

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

by
Benjamin Alan Carr

submitted in partial fulfilment of the requirements for the degree

Doctor of Philosophy

in the
Department of Information Science

University of Pretoria

Supervisor: Prof. Dr. J.C. Cronjé

December 2002

Abstract

Candidate: Benjamin Alan Carr
Supervisor: Prof. Dr. J.C. Cronjé
Department: Information Science
Degree: D.Phil.
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

Kandidaat: Benjamin Alan Carr
Promotor: Prof. Dr. J.C. Cronjé
Department: Inligtingkunde
Graad: D.Phil.
Titel: Inligting, kennis en leer: Is die Web effektief vir Wiskunde onderrig?

Hierdie tesis is 'n omskrywing van 'n ondersoek waarin wiskundige 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-gebaseerde onderrig in voorheen benadeelde gemeenskappe 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.

Acknowledgements

Prof. Johannes Cronjé for accepting me as a student and being supportive especially during the final stages of writing this document.

Dolf Steyn and Lisa Thompson for giving up time to read this document and giving critical comments on it. A special thanks to Dolf for his effort in getting me to complete this report.

Prof. Johan van Staden for giving me plenty of free time for conducting interviews with students, analysing results and writing this report.

The more than **300 students** of the Science Orientation course who were part of this experiment without knowing it.

The **tutors** on the Science Orientation course **Jacquie Smith, Mariana Horak, Adri Pretorius, Gavin Hunter, Tessa Bandunis, Koos Kabini, Inge van Jaarsveld, Noelani van den Berg and Deshni Pillay** without whose help I would not have been able to cope with the students.

René van Zyl for her help in setting up the Web server used for the Science Orientation course.

Tobia Steyn whose idea it was to use Logo in the Science Orientation course.

The many **academics** locally and abroad who communicated their ideas with me, especially **At de Lange and Bob Gorman**.

Zahn Nel for reading some of the chapters and discussing modern day language usage in academic reports.

Rudi Schwarzer for assistance in translating the abstract into Afrikaans.

The **friends and colleagues** who showed an interest in the progress of this report especially **Mark Hultzer** for his many calls from Durban.

Pat, Nyika and the cats...

Table of contents

List of figures	ix
List of tables	xi
Note to the reader	xiii
Chapter 1 Introduction	1
1.1 Introduction	2
1.2 Historical overview of the World Wide Web	2
1.3 Major research questions	4
1.4 Historical overview of the Science Orientation Course	5
1.5 Research questions pertaining to this project	7
1.6 Limitations of this study	8
1.7 Other research	8
1.8 Data collection methods	10
1.9 Thesis outline	11
1.10 Summary	12
Chapter 2 Literature review	13
2.1 Information requirements	14
2.2 Creating knowledge from information	14
2.2.A The Brookes equation	14
2.2.B Assimilating and accommodating information: learning	16
2.2.C Information and knowledge: synonymy	17
2.2.D Information and knowledge in the computer industry	18
2.2.E Philosophical views on information and knowledge	20
2.2.F Working definitions of information and knowledge	22
2.3 Information requirements for Web-based teaching	23
2.3.A The role of the teacher	23
2.3.B The role of the learner	25
2.3.C The role of the medium of delivery	26
2.4 Web-based teaching in disadvantaged communities	29
2.4.A Cultural and language issues	29
2.4.B Political and economic issues	30
2.4.C The digital divide	30
2.4.D South African issues	30
2.5 Conclusion	32

Chapter 3 Methodology	33
3.1 The research problem	34
3.1.A The aim of the research	34
3.1.B The objectives of the research	34
3.2 A description of the Problem Solving Skills module of the Science Orientation course	35
3.2.A Target population	36
3.2.B Aims and objectives of the module	38
3.2.C Module content	39
3.2.D Method	40
3.3 Web-based course development	43
3.3.A The Web server	43
3.3.B Web page design tools	43
3.3.C Design and development of the Web pages	44
3.4 Web-based course evaluation	49
3.4.A Evaluation of students' assignments	50
3.4.B Evaluation of students' tests and examinations	50
3.4.C Evaluation of students' time management skills	50
3.4.D Analysis and evaluation of Web server logs	51
3.4.E Development and evaluation of a questionnaire	51
3.5 Questionnaire	51
3.5.A Computer expertise	52
3.5.B Students' attitudes towards the Web-based course	52
3.5.C Use of the supplementary pages	53
3.5.D Time management	53
3.5.E Administering the questionnaire	53
3.5.F Evaluating the responses	54
3.6 Summary	54
Chapter 4 Results and discussion	55
4.1 Comparison of assessment results	57
4.1.A Examinations	57
4.1.B Assignments	61
4.1.C Church project	64
4.1.D Supplementary examinations	66
4.2 Analysis of student activity on the Web pages	67
4.2.A Objectives	68
4.2.B Naming of parts	70
4.2.C Solutions	70

4.2.D Additional assignments	71
4.2.E Useful information	72
4.2.F The search for inspiration	73
4.3 Student assessment of the Web-based course	76
4.3.A Computer literacy	76
4.3.B Using the Web pages of the SCI 152 course	80
4.3.C Could other courses be run from the Web?	84
4.3.D Solution pages	85
4.3.E Honesty in answering the questionnaire	87
4.4 Time management	88
4.4.A 2000	88
4.4.B 2001	89
4.4.C Assistance with time management	89
4.4.D Reading ahead	90
4.5 Off-task activities	90
4.6 Interaction	92
Chapter 5 Conclusions and recommendations	93
5.1 Course Design	94
5.1.A Face-to-face contact	94
5.1.B Assignment and solution pages	95
5.1.C Time management	96
5.1.D Study aid pages	96
5.1.D.1 Objectives	96
5.1.D.2 Useful information	97
5.1.E Additional recommendations to course design	97
5.2 Web delivery as a means of course presentation	98
5.3 The digital divide	99
5.3.A Computer expertise	99
5.3.B Ability to complete a solo project	99
5.3.C Open Internet access	100
5.4 The influence of students' background	101
5.5 Web-delivery of academic material as an aid to alleviating the educational shortfall in disadvantaged communities	102
5.5.A Scholars as Web learners	102
5.5.B Teachers as Web learners	102
5.5.B Schools as centres of Web-based learning	103
5.6 Knowledge and information	103
5.6.A Teaching and learning	103

5.6.B World Wide Web	104
5.6.C The World Wide Web and teaching	104
5.7 Is the Web effective as a medium for teaching?	105
5.8 Summary	105
Chapter 6 Future work	107
6.1 Email	107
6.2 Web Access logs	107
6.3 JavaLogo	108
Bibliography	109
Appendices	119
A.1 Results at a glance	119
A.2 Questionnaire used to poll the opinions of the SCI 152 students	121
A.3 Email monograph: Information and knowledge by AM de Lange	125

List of figures

Figure 2.3.b.1 Hypothetical teacher learner control continuum	26
Figure 3.2.d.1 The layout of the Gold Fields Computer Centre	41
Figure 3.2.d.2 Photographs of students working in the Gold Fields Computer Centre	42
Figure 3.3.c.1 The Index page of the SCI 152 Web-based course	45
Figure 3.3.c.2 Part of the Assignment 3 page	47
Figure 3.3.c.3 Part of the solutions page for Assignment 3	48
Figure 4.1.a.1 The class averages for the examinations from 1997 to 2001	58
Figure 4.1.a.2 The frequency-distribution graph of the students' examination marks. The class size has been normalized to 50 students	59
Figure 4.1.b.1 Class averages for each of the assignments	62
Figure 4.1.b.2 Class averages for Rd students	62
Figure 4.1.b.3 Class averages for Ra students	62
Figure 4.1.c.1 Class averages for the church project	64
Figure 4.1.c.2 A sample of churches produced by students on the paper-based and Web-based courses	66
Figure 4.2.d.1 One of the exercises from the Additional assignments page	72
Figure 4.2.f.1 Hits on the SCI 152 pages during the course of the 2000 examination	73
Figure 4.2.f.2 Paths followed by four students in moving through the SCI 152 pages during the 2000 examination	74
Figure 4.2.f.3 Hits on the SCI 152 pages during the course of the 2001 examination	75
Figure 4.2.f.4 Paths followed by four students in moving through the SCI 152 pages during the 2001 examination	76
Figure 4.3.a.1 Students' own rating of their computer expertise	77
Figure 4.3.a.2 Students' access to a computer at home	77
Figure 4.3.a.3 Word processor usage by the students	78
Figure 4.3.a.4 Internet usage by the students	78
Figure 4.3.a.5 Derived computer literacy levels	79
Figure 4.3.a.6 Average examination marks achieved by students who responded in the different categories in Figure 4.3.a.5	80
Figure 4.3.b.1 Did the students cope with the course without lectures?	81
Figure 4.3.b.2 Was there sufficient information in the Web pages to complete the assignments?	81
Figure 4.3.b.3 Would the students have liked to have had some lectures?	82

Figure 4.3.b.4 Could the students have completed the assignments without the lecturer and the tutors?	82
Figure 4.3.b.5 Students overall view of the Web-based course	83
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	84
Figure 4.3.c.1 Students' views as to whether an of their other courses could be run from the Web	85
Figure 4.3.d.1 Students response to whether they had compared their answers to the solution pages	85
Figure 4.3.d.2 Students' response to which solution pages were inadequate	86
Figure 4.3.e.1 Students' response to whether they had read the Objectives page	87
Figure 4.4.c.1 Response to Question 22 of the questionnaire: " <i>Do you think a Web page on 'how you could possibly manage your time on this course' would have helped you?</i> "	89
Figure 4.4.d.1 Response to Question 18 of the questionnaire: " <i>Did you, at any stage, read assignments that were not yet due?</i> "	90

List of tables

Table 1.3.1	Major research questions	4
Table 1.4.1	Group definitions from Herselman (1999)	7
Table 1.4.2	Group definitions used in this study	7
Table 1.5.1	Project research questions	8
Table 1.7.1	Current, and recently completed, research on teaching and learning via the Internet	9
Table 1.8.1	Data collection matrix for the major research questions posed in Table 1.3.1	10
Table 1.8.2	Data collection matrix for the research questions posed in Table 1.5.1	11
Table 1.9.1	Thesis outline	11
Table 2.2.e.1	Data, information and knowledge (from Davenport, 1997:9)	21
Table 2.2.f.1	Working definitions	22
Table 2.3.a.1	A model for pedagogical reasoning and action (Shulman, 1987)	24
Table 2.3.c.1	Levels of Web use in education (after Harmon & Jones, 1999)	27
Table 2.3.c.2	Factors influencing the desirability of Web use in education (after Harmon & Jones, 1999)	28
Table 3.2.1	Study skills covered in the Science Orientation course	35
Table 1.4.2	Group definitions used in this study	38
Table 3.2.c.1	SCI 152 assignments	39
Table 3.3.c.1	Factors influencing the SCI 152 course on Harmon and Jones Level 3 Web usage (after Harmon & Jones, 1999)	44
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	56
Table 4.1.a.1	The major differences between the Web-based course and the paper-based course	57
Table 4.1.a.2	The difference in examination results for the Web-based and the paper-based course	59
Table 4.1.a.3	The difference in pass rate for the Web-based and the paper-based courses	60
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	60
Table 4.1.b.1	SCI 152 assignments	62
Table 4.1.b.2	Average assignment results for the paper- and Web-based courses	63
Table 4.1.c.1	Average results for the church project for the paper- and Web-based courses	65

Table 4.2.1	Requests on http://goldilux.up.ac.za/sci152	68
Table 4.2.a.1	Time (in seconds) spent on the Objectives page in 2000	68
Table 4.2.a.2	Time (in seconds) spent on the Objectives page in 2001	68
Table 4.2.b.1	Hits on the page which discussed the PC Logo environment	70
Table 4.2.c.1	Hits on the solution pages	71
Table 4.2.d.1	Hits on the Additional Assignments page	71
Table 4.2.e.1	Hits on the Useful Information page	72
Table 4.2.f.1	Number of students accessing the SCI 152 pages during the course of the examinations	73
Table 4.3.a.1	Weighting factors used in generating Figure 4.3.a.5	79
Table 4.3.b.1	Responses used in generating Figure 4.3.b.5	83
Table 4.3.e.1	A comparison of students' views of the Web-based course between the whole class and the "honest" students	87

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.