

DECLARATION

I submit this thesis in fulfillment of the requirements for the degree of Doctor of Philosophy at the University of the Witwatersrand. I declare that, apart from the assistance acknowledged, this research is my own unaided work. I further declare that I have not submitted this thesis for any other degree or examination at any other university.

Ann Zeta George

22 August 2014

ABSTRACT

The research described in this thesis is a case study of the factors influencing teachers' use of computers for teaching at a private secondary school in South Africa. Two problems motivated the study. Firstly, teachers were not using ICT for meaningful learning despite the South African Education Department's emphasis on the use of ICT in education. Secondly, teachers were not coping with the demands of a new school curriculum involving innovative practices and new content. The case study school had purchased a software package for the sciences which claimed to be suitable for the new South African curriculum. The software package was evaluated as part of the study, to investigate its usefulness for supporting Life Sciences teachers to teach new content during a period of curriculum change. The study comprised two phases, one before and one after the school introduced an innovation promoting the use of ICT for instruction.

In the absence of a suitable model to underpin the investigation a literature-based mind-map was constructed to provide a conceptual framework to guide the study. An analysis of 48 papers reporting on the factors affecting teachers' use of computers led to the identification of 43 factors, which were classified into categories and sub-categories in the form of a hierarchical map showing the relationships between the factors, and providing the framework used to structure the investigation of factors. This was later developed into a holistic model showing the relationships between the factors, based on the theory of planned behaviour, but modified by the addition of knowledge and skills, which were found to influence teachers' computer usage directly, as well as impacting on teachers' beliefs, attitudes and behavioural intentions about using technology. This model could be useful for stakeholders to identify factors that could be used to promote the use of ICT in ways that benefit learning.

During the first phase factors were identified using participant observation recorded by means of a researcher's journal and semi-structured interviews with four teachers, with open-ended checklists being used for the software evaluation. Five categories of teacher-level factors (factors within teachers' control) were identified which affected their use of ICT: teachers' perceptions of the effectiveness of ICT; teachers' attitudes towards ICT; teachers' level of innovativeness; teachers' technological knowledge; and teachers' level of ICT proficiency. Five categories of institutional factors (beyond teachers' control) also emerged: the availability and accessibility of computer hardware; the availability of suitable software; the level of technical support available; the provision of training; and the amount of time available to plan for and use technology for teaching and learning. The biodiversity section of the software package purchased by the school was evaluated in terms of supporting teachers with teaching this new section of content required by the new curriculum. Five features of software design were evaluated: the extent to which the software promoted seven of the nine new classroom practices required by the new South African curriculum, the extent to which the package covered the content needed to teach biodiversity and the pedagogical strategies used to teach this content, how effectively the user interface conveyed messages to users, and the multimedia strategies used in the software package to promote effective learning. The software evaluation aspect of the study led to the development of several open-ended checklists to evaluate different relevant curriculum-related criteria, and a new model for the context-based evaluation of software which could be useful for designers of instructional software.

The introduction at the case study school of an innovation promoting the use of ICT for instruction allowed the study to enter a second phase extending the sample for investigating factors affecting ICT use, and focusing on teachers' use of computers in response to being provided with more ICT resources and being required to set computer-based tasks for learners to complete at home on dedicated technology days (*DigiDays*). During this phase multiple online questionnaires were administered to a sample of 29 teachers, semi-structured interviews were conducted, and 33 ICT-based tasks set by the teachers were reviewed using content analysis, to see whether they used technology effectively. The innovation allowed three obstacles which had emerged during the first phase of the study to be investigated in more depth. Firstly, the setting aside of time for computer-based work addressed the lack of time for using computers in lessons, mentioned by teachers during the first phase of the study, and permitted an investigation of whether this alleviated the time pressures teachers associated with using computers. Secondly, the effect of the training provided for using *Moodle* on *DigiDays* was investigated to see whether it adequately prepared teachers to use computers in ways which enhanced learning. A lack of training which met teachers' needs had emerged during the first phase as a major factor hindering teachers' use of computers. Thirdly, the influence of teachers' levels of innovativeness on their computer use outside of the mandated usage on *DigiDays* was investigated. Teachers were classified into groups based on Rogers' adopter categories (Rogers, 1962, 2003), but using additional features to just the rate of uptake of an innovation, used by Rogers. A quick and easy method involving a questionnaire and associated key for placing teachers into adopter categories was developed. This method could facilitate the classification of teachers into adopter categories and the tailoring of support aimed at promoting the rate of uptake of ICT, based on the characteristics of the different adopter groups.

Case studies of selected teachers were carried out to better understand why they were using computers in certain ways. Based on the model of Donnelly et al. (2011) the selected teachers were grouped according to whether they were using ICT for teaching in instructivist or constructivist ways, and whether or not they showed discerning use of ICT for teaching. A number of subgroups emerged, highlighting the need to understand the complex reasons underlying teachers' behaviours relating to using ICT and underscoring the importance of designing training programmes based on why teachers use ICT for teaching in a particular way.

DEDICATION

This work is dedicated to my family,
to my parents, Alan and Rayda Thompson (in memoriam), who nurtured the flame,
to my husband, Robin, for his love and support,
and to my children, Jason and Jessica, who carry the torch.

ACKNOWLEDGEMENTS

My heartfelt gratitude is addressed to:

- Professor Martie Sanders, for the tremendous amount of support and encouragement I received from her throughout my study. My admiration for her knows no bounds.
- The management of the case study school for allowing me to conduct my research at their institution.
- David Klein (in memoriam) for his vision.
- The teachers at the school who participated in the study.

I would like to extend special thanks to the following people:

- Dr John Fletcher, for his assistance with analysing my data.
- Daphne Parmenter, for the invaluable help she provided. I cannot count the ways.
- Sue Manubata, for always being willing to help in any way she could.
- Kaitlin George (née Hawley), for her help with checking my references (and her support in countless other ways).
- Diego Hamuy Blanco, for his help with preparing my graphs.
- My dad (Alan Thompson) for his patience when checking my manuscript.

I acknowledge the financial support from St John's College.

TABLE OF CONTENTS

	Page
Declaration.....	i
Abstract.....	ii
Dedication.....	iv
Acknowledgements.....	v
Table of contents.....	vi
List of tables.....	xiv
List of figures.....	xvi
List of appendices.....	xx
Chapter 1 Introduction to the study and its context.....	1
1.1 THE INFORMATION AND COMMUNICATION TECHNOLOGY IMPERATIVE IN EDUCATION.....	2
1.1.1 The information and communication technology revolution.....	2
1.1.2 The uses of ICT in education.....	4
1.1.3 The potential of ICT use to promote meaningful learning.....	9
1.2 CURRICULUM CHANGE MEANS NEW DEMANDS ON SOUTH AFRICAN TEACHERS.....	11
1.3 THE PROBLEMS WHICH MOTIVATED THIS RESEARCH.....	12
1.3.1 The failure of ICT to fulfil its potential to improve learning.....	12
1.3.2 South African teachers experienced problems implementing recent curriculum changes.....	15
<i>Teachers' struggled to fully implement the practices required by the new curriculum.....</i>	<i>15</i>
<i>Teachers' inability to produce their own learning support materials.....</i>	<i>16</i>
1.4 THE ROLE OF SUPPORT MATERIALS IN IMPLEMENTING CURRICULUM CHANGE.....	17
1.5 AIMS OF STUDY.....	18
1.6 RESEARCH QUESTIONS.....	19
1.7 FULFILLING THE REQUIREMENTS FOR A PHD.....	20
1.8 CONCLUDING REMARKS.....	22
Chapter 2 Conceptual framework for the study of factors affecting teachers' use of technology.....	23
2.1 THE IMPORTANCE OF USING A CONCEPTUAL FRAMEWORK.....	23
2.1.1 Benefits of using conceptual frameworks.....	23
2.1.2 Conceptual frameworks used in this study.....	24
2.2 CONCEPTUAL FRAMEWORKS FOR EDUCATIONAL TECHNOLOGY RESEARCH.....	24

2.3	DEVELOPING THE CONCEPTUAL FRAMEWORK.....	25
2.4	SUMMARY OF FACTORS AFFECTING TEACHERS' USE OF ICT.....	28
2.4.1	Institution-level factors.....	34
	<i>Finance.....</i>	<i>35</i>
	<i>Hardware-related factors.....</i>	<i>35</i>
	<i>Software-related factors.....</i>	<i>37</i>
	<i>In-service training.....</i>	<i>37</i>
	<i>Support for teachers.....</i>	<i>38</i>
	<i>Time.....</i>	<i>42</i>
2.4.2	Teacher-level factors.....	44
	<i>Teachers' beliefs about ICT.....</i>	<i>45</i>
	<i>Teachers' attitudes towards ICT.....</i>	<i>49</i>
	<i>Teachers' ICT profile.....</i>	<i>52</i>
	<i>Teaching profile.....</i>	<i>57</i>
	<i>Social proficiency.....</i>	<i>58</i>
	<i>Teacher-level factors and adopter categories.....</i>	<i>58</i>
2.4.3	Learner-level factors.....	60
	<i>Learners' ICT competence.....</i>	<i>61</i>
	<i>Learners' level of interest.....</i>	<i>61</i>
	<i>Learners' access to computer hardware at home.....</i>	<i>61</i>
2.5	CONCLUDING REMARKS FOR SECTION	61
Chapter 3	Research design and methods for investigating the factors affecting teachers' use of ICT (Phase 1).....	63
3.1	GENERAL ISSUES RELATING TO THE RESEARCH DESIGN OF THE WHOLE STUDY.....	63
3.1.1	Research design.....	63
3.1.2	Research paradigm.....	66
3.1.3	Research approach.....	70
	<i>Case studies</i>	<i>70</i>
	<i>The setting for this case study.....</i>	<i>71</i>
	<i>Sampling</i>	<i>72</i>
	<i>Type of observer participation</i>	<i>73</i>
3.2	METHODS FOR THE INVESTIGATION INTO FACTORS AFFECTING TEACHERS' USE OF ICT.....	73
3.2.1	Researcher's log.....	74
3.2.2	Interviews.....	76
	<i>Development of the interview schedule.....</i>	<i>77</i>
	<i>Procedure during the interviews</i>	<i>78</i>
3.3	CONTENT ANALYSIS OF INTERVIEWS AND RESEACHERS' LOG.....	79

3.3.1	Preliminary data analysis as data was still being collected.....	80
3.3.2	Organisation of data prior to analysis.....	80
3.3.3	Development and application of the coding system.....	80
3.4	RIGOUR.....	81
3.4.1	Improving the generalisability of the study.....	83
3.4.2	Improving the reliability of the study.....	83
3.4.3	Improving the validity of the study.....	84
3.5	ETHICAL CONSIDERATIONS FOR THE STUDY.....	87
3.6	CONCLUDING REMARKS.....	89
Chapter 4 Factors affecting teachers' use of computers in the school (Phase 1)		91
4.1	OVERVIEW OF FACTORS AFFECTING TEACHERS' USE OF COMPUTERS.....	91
4.2	EXTERNAL FACTORS AFFECTING HOW TEACHERS USE COMPUTERS.....	93
A:	Hardware-related problems.....	93
A1:	The inadequate provision of hardware by the school.....	93
A2:	Technical problems.....	97
B:	Software-related problems.....	99
B1:	Issues related to the <i>EduRom</i> package.....	99
	<i>Teachers were not consulted before the software was purchased</i>	100
	<i>Problems relating to the content</i>	101
	<i>Problems relating to the software design</i>	102
	<i>Problems arising from time needed to bookmark content</i>	104
B2:	Issues relating to the lack of suitable software.....	105
C:	Institutional factors within the school.....	106
C1:	Financial issues affecting availability of computer facilities.....	106
	<i>Lack of budget to buy computers</i>	106
	<i>Lack of budget to employ dedicated SMART Board teacher</i>	106
	<i>Financial considerations, not use, determine who gets a SMART Board in classroom</i>	106
C2:	Poor accessibility of the computer facilities.....	107
	<i>Poor accessibility of available computer facilities</i>	108
	<i>Problems with booking system for the computer lab or SMART Board room</i>	111
C3:	Lack of support from the school for teachers wanting to use computers.....	113
	<i>Support staff not available or unwilling to help</i>	113
	<i>Issues relating to ICT training</i>	114
	<i>Issues relating to poor communication</i>	115
	<i>Venues not ready for use when class arrives</i>	116
	<i>Issues relating to teachers' laptops</i>	116
	<i>Problems with the installation of the software package</i>	116
4.3	INTERNAL FACTORS AFFECTING TEACHERS' USE OF COMPUTERS.....	118

D1: The effect of teachers' ICT profile on computer use.....	118
D2: The effect of teacher beliefs on computer use.....	120
D3: The effect of teacher attitudes on computer use.....	122
<i>The effect of teacher confidence and enthusiasm for using ICT on computer use</i>	<i>123</i>
<i>The effect of teacher innovativeness on computer use</i>	<i>123</i>
4.4 TEACHERS' NEEDS.....	126
4.5 CONCLUDING REMARKS.....	127
CHAPTER 5 Evaluation of the <i>EduRom</i> multimedia software package	129
5.1 RATIONALE BEHIND THE SOFTWARE EVALUATION.....	129
5.2 DEFINING RELEVANT TERMS.....	129
5.3 WHY EDUCATIONAL MULTIMEDIA SHOULD BE EVALUATED.....	130
5.4 THEORETICAL FRAMEWORKS AND SOFTWARE EVALUATION.....	130
5.4.1 Perspectives interactions paradigm.....	131
<i>Application of the perspectives interaction framework to evaluating instructional software</i>	<i>132</i>
<i>Shortcomings of the perspectives interactions paradigm.....</i>	<i>134</i>
5.4.2 Theories of cognitive architectures for multimedia learning.....	134
<i>Theories of the architecture of the human cognitive system</i>	<i>134</i>
<i>Theories of how multimedia learning happens, based on cognitive architecture</i>	<i>136</i>
<i>Shortcomings of the cognitive theories of multimedia learning</i>	<i>139</i>
5.5 CRITERIA FOR A COMPREHENSIVE EVALUATION OF MULTIMEDIA EDUCATIONAL SOFTWARE.....	139
5.5.1 Interface design.....	139
5.5.2 Instructional design for effective pedagogy.....	140
5.5.3 Instructional design for interactive multimedia software.....	141
<i>Animation</i>	<i>141</i>
<i>Interactivity.....</i>	<i>142</i>
5.6 A MODEL FOR THE CONTEXT-BASED EVALUATION OF INTERACTIVE MULTIMEDIA.....	144
5.7 METHODS FOR THE EVALUATION OF THE EDUROM PACKAGE.....	148
5.7.1 Sampling relating to the software package.....	148
5.7.2 The features of instructional software design investigated in this study.....	150
5.7.3 The research instruments.....	151
<i>Development of the Curriculum Requirements Checklist.....</i>	<i>151</i>
<i>Developing the Content Coverage Checklist.....</i>	<i>154</i>
<i>Development of the Pedagogical Strategies Checklist.....</i>	<i>157</i>
<i>Development of the Interface Design Checklist.....</i>	<i>158</i>
<i>Development of the Multimedia Design Checklist</i>	<i>159</i>

5.8 RESULTS AND DISCUSSION.....	160
5.8.1 The extent to which the package addressed the requirements of the new curriculum.....	160
<i>Curriculum requirement 1: Education should be outcomes-based.....</i>	<i>160</i>
<i>Curriculum requirement 2: Lessons should be activity-based.....</i>	<i>161</i>
<i>Curriculum requirement 3: Learning should focus on skills development</i>	<i>164</i>
<i>Curriculum requirement 4: The curriculum content should be relevant to learners... 165</i>	<i>165</i>
<i>Curriculum requirement 5: Group work should be promoted</i>	<i>167</i>
<i>Curriculum requirement 6: Learning should be learner-centred.....</i>	<i>167</i>
<i>Curriculum requirement 7: Continuous assessment should be applied</i>	<i>168</i>
5.8.2 Appropriateness of the content coverage of the EduRom package.....	171
<i>Criterion 1: Suitability of content.....</i>	<i>171</i>
<i>Criterion 2: Language and terminology usage.....</i>	<i>184</i>
5.8.3 The use of appropriate pedagogical strategies to enhance learning.....	184
5.8.4 The interface design of the software package.....	187
Navigational features	187
<i>Use of icons</i>	<i>187</i>
<i>Mapping</i>	<i>191</i>
Screen appearance.....	192
<i>Text design/presentation</i>	<i>193</i>
<i>Screen layout.....</i>	<i>195</i>
<i>Graphics and images</i>	<i>196</i>
<i>Use of colour</i>	<i>202</i>
Media use and integration.....	203
<i>Use of animation.....</i>	<i>204</i>
<i>Media integration</i>	<i>206</i>
5.8.5 The multimedia strategies used to promote effective teaching and learning.....	209
5.9 CONCLUDING REMARKS REMARKS ABOUT THE SOFTWARE EVALUATION.....	209
Chapter 6 Methods for investigating the factors affecting teachers' use of ICT after an ICT innovation (Phase 2)	211
6.1 BACKGROUND INFORMATION ABOUT THE INNOVATION.....	211
6.2 DATA COLLECTION METHODS.....	215
6.2.1 Questionnaires.....	215
<i>Developing the questionnaires</i>	<i>216</i>
<i>Administering the questionnaires.....</i>	<i>218</i>
6.2.2 Interviews.....	218
<i>Development of the interview schedule</i>	<i>219</i>

<i>Conducting the interviews</i>	219
6.3 DEVELOPMENT AND ANALYSIS OF THE QUESTIONNAIRE ON HOW TEACHERS WERE USING COMPUTERS BEFORE AND AFTER THE INNOVATION	219
6.3.1 The number of categories and the presence of a median category.....	220
6.3.2 Naming the categories.....	220
6.3.3 Analysis of data on how teachers were using computers, before and after the innovation.....	221
<i>Analysis by task</i>	221
<i>Analysis by teacher</i>	226
6.3.4 Ranking DigiDay tasks.....	227
6.4 CHECKING VALIDITY FOR THIS PART OF THE STUDY	231
6.5 CONCLUDING REMARKS	232
Chapter 7 Factors affecting teachers' use of ICT after the innovation	233
7.1 THE CHANGES IN COMPUTER TASK USAGE	233
7.1.1 Changes in computer tasks carried out by teachers.....	233
7.1.2 Changes in tasks carried out by learners using computers.....	238
<i>Scoring the DigiDays tasks according to potential to promote meaningful learning</i>	239
<i>Analysing the potential of the DigiDay tasks to promote meaningful learning</i>	246
7.1.3 Changes in individual teacher's computer use.....	250
<i>Case studies of selected teachers</i>	251
<i>Case studies of teachers who showed no change in technology use</i>	251
<i>Case studies of teachers who showed significant change in computer use, after DigiDays</i>	255
<i>Case studies of teachers who showed non-significant change in computer use, after DigiDays</i>	270
<i>Analysing the changes in computer usage for the 13 case study teachers</i>	278
7.2 FACTORS UNDERLYING THE CHANGES IN TEACHERS' COMPUTER TASK USAGE, AFTER THE INNOVATION	283
7.2.1 Factors arising at the institutional-level.....	283
<i>Support-related factors</i>	284
<i>The ICT culture</i>	286
<i>The level of technical support available in the school</i>	287
<i>Availability of finances to supply needs</i>	289
<i>Hardware-related factors</i>	289
<i>Software-related factors</i>	292
7.2.2 Factors arising at the teacher-level.....	294
<i>Teachers' ICT competence</i>	294
<i>Teacher beliefs</i>	295
7.2.3 Factors arising at the learner-level.....	302

	<i>Learners' access to computer hardware at home</i>	<i>302</i>
	<i>Functionality of equipment.....</i>	<i>304</i>
	<i>Level of interest.....</i>	<i>304</i>
	<i>Learners' ICT competence</i>	<i>305</i>
7.3	EFFECT OF ICT TRAINING PROVIDED ON TEACHERS' USE OF TECHNOLOGY, AFTER THE INNOVATION.....	306
7.3.1	The nature of the ICT training provided.....	306
	<i>Teachers who found the training useful.....</i>	<i>307</i>
	<i>Teachers who found the training useful, but still needed help</i>	<i>307</i>
	<i>Teachers who had not found the training useful.....</i>	<i>307</i>
7.3.2	The amount of training.....	308
7.4	EFFECT OF TIME PROVIDED FOR USING ICT FOR TEACHING ON TEACHERS' USE OF TECHNOLOGY AFTER THE INNOVATION.....	309
7.4.1	Time to learn how to use ICT.....	309
	<i>Teachers did not have the time to learn how to use new programmes.....</i>	<i>310</i>
	<i>Teachers did not have the time to learn how to use Moodle.....</i>	<i>310</i>
7.4.2	Time to prepare lessons involving ICT.....	310
	<i>Using computers saves teachers time.....</i>	<i>311</i>
	<i>Using computers increases teachers' workload</i>	<i>311</i>
7.4.3	Time to use ICT in lessons.....	313
	<i>Lessons are not long enough to promote computer usage</i>	<i>313</i>
	<i>Time lost in lessons due to problems with the functionality of equipment.....</i>	<i>314</i>
7.4.4	Factors relating to time and using technology on DigiDays.....	315
	<i>What teachers were using their DigiDays for</i>	<i>316</i>
7.5	CONCLUDING REMARKS.....	317
Chapter 8	Effect of innovativeness on teachers' use of ICT.....	319
8.1	DEVELOPING A METHOD FOR CLASSIFYING TEACHERS INTO ADOPTER CATEGORIES.....	319
8.1.1	Developing a questionnaire to identify adopter categories.....	320
	<i>Defining suitable features and descriptors for grouping individuals into adopter categories</i>	<i>321</i>
	<i>Developing the questions and alternative answers</i>	<i>322</i>
	<i>Analysing the questionnaire data.....</i>	<i>323</i>
8.1.2	Developing a dichotomous key to classify teachers.....	325
8.1.3	Reworking the questionnaire.....	328
8.1.4	Concluding remarks about developing the method for classifying teachers into adopter categories.....	329
8.2	EFFECT OF LEVEL OF INNOVATIVENESS ON TEACHERS' USE OF ICT, AFTER THE INNOVATION.....	331
8.3	CONCLUDING REMARKS.....	335

Chapter 9	Summary of findings, and recommendations to promote the judicious integration of ICT.....	337
9.1	LIMITATIONS OF THE STUDY.....	337
9.1.1	Researcher subjectivity.....	337
9.1.2	The threat of “subject effects”.....	338
9.1.3	The limitations on generalisability of case study findings.....	338
9.2	SUMMARY AND INTERPRETATION OF FINDINGS.....	339
9.2.1	External factors which emerged from the study.....	339
	<i>Hardware-related factors</i>	339
	<i>Provision of in-service training</i>	340
	<i>Software-related factors</i>	340
	<i>Support-related factors</i>	341
	<i>Time needed to integrate ICT</i>	342
9.2.2	Internal factors which emerged from the study.....	343
	<i>Teachers’ beliefs about using ICT for instruction</i>	343
	<i>Attitudes towards ICT</i>	344
	<i>ICT profile</i>	345
9.3	MODELLING THE FACTORS AFFECTING TEACHERS’ USE OF COMPUTERS FOR TEACHING.....	345
9.4	RECOMMENDATIONS FROM THE STUDY.....	352
9.4.1	Recommendations to the case study school.....	353
9.4.2	Recommendations to other schools.....	355
9.4.3	Recommendations for further research.....	355
9.5	CONCLUDING REMARKS.....	356
	LIST OF REFERENCES.....	357

LIST OF TABLES

Table 1.	Some software applications used in education and their potential benefits.....	6
Table 2.	Classification of ICT usage in education, based on Ward and Parr (2010).....	8
Table 3.	Definitions of factors	30
Table 4.	Descriptions of the types of knowledge in the TPCK (now TPACK) framework (Mishra & Koehler, 2006).....	56
Table 5.	Advantages of interviews over questionnaires.....	77
Table 6.	Summary of ten standards for judging rigour in case studies (based on Marshall & Rossman, 1989) and how these have been met in this study.....	87
Table 7.	The hardware-related factors teachers said affected their use of computers in the school.....	93
Table 8.	Facilities available to teachers wanting to use computers in their lessons (Year 1 to Year 2).....	94
Table 9.	The extent of use of the computer facilities by teachers in the study.....	95
Table 10.	Issues relating to the software package.....	101
Table 11.	Administrative issues relating to accessibility of computer facilities.....	108
Table 12.	Administrative issues relating to booking the computer facilities.....	111
Table 13.	Problems I experienced relating to a lack of communication.....	115
Table 14.	Teachers' level of skills or knowledge about ICT.....	119
Table 15.	Teachers' attitudes towards using computers.....	123
Table 16.	Factors that would encourage teachers to use computers.....	127
Table 17.	The different types of outcomes and when they were implemented.....	153
Table 18.	Linkage of outcomes required by the National Curriculum Statement for life Sciences (adapted from Department of Education, 2002).....	154
Table 19.	Main topics identified in the National Curriculum Statement for biodiversity.....	156
Table 20.	Outline of the expanded content that should be included in the knowledge area Diversity, change and continuity at Grade 10 level.....	156
Table 21.	Summary of which aspects of Learning Outcome 3 are covered in the five software topics.....	161
Table 22.	Summary of the activities present in the five topics.....	162
Table 23.	Extracts from the completed <i>Curriculum Requirements Checklist</i> showing the extent to which the five software topics promote skills development.....	165

Table 24. Summary of whether learning in the five topics can be considered learner-centred (from the <i>Curriculum Requirements Checklist</i>).....	167
Table 25. Summary of the extent to which the seven curriculum requirements were met in the software.....	171
Table 26. Grammatical and spelling errors in the five software topics.....	184
Table 27. Summary of 21 icons in the five topics that do not have mouse-over labels.....	188
Table 28. Icons which have the same action in the package.....	190
Table 29. Icons used in the software that do not lead to an action.....	190
Table 30. Summary of the use of mixed media on the main screens of the five topics.....	206
Table 31. Advantages of questionnaires over interviews	216
Table 32. Summary of the questionnaires used in the preliminary stages of this study.....	217
Table 33. Criteria for scoring technology-based tasks	231
Table 34. Some <i>DigiDays</i> tasks from the first two years of the innovation.....	242
Table 35. Summary of the reasons why teachers did not find the <i>Moodle</i> training useful.....	307
Table 36. Problems with not having enough time to learn how to use ICT	310
Table 37. Teachers' perspectives on the length of time needed to prepare lessons using ICT.....	311
Table 38. Summary of problems relating to time needed to use technology during lessons.....	313
Table 39. Rogers' adopter categories and some of his descriptions (Rogers, 2003).....	320
Table 40. Adopter categories and descriptors for the questionnaire (based on Rogers, 2003).....	321
Table 41. Adopter categories of 27 teachers.....	331

LIST OF FIGURES

Figure 1. Outline of the argument to be presented in this chapter.....	1
Figure 2. Comparison of the percentage of schools with computers for teaching and learning in the nine provinces in 2002 and 2005.....	3
Figure 3. Continuum showing how teachers' technology usage changes as ICT is integrated.....	10
Figure 4. Representation of how curriculum materials can facilitate curriculum implementation, using the catalyst analogy of Ottevanger (2002)	18
Figure 5. Theoretical framework of factors and their groupings derived from 48 papers reviewed.....	29
Figure 6. Proportion of factors affecting teachers' use of computers, operating at different levels identified in the review of 48 papers.....	32
Figure 7. Relative frequencies of 14 categories of factors identified from 48 papers reviewed.....	33
Figure 8. Relative frequencies of the 43 factors affecting teachers' use of ICT as identified from 48 papers.....	33
Figure 9. Proportions of six institutional-level categories across the 48 papers reviewed.....	34
Figure 10. Twenty-one institution-level factors affecting teachers' use of ICT, identified from 48 studies reviewed.....	34
Figure 11. Support-related factors identified from 48 papers.....	39
Figure 12. Five categories of factors at the teacher level identified from 48 papers reviewed.....	44
Figure 13. Frequency of 19 teacher-level factors identified from 48 papers reviewed.....	45
Figure 14. Theory of planned behaviour (Ajzen, 1991).....	46
Figure 15. The seven factors comprising teachers' attitudes towards ICT, calculated as proportions of the 73 instances in this category.....	49
Figure 16. Categories of adopters based on innovativeness (Rogers, 2003).....	50
Figure 17. Relative frequencies of the six factors making up teachers' ICT profile, out of 83 cases.....	52
Figure 18. Diagrammatic representation showing the pedagogical knowledge and content knowledge components of pedagogical content knowledge (Mishra and Koehler, 2006).....	54
Figure 19. Diagrammatic representation showing the pedagogical knowledge, content knowledge, and technological knowledge components of technological pedagogical content knowledge (Mishra & Koehler, 2006).....	55
Figure 20. Teachers' ICT integration model (Donnelly et al., 2011).....	58
Figure 21. Proportions of learner-level factors out of a total of 23 cases, identified from 48 papers reviewed.....	60
Figure 22. Research design for the study.....	64-65
Figure 23. Sampling in this study.....	72

Figure 24. An extract from my digital log showing descriptive and reflective notes.....	75
Figure 25. A summary of the process of analysing qualitative data (based on Creswell, 2012; Marshall & Rossman, 1989; and McMillan & Schumacher, 2010).....	79
Figure 26. Concept map summarising the factors affecting how teachers use computers for teaching and learning at the school.....	92
Figure 27. Timeline showing changes in resources during the first phase of the study.....	94
Figure 28. A simplified version of the theory of planned behaviour (Ajzen 1991).....	120
Figure 29. The relationships which form the basis of the perspectives interaction paradigm (Squires and McDougall, 1994).....	131
Figure 30. A schematic representation of dual coding theory (Paivio, 1986).....	134
Figure 31. Cognitive theory of multimedia learning [Mayer (2001) based on the work of Miller (1956), Paivio (1986) and Baddeley (1986)], cited by Reed, 2006.....	138
Figure 32. A model for context-based evaluation of software	146
Figure 33. A section of the contents page of the courseware.....	149
Figure 34. The relationship between the didactics, topics and screens in the software.....	149
Figure 35. The 13 units in the software package, and topics with links to biodiversity.....	150
Figure 36. The features of instructional software design evaluated in this study.....	151
Figure 37. The substantive and syntactic components of content knowledge.....	155
Figure 38. The hierarchy of dimensions and sub-dimensions of interface design features used in this study.....	159
Figure 39. A “Remember” screen showing a read, listen and record activity.....	163
Figure 40. An example of a drag and drop classification activity.....	164
Figure 41. The Russian nesting doll graphic in Topic 3	166
Figure 42. Example of an activity report overlay for an assessment activity.....	169
Figure 43. The <i>Check what you know</i> overlay for Topic 3 showing the percentages obtained for two of the activities.....	170
Figure 44. The units and topics in the software dealing with content on biodiversity.....	172
Figure 45. The screen with content on biodiversity of plants and animals in Topic 124.....	174
Figure 46. One of the sub-screens to a “Curiosity” screen which contains important information on the value of diversity.....	174
Figure 47. Developer's answer regarding the lack of organisation of the software content in relation to the new South African curriculum.....	175
Figure 48. The screen and its sub-screens introducing the variety of living forms.....	176
Figure 49. The screen introducing the Monera and Protista kingdoms and one of its five sub-screens.....	178
Figure 50. The main screen introducing the plant kingdom, and an example of one of the 25 sub-screens to this main screen.....	179
Figure 51. One of the screens on which the need for conservation is discussed.....	181

Figure 52. The screen which deals with the need for conservation and the value of biodiversity (on four sub-screens).....	181
Figure 53. Two of the sub-screens which deal with the value of biodiversity.....	182
Figure 54. A section of a main screen showing the information users can use to orientate themselves in the software package.....	191
Figure 55. The single graphic in the software which uses flashing symbols.....	194
Figure 56. A screen with left-justified and “wrapped” text.....	195
Figure 57. A comparison of the first screen of Topic 3 and the first screen of Topic 124.....	196
Figure 58. The first part of the ecosystem graphic in Topic 124.....	197
Figure 59. The second and third parts of “ecosystem” graphic in Topic 124.....	198
Figure 60. The “energy flow” graphic in Topic 124.....	199
Figure 61. The “biome” map in Topic 124.....	200
Figure 62. The “waste production” flow chart from Topic 132.....	201
Figure 63. The only animation in the five topics	204
Figure 64. A screen showing two of the three different combinations of media in the software package.....	206
Figure 65. An example of the ‘pink area’ which replaces photographs when some audio inserts are played.....	207
Figure 66. Timeline showing events at the school relevant to the introduction of the innovation, at the beginning of the second phase of the study.....	212
Figure 67. Changes in the number of teachers carrying out different tasks on computer, after the innovation.....	234
Figure 68. Changes in the number of learner computer-based tasks, used by teachers, after the innovation.....	238
Figure 69. Potential of the DigiDay tasks to promote meaningful learning.....	246
Figure 70. Individual teachers' total computer usage, before and after the innovation.....	250
Figure 71. Increases and decreases in different computer tasks, after the innovation, for 26 teachers.....	251
Figure 72. Scattergram of 13 teachers based on how they were using ICT for teaching.....	278
Figure 73. The decision diagram which led to the idea of developing a key	325
Figure 74. An early key which used more than one feature to divide groups.....	326
Figure 75. An early key which allowed for more than one pathway to an adopter group.....	326
Figure 76. Comb-shaped (A) and fan-shaped keys (B).....	327
Figure 77. The diagrammatic form of the key.....	328
Figure 78. The verbal form of the key.....	328
Figure 79. The final version of the questionnaire for placing teachers into adopter categories.....	330
Figure 80. Percentages of teachers in adopter categories.....	333
Figure 81. A model of the factors affecting teachers use of ICT.....	346

Figure 82. A model of the external and internal factors affecting teachers' use of ICT.....	347
Figure 83. Diagrammatic representation showing the pedagogical knowledge, content knowledge, and technological knowledge components of technological pedagogical content knowledge (Mishra & Koehler, 2006).....	350
Figure 84. An approach to ICT training aimed at promoting the development of TPACK.....	351
Figure 85. Recommendations for areas which could be targeted for training based on teachers' needs.....	354

LIST OF APPENDICES

Appendices follow immediately after the list of references.

- Appendix A: Some of the major South African ICT initiatives to provide hardware, software and teacher training
- Appendix B: The requirements of the South African curriculum and the supporting reasons for these requirements
- Appendix C: Research-based evidence for teachers' failure to comply with some practices required by the new curriculum
- Appendix D: Summary of 48 studies investigating teachers' use of computers
- Appendix E: Frequency counts for factors from 48 papers reviewed
- Appendix F: Institution-level factors affecting teachers' use of ICT, summarised from 48 studies reviewed
- Appendix G: Teacher-level factors affecting teachers' use of ICT, summarised from 48 studies reviewed
- Appendix H: Learner-related factors affecting teachers' use of ICT, summarised from 48 studies reviewed
- Appendix I: Teacher interview schedule for first phase of study
- Appendix J: Ethics clearance form for first phase of study
- Appendix K: Ethics clearance form for second phase of study
- Appendix L: Permission from the school authorities to carry out the study
- Appendix M: Talk inviting teachers to participate in the second phase of the study
- Appendix N: Participant information sheet and consent form (Phase 1)
- Appendix O: Participant information sheet and consent form (Phase 2)
- Appendix P: Guidelines for evaluating interface design
- Appendix Q: Theoretical framework of pedagogical principles of good teaching practice
- Appendix R: Basic principles of multimedia learning
- Appendix S: Advanced principles of multimedia learning
- Appendix T: An example of the *Curriculum Requirements Checklist*
- Appendix U: The outcomes of the new curriculum
- Appendix V: Typology of activities that can be carried out on computer (adapted from Mashalaba & Sanders, 2003)
- Appendix W: The *Content Coverage Checklist*
- Appendix X: Terms and concepts which should be covered in the section *Diversity, change and continuity* at Grade 10 level
- Appendix Y: The *Pedagogical Strategies Checklist*
- Appendix Z: The *Interface Design Checklist*
- Appendix AA: The *Frequency Count Checklist*
- Appendix AB: Reeves and Harmon (1993): ten dimensions for evaluating instructional multimedia and how they are used for evaluating interface design in this study
- Appendix AC: The *Multimedia Design Checklist*

- Appendix AD: The completed *Curriculum Requirements Checklist* showing the extent to which the outcomes are addressed in the software package
- Appendix AE: Analysis of the types of activities used in the five topics (from the *Curriculum Requirements Checklist*)
- Appendix AF: Summary of relevance of content in the five topics (from the *Curriculum Requirements Checklist*)
- Appendix AG: Description and analysis of assessment activities in the five topics (from the *Curriculum Requirements Checklist*)
- Appendix AH: Examples of poor grammar usage in the five software topics (taken from language and terminology usage section of the *Content Coverage Checklist*)
- Appendix AI: The completed *Pedagogical Strategies Checklist*
- Appendix AJ: The section of the completed *Interface Design Checklist* dealing with text design
- Appendix AK: The completed section of the *Interface Design Checklist* dealing with the screen layout
- Appendix AL: The section of the completed *Interface Design Checklist* dealing with the use of graphics and images
- Appendix AM: The section of the completed *Interface Design Checklist* for the use of colour in the software
- Appendix AN: The *Completed Multimedia Strategies Checklist* for evaluating the use of basic multimedia principles that can be used to enhance learning
- Appendix AO: The *Completed Multimedia Strategies Checklist* for the five topics of the advanced multimedia principles that can be used to enhance learning
- Appendix AP: Questionnaire 1: *Background information*
- Appendix AQ: Questionnaire 2: *Teachers' computer use inside and outside of school*
- Appendix AR: Questionnaire 3: *Teachers' levels of innovativeness*
- Appendix AS: Questionnaire 4: *Teachers' computer use before and after the innovation*
- Appendix AT: Teacher interview schedule for second phase of study
- Appendix AU: Sign test calculations for 19 tasks
- Appendix AV: Sign test calculations for the changes in 19 tasks, for 26 teachers who showed changes
- Appendix AW: Scoring guide for lesson plans that use technology resources