8
n(00-01)	60	60	62	59	54	50	
00-01	78.2	70.9	68.0	65.4	56.7	59.0	66.4

Table A1.3 Church project

	Paper based		Web based	
	n	%	n	%
All students	92	71.5	104	62.7
Rd students	63	76.0	44	60.5
Ra students	29	61.7	60	64.4

Appendix 2: Questionnaire used to poll the opinions of the SCI152 students

Section A: Computer Literacy

1. How would you have rated your expertise with computers **before** you started at this University?

None... Novice... Average... Expert...

---

2. Do you have access to a computer at home?

Yes No

---

3. Do you think a textbook would have helped in this part of the course?

Yes No

---

4. Have you used a word processor before?

Yes No

---

5. Do you think this part of the course was a waste of time?

Yes No

---

6. Did you complete King's Quest?

Yes No I don't have time to waste on games

---

7. Have you used the Internet before?

Yes No

---

8. What did you think of the Internet awareness practical?

A waste of time... Too difficult... Useful... Interesting...

---

9. Do you think this part of the course could be run from the Web?

Yes No

---

10. Do you think any of your other courses could be run from the Web?

Yes No

---

11. If you answered YES, write down those that you think could:

Section B: LOGO

Time Management

(Keep in mind when answering the following questions that your practical period is from 10:30 to 15:30)

12. How many LOGO practical sessions did you attend?

0 1 2 3 4 5 6 7

---

13. Did you attend the session on 24 May?

Yes No

---

14. Did you attend the extra session on 27 May?

Yes No

---

15. Did you have sufficient time to complete all the assignments?

Yes No

---

16. Did you have sufficient time to complete the Church Project **to your satisfaction**?

Yes No

---

17. From the first LOGO assignment, did you ever try to work ahead?

Yes No

---

18. Did you, at any stage, read assignments that were not yet due?

Yes No

---

19. In which week of the LOGO course did you find out about the Church Project?

1 2 3 4 5 6 7 What Church Project?

---

20. Did you ever schedule time to complete your assignments?

Yes No

---

21. Have you tried to apply Time Management Principles, from the SCI153 course, to any of your other subjects?

Yes No

---

22. Do you think a Web page on "how you could possibly manage your time on this course" would have helped you?

Yes No

Other Course Information

23. Did you look at the "Additional Assignments"?

Yes No

24. Did you try any of the "Additional Assignments"?

Yes No

25. Did you read the "Course Objectives"?

Yes No

26. Did you read the "Useful Information"?

Yes No

Solutions

27. Have you compared your answers with the solution pages?

Yes No What solution pages?

28. Which solution pages have you looked at?

0 1 2 3 4 5 6

29. Which solution pages, of those you looked at, gave insufficient information?

1 2 3 4 5 6 All were adequate

30. Have you queried your LOGO marks with the lecturer or the tutors?

Yes No

31. Why did you not collect your tests?

But I did... I wasn't interested... I didn't know I could... I was too embarrassed...

General LOGO

32. Do you feel that you coped with the LOGO course without lectures?

Yes No

33. Would you have liked to have had some lectures?

Yes No

34. Do you think you could have completed the assignments without the physical presence of the lecturer and the tutors (ie away from the campus)?

Yes No

35. Was there sufficient information, for you to complete the assignments, in the LOGO web pages?

Yes No

---

36. Were the lecturer and the tutors helpful during the practical periods?

Yes No

---

37. Were the lecturer and the tutors attentive to your problems during the practical periods?

Yes No

---

38. Have you discussed LOGO work with the lecturer outside the practical period?

Yes No

---

39. If you answered YES to the previous question:

39a. How often?

1 1 to 5 more than 5

39b. Did the lecturer answer your question(s) satisfactorily?

Yes No Sometimes

39c. What was the lecturer's attitude towards your query?

Unhelpful Helpful

---

40. Did the lecturer show an interest in your work?

Yes No

---

41. Do you think the lecturer understands his subject?

Yes No

---

42. Rate your maths capabilities **before** this course.

Not too good... OK... Good... Very good...

---

43. Have you learnt anything from the LOGO course?

Yes No

---

44. In your own words, qualify your answer to the previous question (use the back of this sheet if necessary).

Appendix 3: Email monograph: Information and Knowledge by AM de Lange

(This document has not been modified in any way, other than to remove the hard carriage returns in the paragraphs, inserted by the email software.)

From: AM de Lange <amdelange@gold.up.ac.za>
To: <alan@gold.up.ac.za>
Subject: Information and Knowledge
Date: Monday, August 21, 2000 20:00

This contribution is complex. Hit the ESC key to flee from this complexity if necessary.

I think that this complexity is unavoidable as a result ot the Law of Requisite Complexity. The more I delved into the topic, the more I came under the impression how the presentation of "information" evolved through the centuries to such a level of complexity that it now appears to be like "knowledge". To distinguish between the two have become almost like trying to distinguish between an authentic note of currency and an almost perfect counterfeight copy of it. Nevertheless, it is of paramount importance to distinguish between the two, even if it entails that we have to delve deep into complexity.

We are being flooded with composite nouns like "knowledge management", "knowledge transfer", "knowledge engineering", "learning organisation", "learning community", "information technology" and "information society". The less we know what each of "knowledge", "learning" and "information" means, the more we will become confused by the meaning of these composite nouns. This confusion is caused by writers who use these words indiscriminately, unaware of their present and past meanings.

The fact that we have to deal with these nouns in a COMPOSITE manner, whether bewildering or meaningful, points that we are now in a profound bifurcating period which concerns our very intelligence and even spirituality. Should we desire these composite nouns (or even new words to rename them) to represent constructive emergences rather than destructive immergences, we will have to make sure among other things what their constituent nouns mean (see the essentiality sureness).

Why? In the evolution of every realm like the geosphere, biosphere or the logosphere, species of a new order generate from species of an older (which will afterwards function as the genera) in a linked manner. It is like twigs developing from a branch or branches developing from a trunk. Twigs have to be linked to a branch and branches have to be linked to a trunk to come into existence and to remain alive. Twigs and branches cannot live unlinked in the void because then their "identity" will become syncategorematic. Likewise an evolutionary species cannot be created in the void without loosing the "categoricity" of its "identity". Its emergence has to happen within an "evolutionary tree" to suite sureness.

In this contribution we will consider the evolution of the logosphere. This evolution of words is better known in linguistics as etymology. We will focus on the evolution of two words, namely namely "knowledge" and "information". We will link their present meanings to past meanings so as to become aware what future meanings we may give to them. This will help us to avoid confusion as a result of destructive immergences in meanings.

The Anglo-Saxon substrate of Modern English comes from Old English. The etymology of the word "knowledge" relates to the Old English word "cnawlec". The "-lec" is a suffix meaning "having resemblance to". The equivalent of "-lec" in Modern English is "-like". In my own mother tongue Afrikaans the equivalent of "-lec" is "-lik" while in German it is "-lich".

The root "cnaw" comes from the verb "cnawan" which means "pretty, well and lofty thinking". In Afrikaans a remnant of this meaning is still to be found in the word "knap" (German "klug"). Hence the syntactical evolution of "knowledge" in Afrikaans from "cnawlec" would have been to the word "ken(ou)lik". But "kenlik" itself means in English "obvious" (German "sichtlich"). The actual semantical equivalent of "knowledge" in Afrikaans is "kennis" (German "Kenntnis"). We also have in Afrikaans the adverb "nou(geset)" (German "genau"). The word "genau" is a pretty reflection on the phonology of "cnaw". The word "nougeset" means "within knowledge".

Should the English people have derived the word corresponding to "knowledge" from Greek rather than Old English, it would have corresponded syntactically somewhat to " 'eunoia' " ("eu"=good, "noeo"=think). Compare this with our recent LO-dialogue on " 'orthonoia' ", "metanoia" and "paranoia". But should they have derived it from Latin, it would have corresponded syntactically to " 'bonagnition' " where "bonus"=good and "nosco"=know. This reminds us of the close relationship between "knowledge" and "cognition" where "co-"=together. It means that knowledge has very much to do with cognition. How?

In the "(c)no-" of "noeo" and "nosco" as well as in the "cna-" of "cnawlec" we are reminded of the ancient Indo-Germanic root "cno"=bulge. The English word "knob" still retains this ancient meaning for which we today will use the word "emerge". Thus the word "knowledge" has its etymological roots firmly in the sense of "that which is bulging or emerging". In other words, the evolution of the root word for knowledge in Mesopotamia (Sumer) began with the awareness to emergent phenomena INCLUDING this very awareness itself as an emergent phenomenon.

It is for this reason that we have to distinguish in learning between its two asymptotes: emergent learning and digestive learning. The emergent learning correspond to cladogenesis in biological evolution while the digestive learning correspond to anagenesis. The emergent learning requires a high rate of "entropy production" so as to move towards the edge of chaos. The digestive learning requires a low rate of "entropy production" so as become close to equilibrium. Cognition is an outcome of emergent learning. Digestive learning, unlike emergent learning, relies very much on external sources of information

The word "information" is related etymologically to the Latin prefix "in"=in and the noun "forma"=form. The suffix "-tio" in Latin transformes the noun of any material thing into a corresponding abstract concept. Hence it is as if the word "information" is saying literally "in abstract form". Perhaps this is why the word is so easily misused for knowledge because the "in abstract form" of information cannot exist without some or other "physical representation" of it in a dazzling diversity. Knowledge is abstract too, but it requires physically the "functioning brain". This "functioning brain" cannot ever act as the "physical representation" for "information", despite the dazzling diversity otherwise.

In my mother tongue Afrikaans the semantical equivalent of "information" is "inligting" where the "in"=in, "lig"=light and "-ing"=ing. It is as if "inligting" says "to bring into light so as to be able to look at it". However, should we focus on the "abstract" aspect of information as the suffix "-tion" ought to tell us, one semantical equivalent of "abstract" in Afrikaans is "uittreksel" where "uit"=out, "trek"=pull and "-sel"= -xxx. This suffix "-sel" is a peculiar construct in Afrikaans by which a verb is transformed into a noun which will refer to the OUTCOME of that verb. It functions like the suffix "-ment" in English with respect to verbs from Latin origin like "achieve-ment" and "state-ment".

The Afrikaans word "inligting" would correspond syntactically to the English word "enlightenment". This perhaps suggests another reason why "information" has been inflated. The increased availability of "information" since some three centuries ago sustained a period of major digestive learning of which the outcome was called the "enlightenment".

Many outcomes of knowledge or facets of it may be described by words ending with the suffix "-tion". The following list contains only lesser complex synonyms of knowledge like apprehension, cognition, comprehension, erudition, information, intuition, perception and recognition. Because they are simpler synonyms it means that each tells about some facet of knowledge. Therefor it also means that not one of them, not even information, can be semantically equivalent to knowledge. In other words, using the word information when meaning knowledge or vice versa is a grave immergence in meaning.

Let me now attempt to give a short description of knowledge. In this description knowledge will be refered in the manner of an irreversible, spontaneous, self-organising system.

Knowledge comprises the whole of all acts and outcomes of conscious thinking. Knowledge places no restriction on its sources, whether internal or external. It employs them by way of authentic learning so as to complexify continually. Knowledge functions within the human independant of technology. It is a processing structure (whole becoming-being). It is rich in diversity and aware of its limitations. It is open to new inputs and eager to connect effectively with them so as to increase in sureness. As an irreversible, spontaneous, self-organising system it is a subsystem of human spirituality.

Allow me also to attempt a short description of information.

Information is a collection of abstract forms represented (carried, coded) by any artifact outside the human mind. Information is produced by knowledge so as perhaps to assist some mind in its future complexification. Information itself has no implicit knowledge, but can be recognised by a knowledgeable person as information. Information is unware of itself, its aggregate nature, its limitations and poverty, its closure by the very artifacts signalling it and its inability to self-organise irreversibly and spontaneously. It can be manipulated (engineered) outside the mind with technology (another artifact of knowledge), but without feasible artifical intelligence the outcome will not gain in any knowledge, not even implicitly. Even present information management by way of information engineering will not add any knowledge to the outcome, since it happens outside the mind and lacks substantial artificial intelligence despite all attempts so far.

We can compare the two descriptions above. But let us rather make comparisons with respect to definite issues.

Perhaps the most profound difference is that knowledge resides "inside-the-person" whereas information is "outside-the-person". Knowledge is closely linked to personality whereas information is by way of speaking "faceless". A person can be profoundly knowledgeable without ever having written any book. Yet people study the information in books so as to evolve in knowledge. People with much or little knowledge, except for a basic literacy, can write books. The information in such a book will be telling of the knowledge with which the person had written the book. But this information "in the book" can never be equated with the knowledge "in the author".

The advent of computers removed an important restriction on information "in the book". Book based information is static (being). Computer based information can also be represented dynamically (becoming). Despite this active representation of information "in the computer", it is still not knowledge. It lacks the irreversible, spontaneous, self-organising nature of knowledge. The lack of this very nature when even copying human learning into computerised models of artificial learning, artificial intelligence or even artifical life still makes it not knowledge.

Knowledge has many layers in it so that we can speak of its top layer as "sapient knowledge" (wisdom) and a couple of layers down as "tacit knowledge" (intuition). Although information can also have many layers created on purpose in it, it has neither wisdom nor intuition in them. Thus the thinking mind needs its own intuition and wisdom to deal knowingly with information as one of its sources. In contrast wisdom and intuition can be expressed as information, but lose their very nature by this expression. Hence the "information on wisdom" appears to be folly for some people while the wise recognise their own wisdom with it. Likewise the "information on intuition" appears to be ignorance for some people while the experienced recognise their own intuition with it.

Knowledge evolves (complexifies) spontaneously. Engineering attempts to force the growth of knowledge non-spontaneously result in its degradation (simplification). No matter how massive any collection of information has become, every increment in it was the result of reduction of knowledge. This reductionistic property of information disqualifies any part of it as well the sum of it from representing knowledge. But knowledge self overcomes this reduction by a continual migration through emergences from sensory inputs to experience, then to intuition, followed by formalisations and finally by wisdom. Even further emergences from wisdom to higher orders of spirituality are possible. However, information does not sustain higher order such as faith or caring love. It is rather infamous for making faith and love banal.

Knowledge has an ordinate cyber loop in it so as to manage its evolution in a changing world. The upwards action begins in the physical world with sensory inputs while the downward action begins in the spiritual world with caring love. Information has no (and perhaps will never have) an implicit means to guide its own evolution. Consequently it depends on knowledge to make its growth feasible and valuable. It means that information management depends fully on knowledge. Information management is often confused with knowledge management, even though the latter only happen within the mind itself spontaneously. Knowledge management can also be described as double loop learning, i.e. learning to learn. The counterpart for information management, namely informing to inform or "double loop informing" is actually meaningless. Forcing knowledge management by external means such as information management, sometimes called knowledge engineering, is detrimental to the evolution of knowledge

The mind can store information by memory, but information cannot ever store knowledge. Not even informative books on knowledge as their topic can store knowledge. Such books will have information on knowledge, but they do not have any knowledge self since then they would have evolved on their own as a result of such knowledge. Electronic Based Information Technology (EBIT) are replacing more and more books because in certain aspects EBIT is superior to paper based information technology. One such an aspect is the economy and feasibility of storing information by devices called electronic "memory" devices. Despite their name as "memory" devices EBIT is not any knowledge. Nowadays EBIT allows dramatic simulations of the dynamics of the mind, yet despite all this dynamics in the information presented by EBIT, this sometimes glorified information is still not knowledge.

Knowledge is like an organism. The faculties of knowledge are like the organs of an organism. Each faculty of knowledge has like an organ a morphology (structures) and a physiology (processes). Although information itself can also be presented with structures and processes, it is still not more than a mere simulation of knowledge. Any simulation of knowledge, impressive as it can be, cannot transcend itself as information so as to match the actual knowledge itself. Thus information remains a puppet of which the strings are pulled by knowledge. Information, like the puppet, is often a mere caricature and sometimes a grotesque monstrosity of the knowledge which it supposedly images.

The aggregation of information upon information may become far more than that which one person can ever cover knowingly. Thus we are tempted to equate information with knowledge or even consider it as superior to knowledge. However, we should bear in mind that knowledge itself also has a collective ("mitsein") dimension when learning individuals transcend together into a learning organisation. This seldom explored "collective knowledge" of a learning organisation is more than a match against all percievable aggregates of information.

Perhaps the composite noun "information source" causes the most confusion because it has become fashionable to use it. Like all fashion it changes continually in its meaning. The etymology of the English word source goes back to the Latin "surgo"=rise. Hence this word has strong connotations with the concept "emergence". Information has always a "physical model" which "carries" it. Only humans can become aware of the "information" carried by the "physical model" by way of a mental emergence. Other living species, plant or animal, seem to have no awareness to the "information" carried by the "physical model". Perhaps this "physical model" repesenting the "information" ought to be the only thing which may be called the "information source".

Reality in all its realms serve as the "source of knowledge". Hence the "knowledge source" is physical and spiritual, i.e. the "world-inside-the-person" as well as the "world-outside-the- person". On the other hand, all "information sources" are cultural artifacts. They have been created by humans to codify with protocols some facets of knowledge. They can be perceived only by knowledgeasble humans and not, for example, other kinds of animals. It is not possible to codify all knowledge into information because of the "measurement problem" -- the advanced reduction of patterns of the wave packet when explicating some of them as information. Thus "information sources", despite their sometimes massive and enticing nature, are inferior to the knowledgable mind which has produced them as measures of itself.

The way in which I think of "information" is that it is a source of data. To perceive bits of "data" in "information" itself also requires a mental emergence, the so called "analytical faculty of mind". Many people seem to speak of "source of information" when they actually deal in their minds with a "source of data", something which I consider as "information" itself. Knowledge on the other hand, is not a source of data, but a producer of sources of data in any required form. Knowledge can produce and digest data, but information can neither produce data nor digest them.

By now my own personal contemplations on what information and knowledge mean for me, may have become as confusing as the many composite names involving "information" or "knowledge" in them. Thus I should rather end these musings on "information" and "knowledge". But I cannot end by stressing once again that knowledge lives within me with mental "cno"s essential to it whereas information is documented outside me, devoid of any "cno"s (emergences), except telling about them.

Knowledge is like the country side and information like a map depicting the country side. Let us not confuse the map with the real thing which it represents.

With care and best wishes
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