

The viability of an Interactive Geographic Information System Tutor (I-GIS-T) application within the FET phase

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Education in Geography at the Potchefstroom campus of the North-West University

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*Hereby I bestow thanks to the Father, who took me up and supplied my needs.
I give thanks to Jesus Christ, the Son of God, who through His blood, exchanged my life for life eternal
and the Holy Spirit for empowering His own to discern, to watch, pray and remain steadfast in the Faith
within a troubled world that is so much in rebellion towards Him.*

PREFACE

The work described in this dissertation was carried out at the School of Education, North-West University, from January 2011 to October 2012 under the supervision of Dr CP van der Westhuizen.

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

Elfrieda Fleischmann

October 2012

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May we all continue to walk in the Light as He is in the Light.

ABSTRACT

When comparing numerous educational advantages of Geographic Information Systems (GIS) with the slow integration of GIS practice within education globally, results are confounding. This paradoxical development is also found within South Africa. In fact, GIS has been included in the Further Education and Training (FET) phase by the Department of Basic Education (DoBE) since 2006. However, following the same global trend, curriculum development in South Africa has outpaced educational GIS software research. In addition, the e-learning White paper of SA also urges software development. Barriers hindering GIS practice include the lack of suitable curriculum-aligned GIS software within the South African digital divide context. A need therefore exists for further research regarding educational GIS practice applications within South Africa.

Bearing this in mind, a case study was done investigating the viability of an educationally orientated Interactive-GIS-Tutor (I-GIS-T) application within FET phase in Geography. The study was conducted with the grade 11 Geography learners of a secondary school in a rural area of KwaZulu-Natal, as well as with their Geography teacher and two other Geography teachers of the same school. These three teachers have different ICT/GIS abilities and years of teaching experience. Furthermore, the study aimed to identify the main GIS educational barriers, globally and locally, as well as to investigate the viability of the I-GIS-T in relation to these identified barriers.

The strategy followed was a case study evaluation, with a qualitative approach to data collection and analysis, supported by quantitative data, since this was most suited to the research questions and context. Pragmatism was therefore the underpinning philosophy within this case study.

One-on-one semi-structured teacher interviews were conducted to identify the main barriers of GIS education within the FET phases. Data collection by means of questionnaires, individual interviews, focus group interviews, video recordings and field notes provided a thick description regarding the viability of the I-GIS-T within the natural class setting. ATLAS.ti™ and SPSS software were utilised with analysis of qualitative and supportive quantitative data. Attitudinal tests provided supportive quantitative data.

Findings indicated that main GIS practice barriers, globally as well as in the school of study, were the lack of preparation time, a full curriculum, lack of GIS support, complex educational GIS software and the teacher's lack of ICT skills. The grade 11 Geography teacher and most of the learners evaluated the I-GIS-T as workable. The I-GIS-T also surmounted the main GIS practice barriers. Furthermore, GIS attitudinal tests revealed an overall positive shift on all the attitudinal questions. The combination of lack of basic computer skills and language (where English is not the mother tongue) were the main reasons why some learners suggested that they struggled with the software. Future I-GIS-T development recommended incorporation of a multi-language choice component, as well as exploratory activities.

Within this case study, learners who have mastered basic computer skills found the I-GIS-T effective and workable and therefore a viable GIS software application option within the FET phase Geography. In order to be able to generalise statistically, further quantitative research is suggested. In fact, future *quantitative* research, employing SEM (Structural Equation Modeling) within the Technology Acceptance Model (TAM) might prove the I-GIS-T to be a viable option within FET schools throughout SA, as well as in other developing countries.

Keywords

Geospatial Information Systems, GIS, Viability, Education, Multimedia, Tutor, Barriers, Advantages, Attitude and Evaluation.

SAMEVATTING

Wanneer die baie opvoedkundige voordele van Geografiese Inligtingstelsels (GIS) met die stadige integrasie van GIS-praktyk binne onderwys wêreldwyd vergelyk word, is die resultate verwarrend. Hierdie paradoksale ontwikkeling kom ook in Suid-Afrika voor. GIS is in der waarheid al sedert 2006 in die Voortgesette Onderwys en Opleiding (VOO)-fase van die Departement van Basiese Onderwys (DBO) ingesluit. Kurrikulumontwikkeling in Suid-Afrika het egter, in navolging van dieselfde wêreldwye neiging, navorsing in opvoedkundige GIS-sagteware vooruitgeloop. Daarbenewens moedig die e-leer Witskrif van Suid-Afrika ook die ontwikkeling van sagteware aan. Struikelblokke wat GIS-praktyk verhinder, sluit die gebrek aan geskikte GIS-sagteware wat in lyn met die kurrikulum binne die Suid-Afrikaanse digitale gapingkonteks is, in. Daar bestaan dus 'n behoefte aan verdere navorsing met betrekking tot opvoedkundige GIS-praktyktoepassings in Suid-Afrika.

Met bogenoemde in gedagte, is 'n kwalitatiewe studie gedoen wat die lewensvatbaarheid van die toepassing van 'n onderwys-geöriënteerde Interaktiewe GIS-Tutor (I-GIS-T) binne die VOO-fase in Geografie ondersoek het. Die studie is met graad 11 Geografie-leerders van 'n sekondêre skool in 'n landelike area van KwaZulu-Natal onderneem, sowel as met hulle Geografie-onderwyser en twee ander Geografie-onderwysers van dieselfde skool. Hierdie drie onderwysers beskik oor verskillende IKT/GIS-vaardighede en jare se onderwysondervaring. Die studie het verder beoog om die hoof GIS opvoedkundige struikelblokke, wêreldwyd en plaaslik, te identifiseer, sowel as om die lewensvatbaarheid van die I-GIS-T in verhouding tot hierdie geïdentifiseerde struikelblokke te ondersoek.

Hierdie gevalle studie bevat hoofsaaklik kwalitatiewe data met ondersteunende kwantitatiewe data om die navorsingsvrae te beantwoord. Aangesien die metodologie daarop gefokus was om die navorsingsvrae so goed as moontlik te beantwoord, is pragmatisme as die ondersteunende filosofie gebruik.

Een-tot-een semi-gestruktureerde onderhoude is met onderwysers gevoer om die belangrikste struikelblokke tot GIS-onderwys binne die VOO-fases te identifiseer. Dataversameling deur middel van vraelyste, individuele onderhoude, fokusgroeponderhoude, video-opnames en veldnotas het 'n omvattende beskrywing aangaande die lewensvatbaarheid van die I-GIS-T

binne die natuurlike klasagtergrond voorsien. ATLAS.ti™ en SPSS-sagteware is gebruik met analise van kwalitatiewe en ondersteunende kwantitatiewe data. Gesindheidstoetse het ondersteunende kwantitatiewe data voorsien.

Bevindinge het die belangrikste struikelblokke in GIS-praktyk, wêreldwyd sowel as in die studierigting, aangedui as die gebrek aan tyd vir voorbereiding, 'n vol kurrikulum, gebrek aan GIS-ondersteuning, ingewikkelde GIS-sagteware en die onderwyser se gebrek aan IKT-vaardighede. Die graad 11 Geografie-onderwyser en die meeste van die leerders het die I-GIS-T as werkbaar geëvalueer. Die I-GIS-T het ook die belangrikste GIS-praktyk struikelblokke oorkom. Daarbenewens het die GIS-gesindheidstoetse met die gesindheidsvrae 'n algemene positiewe verskuiwing openbaar. Sommige leerders het die kombinasie van 'n gebrek aan basiese rekenaarvaardighede en taal (waar Engels nie die huistaal is nie) aangedui as die hoofredes waarom hulle met die sagteware sukkel. Toekomstige I-GIS-T-ontwikkeling stel inkorporasie van 'n veeltaligekeuse-komponent voor, sowel as ondersoekende aktiwiteite.

Binne hierdie gevallestudie het leerders wat basiese rekenaarvaardighede bemeester het, die I-GIS-T doeltreffend en werkbaar en derhalwe 'n lewensvatbare GIS-sagteware toepassingsopsie binne die VOO-fase Geografie gevind. Om statisties te kan veralgemeen, word verdere kwantitatiewe navorsing voorgestel. Toekomstige *kwantitatiewe* navorsing, met toepassing van SEM (Strukturele Ekwasiemodellering) binne die Tegnologie-Aanvaardingsmodel (TAM), mag inderdaad bewys die I-GIS-T is 'n lewensvatbare opsie in VOO-skole regoor SA, sowel as in ander ontwikkelende lande.

Sleutelwoorde

Georuimtelike Inligtingsisteme, GIS, Lewensvatbaarheid, Onderwys, Multimedia, Tutor, Struikelblokke, Voordele, Gesindheid en Evaluering.



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2012/07/31

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The North-West University Ethics Committee (NWU-EC) hereby approves your project as indicated below. This implies that the NWU-EC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title : The viability of an Interactive Geographic Information System Tutor (I-GIS-T) application within the FET phase															
Project Leader: PRof CP van der Westhuizen															
Ethics number:		N	W	U	-	0	0	0	6	-	1	2	-	A	2
		Institution			Project Number					Year		Status			
Status: S = Submission; R = Re-Submission; P = Provisional Authorisation; A = Authorisation															
Approval date: 2012/02/16										Expiry date: 2017/02/15					

Special conditions of the approval (if any): None

General conditions:

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- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-EC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
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Prof Amanda Lourens
(chair NWU Ethics Committee)

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LIST OF ACRONYMS

CAPS:	Curriculum Assessment Policy Statement (current assessment policy in South African schools).
CAL:	Computer Assisted Learning
DoBE:	Department of Basic Education
ESRI:	Environmental System Research Institute (developer of ArcView and ArcMap software).
FET:	Further Education and Training (grade 10-12/K10-12)
GIS:	Geographic Information System
GST:	Geospatial Thinking
HU:	Hermeneutic Unit
ICT:	Information Communication Technology
I-GIS-T:	Interactive Geographic Information System Tutor
KZN:	KwaZulu-Natal
NWU:	North-West University in South Africa
SA:	South Africa
SEM:	Structural Equation Modelling
STAT:	Spatial Thinking Ability Test
TAM:	Technology Acceptance Model
TPCK:	Technological Pedagogical Content Knowledge

LIST OF ADDENDA (find enclosed CD)

Addendum 4.1:	Letter of permission from KZN DoBE
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Addendum 4.3:	Letter to the Principal
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Addendum 4.17:	Sound file of Focus group 1 interview
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Addendum 4.19:	Learner evaluation of I-GIS-T application
Addendum 4.20:	Attitudinal pre and post test
 Addendum 5.1:	 I-GIS-T demo

CHAPTER 1

INTRODUCTION AND PROBLEM STATEMENT

1.1. BACKGROUND AND RATIONALE

The Geographic Information System (GIS), as embraced by the Curriculum and Assessment Policy Statement (CAPS) (Department of Education, 2011:7) may, if corresponding to the current global trend, be the cause of much hesitation and anxiety amongst Geography teachers. Firstly, teachers do not know how to teach GIS in a way in which learners can harvest the rich field of benefits obtained from GIS teaching as highlighted in literature (Baker, Palmer & Kerski, 2009:174; Bednarz & van der Schee, 2006:202) and secondly, teachers do not have the time to study and implement complex GIS software (Kerski, 2008:336; Milson & Earle, 2007:227). Even though learner-centred learning is the credo of the 21st century, anecdotal evidence suggests that Geography teachers tend to revert to textbook GIS in order to circumvent the barriers in GIS practice. As this paradox has found its way into the classroom, a self-paced interactive GIS plug-and-play tutor application might overcome teaching-learning barriers and prove to be a viable option.

This case study, which is the first phase within the I-GIS-T project, will explore the viability for such a GIS application within FET¹ phase Geography. This study will also serve as an indication of the feasibility of further research within the proposed I-GIS-T project.

1.2 PROBLEM STATEMENT AND MOTIVATION

Recently there has been a growing interest regarding GIS education internationally (Baker *et al.*, 2009:184). The global educational importance and usefulness of GIS is evident by the fact that GIS technology has emerged to be “one of the 25 most significant developments that transformed the life of all humanity in the 20th century” (Demirci, 2008:169), and has been listed as “one of the three most important and emerging scientific fields” (Gewin, 2004:376). This growing prominence of GIS technology reflects its usefulness in managing the complex collection, manipulation, analyses, interpretation and communication of geographical

¹ FET phase – Grade 10-12 in SA

information (Williams, 2000:45-46) in order to address global and local challenges, such as natural disasters, vanishing natural resources, or climate change (Bednarz & Bednarz, 2008a:319; Yano, 2001:173). **GIS** is defined as an

“integrated software system for the handling of geospatial information: for its acquisition, editing, storage, transformation, analysis, visualization, and indeed, virtually any task that one might want to perform with this particular information type” (National Research Council, 2006:159).

Because of this emerging importance and demand for GIS, it has begun to make its appearance in education globally.

The advantages of GIS in school education are well documented. Firstly, GIS fosters development of **higher-order thinking skills**, such as critical thinking (Fitzpatrick & Maguire, 2001:70) and problem solving (Bednarz & van der Schee, 2006:191; West, 2003:269). Furthermore, Songer (2007:35) advocates a sequential parallelism between Bloom’s taxonomy of cognitive levels of thinking and Baker’s postulated GIS process framework. On the contrary, Bloom’s taxonomy is currently much criticised by scholars (Booker, 2007:348; Krathwohl, 2002:218; Krathwohl & Anderson, 2010:64; Wineburg & Schneider, 2009:59) necessitating further research of educational GIS within this discourse. Secondly, GIS education enhances **spatial thinking abilities** (Demirci, 2011:49; Hall-Wallace & McAuliffe, 2002:5; Lee, 2005:96; Lee & Bednarz, 2009:195). Black (2005:402) highlights the need for further research on the influence that GIS has on spatial ability, as spatial ability (especially mental rotations) shows a high correlation with test scores, conceptual difficulties and misconceptions. Thirdly, GIS fosters positive **attitude and values** towards Geography (Aladağ, 2010:22; West, 2003:270). Positive values and attitudes are essential elements for optimal and self-directed learning, as intrinsic motivation and positive values and attitudes will influence the learner to willingly spend more time on a certain subject (Kerski, 2009:172). The importance of motivation is investigated in depth in the works of Maslow (1970:23) as well as within the behaviourist tradition that supports positive reinforcement (Donald, Lazarus & Lowana, 2010:96) in its tradition. However, the behaviourist tradition mainly view motivation as an externally driven process (Donald *et al.*, 2010:98). While behaviourism emphasises the external, constructivism (as in Piaget and Burner), emphasises the internal motivation (Donald *et al.*, 2010:99).

Considering these advantages that GIS has to offer Geography education, the lingering global diffusion of GIS into education remains a confounding and challenging issue. Current

implementation of the GIS resources in school education is delayed by the complexity of GIS software, inappropriateness of the materials, insufficient curriculum time and segregation of individual lessons (Liu & Zhu, 2008:18). Furthermore, GIS technology and support for pedagogic infrastructure are crucial for the successful implementation of GIS (Demirci, 2008:171). Naturally, without affordable, user-friendly, curriculum-orientated GIS software, the educator's ability to implement GIS technology in the classroom turns out to be severely restricted (Kerski, 2009:143). Efficient GIS teaching methods in classrooms are also subject to diverse physical surroundings (Demirci, 2011:57). Consequently, the challenges impeding the advancement of GIS education on a global and national level calls for urgent research. Overall, unless methodologically sound research on the educational use of GIS and its applications addresses the current research gaps, it is unlikely that GIScience² will grow and flourish in the classroom (Baker & Bednarz, 2003:233).

South Africa however, with its multi-linguistic culture, its multi-economic sectors, and its groups of both disadvantaged and highly educated people, faces many additional challenges in the pursuit of reaching the international education standard in GIS. During 2006, the Department of Basic Education (DoBE) commenced integrating GIS as a component of the Grade 10 Geography syllabus for the first time (Scheepers, 2009:40) and re-embraced GIS in the CAPS document of 2011 (Department of Education, 2011:7). Anecdotal evidence suggests the introduction of GIS in South African schools to be a challenge (Breetzke, Eksteen & Pretorius, 2011:2). The slow diffusion of GIS in the SA education system (Scheepers, 2009:40) and the lack of GIS curriculum-orientated support for Geography teachers remain a serious concern.

In response to the challenges and limitations experienced during GIS teaching and learning in the FET phase, an Interactive-GIS-Tutor (I-GIS-T) has been developed. The I-GIS-T is a USB friendly, self-paced, minimal GIS tutor application. With all the possibilities and advantages for the teacher and learner this tool possibly holds, it is essential within the South African context to test the viability of the I-GIS-T as a future GIS educational tool.

Should the I-GIS-T application in this case study prove to circumvent main GIS practise barriers, show a noteworthy development of a positive GIS attitude (in motivation), and prove to be workable, user friendly and useful in the class situation, then this application might indeed be a viable option for teaching GIS in the South African schools that do have computers.

²**GIScience**– Learning Science *through* GIS

1.3 RESEARCH AIM, OBJECTIVE AND PURPOSE OF STUDY

This case study intends to test the viability of an Interactive GIS-Tutorial (I-GIS-T) application, within a pre-selected FET school in KZN in SA. A sequential design that consists primarily of qualitative methods was applied over three parts. However, during the second part a pre- and post-questionnaire included quantitative data to support or clarify some of the qualitative data. Qualitative methods such as video recordings, open-ended questions in questionnaires, focus group interviews and semi-structured interviews were the methods of data collection. Video-recording during the I-GIS-T activity provided a more complete understanding on the workability of the I-GIS-T application that in turn served as indication of the viability of the I-GIS-T. The qualitative data explored the barriers, workability and future development of the I-GIS-T application for FET phase learners. The quantitative data during this phase provided supportive evidence regarding attitudinal development towards GIS practice within the FET phase participants after the use of the I-GIS-T application.

According to the literature, an urgent need for further research exists regarding GIS education and workable GIS interfaces in order to foster optimum learning of and through GIS (Baker & Bednarz, 2003:232). These authors specify, in particular, the need for further research regarding spatial cognition, content (declarative) knowledge acquisition, process skills, assessment, instructional models and standardised curriculum packages. This study will therefore add to the body of knowledge, serving to streamline teaching *of* and *through* GIS within SA.

It is therefore imperative, from a South African perspective, to determine whether an I-GIS-T application can effectively contribute to GIS teaching and learning and foster learner-centred learning. In order to do so, this study was guided by the following **primary research question**:

What is the viability of the I-GIS-T application as a GIS teaching-learning tool within a FET phase Geography class?

- *Viability* as defined in Webster's encyclopaedic unabridged dictionary of the English language (1996:2118) within the context of this study implies the following: usable/workable/practicable, stimulating the senses/intellect and the ability to be further developed.

In order to answer the primary research question, the following **secondary questions** needed to be addressed:

1. What are the main advantages and barriers of GIS practice in schools globally?
2. What barriers do FET phase teachers face regarding GIS practice?
3. To what extent does the I-GIS-T application influence learner attitude towards GIS within the FET phase?
4. To what extent is the I-GIS-T workable within GIS practice in the FET phase?
5. How can the I-GIS-T be further developed to enhance GIS practice within the FET phase?

Should this research confirm the I-GIS-T application to be an effective teaching learning tool for GIS in the FET phase of the selected schools in this case study, the I-GIS-T application might indeed be a viable option for the educational GIS requirements within the FET schools in SA as a whole.

The purpose of this study therefore was the following:

- To determine the main advantages and barriers of GIS practice in schools globally.
- To determine empirically the barriers FET phase Geography teachers face regarding GIS practice.
- To determine empirically to what extent the I-GIS-T application influences learner attitude towards GIS within the FET phase.
- To determine empirically to what extent the I-GIS-T is workable within GIS practice in the FET phase.
- To determine how the I-GIS-T can be further developed to enhance GIS practice within the FET phase.

1.4 RESEARCH DESIGN AND METHODOLOGY

A case study evaluation design (Yin, 2012:167) was chosen in order to bring together a detailed account of the viability of the I-GIS-T application. In addition, this case study is Phase 1 of the I-GIS-T project, piloting for further investigation that will be taken up in a PhD study.

Availability samplings of three Geography teachers and a Geography (Grade 11) FET phase class were done. Figure 1.1 depicts the research design within this study.

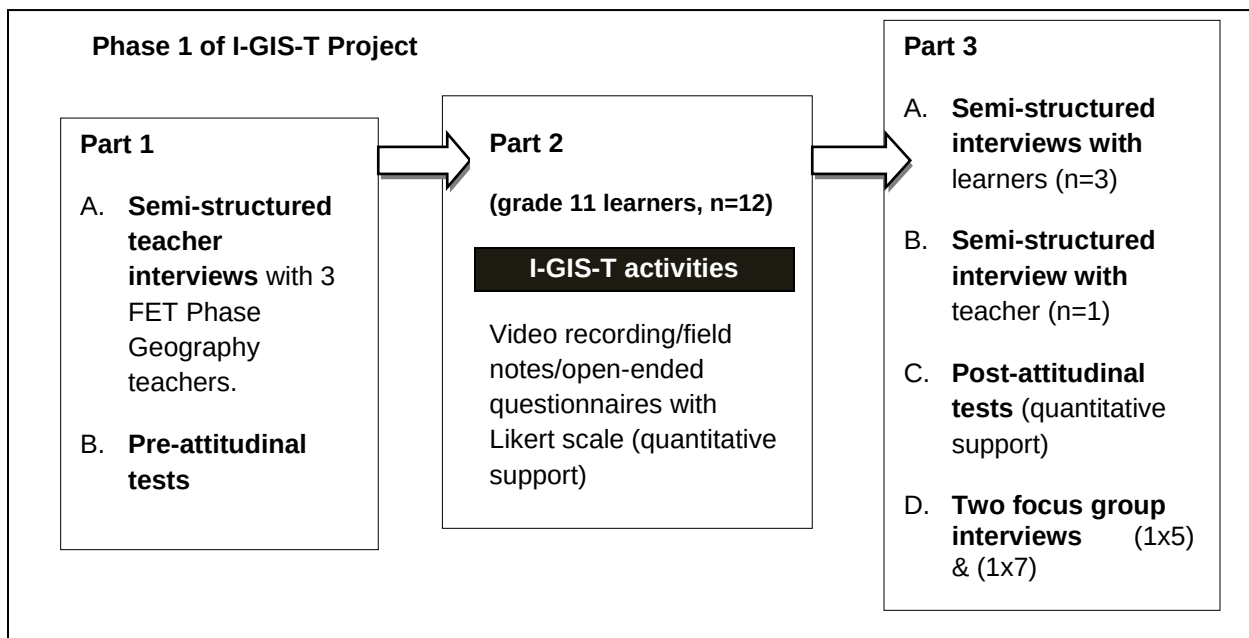


Figure 1.1 Qualitative research design (with quantitative support)

The chronological order of the study was as follows:

Part 1A included a semi-structured one-to-one interview with three FET phase teachers. These interviews were conducted in order to gain insight regarding GIS practice barriers. Interviews were recorded, transcribed and analysed. Part 1B included pre-attitudinal tests.

During part 2 the I-GIS-T learner activities were done in the school's computer lab. Video recordings, field notes and questionnaires (both quantitative and open ended) provided a thick description on the difficulties, feasibilities and workability of the I-GIS-T as well as triangulation possibilities. The open-ended questionnaires provided supportive quantitative data.

Part 3A included one-to-one semi structured interviews with three learners from different achievement groups regarding the workability of the I-GIS-T application. During part 3B a semi-structured interview with the grade 11 teacher on the feasibility of the I-GIS-T after the I-GIS-T activity was done pertaining to her grade 11 class. Part 3C consisted of the completion of post-attitudinal tests by learners. Part 3D included two focus group semi-structured learner interviews after a “wash-out period³” followed the I-GIS-T activities.

Data collection strategies, which included video recordings, field notes and the completion of open-ended questions during the I-GIS-T exercise, provided a thick description. Attitudinal pre- and post-tests provided quantitative support.

ATLAS.tiTM software was used to code and analyse qualitative data. NWU Statistical Consultation Services scrutinised and assisted with the merging of data, triangulation with quantitative data, and verification of the quality of inferences, using STATISTICA version 10, StatSoft, Inc. (2011).

1.5 CHAPTER DIVISION

The conducted research is presented according to the following chapters:

Chapter 2 aims at situating this case study within the existing understanding of GIS development and learning by means of a literature-based theoretical framework. Furthermore, this chapter attempts to answer the first section of the first secondary research question regarding the main global GIS practice advantages.

Chapter 3 attempts to answer the second section of the first secondary research question. Global GIS practice barriers, suggestions of scholars to circumvent these barriers, South African GIS teaching and learning support materials as well as the evaluation of multimedia GIS packages are discussed.

Chapter 4 documents and motivates the research design and methodology. A discussion follows on sample and site description, data collection procedure, data analysis, the role of the researcher, validity and reliability, strengths and limitations and ethical considerations.

³Wash out period: allowing of a time gap in order to alleviate over-cloudiness of multimedia on the senses

Chapter 5 describes the unfolding of the I-GIS-T evaluation within this case study, which leads to the study results. This chapter unpacks the I-GIS-T activities and describes the learners' interaction with the I-GIS-T application as well as the interviews conducted.

Chapter 6 aims to describe and interpret the results of this case study evaluation in the attempt to answer the second to fifth secondary research questions. This chapter contains the analysis of the qualitative data collected from seven one-on-one and two focus group interviews, open-ended questionnaires as well as supportive quantitative data. The main trends and patterns in the data are displayed through networks, followed by tables and discussions of findings. Finally, main results, both positive and negative, are highlighted within a conclusion.

Chapter 7 concludes this case study with a digest of knowledge claims, limitations, implications, conclusions and recommendations regarding further research. Knowledge claims are drawn from results that emerged during this study as represented and discussed in chapters 2, 3 and 6. Limitations of this study are outlined which identify research gaps, reflecting opportunities for further research.

CHAPTER 2

REVIEW OF SCHOLARSHIP

2.1 INTRODUCTION

This chapter aims at situating this case study within the existing understanding of GIS development and learning by means of a literature-based theoretical framework. Furthermore, this chapter attempts to answer the first section of the first secondary research question as posted in chapter 1 regarding the main global GIS practice advantages.

As this case study evaluation will explore the viability of the I-GIS-T application, an overview regarding the global development of GIS, GIS education and models and GIS practice advantages and multimedia learning theories will provide this literature-based framework.

2.2 KEY CONCEPTS

Key concepts used during this research (acronyms are taken up in the acronym list):

Diffusion is the “process by which an innovation is communicated through certain channels over time among the members of a social system” (Rogers, 1995:10).

Digital divide is the technological expanse between those who have access to technology and those who do not (Goldstein, 2010:33), or the “persistent division between educational institutions that are well equipped with computer hardware and software and those that are not” (Kerski, 2008:339 quoting Warschauer, 2004).

e-Education - In the South African context, the concept of e-Education revolves around the use of ICTs to accelerate the achievement of national education goals (Department of Education, 2004:14).

Geographic Information System (GIS) is defined as an “integrated software system for the handling of geospatial information: for its acquisition, editing, storage, transformation, analysis, visualisation, and indeed, virtually any task that one might want to perform with this particular information type” (National Research Council, 2006:159).

GIScience – Learning Science *through* GIS

GISystems – Learning *about* GIS

Information Communication Technology (ICT) – can be broadly classified as: hardware, software, media and services (Kennewell, 2004:5).

Innovation – is an “idea, practice, or object that is perceived as new by an individual or other unit of adoption” (Rogers, 1995:11).

Interactive – GIS – Tutorial (I-GIS-T) is an interactive multimedia GIS tutorial software package developed by NWU operating from an USB stick.

Motivation – is the process whereby goal-directed activity is instigated and sustained (Pintrich & Schunk, 2002:5).

Multimedia – the presentation of material using both words (text/spoken) and pictures (graphs, photos, maps, dynamic graphs, animation and video) (Mayer, 2001:2).

Spatial citizenship - consists of three main contributing areas of research. These areas are 1) citizenship education, 2) appropriation of space and 3) links between spatial representations, and therefore, GI and society (Gryl, Jekel & Donert, 2010:2).

Teaching *about* GIS – implies that the technology is marginal to the intellectual mainstay of Geography and therefore is taught as a technological field with an assortment of marketable skills (Kerski, 2009:63).

Teaching *through* GIS – stresses the use of GIS to teach geographic concepts. Here GIS is not seen as an end in itself, but rather a means to discover the spatial patterns of geographic phenomena (Kerski, 2009:64).

Viable – Viability, as defined in *Webster's encyclopaedic unabridged dictionary* of the English language (1996:2118), within the context of this study implies the following: usable/workable/practicable, stimulating the senses/intellect and the ability to be further developed.

Workable – Workable, as defined in *Webster's encyclopaedic unabridged dictionary* of the English language (1996:2189), within the context of this study, implies the following: practicable or feasible and capable of or suitable for being worked.

2.3 GLOBAL HISTORY OF GIS WITHIN PARADIGM TENSIONS

Paradigms and tensions are noticeable, not only when observing the developmental history of GIS but also within the software itself. This section therefore aims to describe the development of GIS within these paradigm tensions, in order to develop the argument of inclusion of both quantitative and qualitative paradigms as found within pragmatism, within the methodology of this study (chapter 4).

During the 1950s and 1960s, Geography experienced a quantitative (positivist spatial science) revolution that included spatial statistics and time-space geography marking the beginning era of computer use for modelling and data analysis (Vincent, 2004:12; Yano, 2001:173; Yu, Huynh & McGehee, 2011:191). Most authors agree that the first GIS system was designed during the 1960s, known as the Canadian GIS system (Goldstein, 2010:29; Goodchild & Janelle, 2010:2; Tate & Unwin, 2009:S1; Vincent, 2004:13; White, 2005:24). During this time, GIS began to quietly make inroads into decision making of universities (Harvard University Lab), governments and industries by including digital-spatial data sets and geographic analysis. As noted, the early GIS research and development stages culminated in 1977 at a conference organised by the Harvard Laboratory for Computer Graphics and Spatial Analysis (Goldstein, 2010:29; Vincent, 2004:13).

Moreover, GIS technology came to the fore during the 1970s and 1980s (Bian & Wang, 2008:269). The term GIS, however only gained currency within literature in the mid-**1970s** (Tate & Unwin, 2009:S1; Yu *et al.*, 2011:191). During the 1970s and 1980s, an interest grew in digital mapping (White, 2005:24) and GIS was portrayed as computer-based toolboxes (National Research Council, 2006:158). In other words, GIS was seen as a computer-based system that organises the globe's attributes into different thematic layers and, through the use of tools, examines patterns, linkages and relationships in order to analyse and solve problems (Kerski, 2008:329). It is important to take note that the epistemology and method underpinning GIS during these years were still under the patronage of positivist and empiricist versions of science.

Because GIS was not designed with either learners or learning in mind (National Research Council, 2006:164), GIS adoption in schools lagged far behind the commercial GIS explosion within business and government (Audet & Abegg, 1996:22; White, 2005:24). Meanwhile, the commercial usefulness of GIS lead to the rapid spreading of GIS to other countries such as Australia, Brazil, Japan, UK, India, and Ghana (White, 2005:25) within the early 1980s (Goldstein, 2010:29).

The 1980s was known as the decade of GIS development (Bian & Wang, 2008:269). During the early 1980s approximately ten GIS Geography courses were offered in the US and Canada (Demirci, 2008:169), and during the late 1980s demand for GIS Geography courses rapidly grew (Chen, 1997:261). The 1990s focused on visualisation and multimedia with GIS, creating a completely new area of electronic and multi-media products (Cartwright & Hunter, 2001:295; Cornelius & Heywood, 1998:35). These new developments lead to fertile ground for computer-aided learning (CAL) (Carver, Evans & Kingston, 2004:425; Cornelius & Heywood, 1998:35) providing impetus for GIS instruction during the 1980s and 1990s (Fagin & Wike, 2011:3).

GIS was endorsed during the 1990s (Bian & Wang, 2008:269). During this time there was a need for programmes designed to teach GIS in order to keep up with the rapid explosion of GIS software (Audet & Abegg, 1996:22; Goldstein, 2010:30; Vincent, 2004:2) that in turn demanded a capable GIS workforce (Chen, 1997:261; Forer, 1997:169; Wike, 1998:491). During this time GIS percolated into higher education (Fagin & Wike, 2011:3; Wike, 1998:501; Yu *et al.*, 2011:192) as many conference presentations elaborated on the prospects of GIS in schools (Chalmers, 2002:23). Moreover, developers and educators began to examine the use of multimedia during 1976 through MIT Media Lab (Cartwright & Hunter, 2001:294) and the 1980s with the ARCDemo and GIS Tutor applications (Zerger, Bishop, Escobar & Hunter, 2002:70). MapInfo launched the first desk-top GIS application in 1986 (Chalmers, 2002:23). The Environmental Systems Research Institute (ESRI), established by Jack Dangermond in 1969 (Green, 2001:5), released ArcView, a desktop-mapping GIS, during 1992 selling over 10 000 copies within six months (Chalmers, 2002:23) and established a Virtual Campus for GIS learning (<http://campus.esri.com/>) (Zerger *et al.*, 2002:70). During the 1990s, 30 - 50 commercial GIS applications launched into the market creating a “classic bubble” through enormous investments in underdeveloped products against an immature market (Raper, 2009:18). Therefore, by 2000, the available commercial GIS applications, diminished through consolidation and market failure, to less than ten (Raper, 2009:18) with mainly three GIS application retailers in the global market: ESRI, MapInfo, and Intergraph. It should be noted however, that the increasing use of Open Source GIS applications such as Q-GIS and Grass within commercial as well as academic use, resulted in a completely new direction in educational GIS development.

Within the “e-learning revolution” (Carver *et al.*, 2004:425), the World Wide Web provided a platform for on-line interactive GIS opportunities on a worldwide basis (Cartwright & Hunter, 2001:297). Although a variety of educational GIS applications were on the increase, little

attention had been paid to the cognitive concerns during the learning process of these applications (Audet & Abegg, 1996:23).

The first wave of GIS critiques came during 1990 -1994 (Leszczynski, 2009:352; Schuurman, 2000:570). Taylor (1990:211) critically analysed the GIS revolution as follows: "GIS is Geography's own little bit of the 'high-tech' revolution and has suffered accordingly with the seemingly endemic high-tech disease of mega-hype." Taylor further argued that GIS proponents based their research on a naive empiricist approach, failing to renovate GIS into GKS (Geographical Knowledge Systems) leaving "Geography intellectually sterile – high-tech trivial pursuit." In fact, Taylor labelled GIS as "positivists' revenge" (Taylor, 1990:212). The development of multimedia visualisation techniques within GIS, though, suited the presentation of qualitative spatial information and has been recognised as an influential resource of geographic information (Cartwright & Hunter, 2001:297).

During 1995, the second wave of GIS critiques manifested resistance towards positivism as the primary motive (Schuurman, 2000:580).

The third wave of criticism during 1998 was marked by a period when both critics and defenders of GIS were informed about each other's work, leading to a willingness to integrate dialogue and debate on the achievement as well as the epistemological bases of GIS (Leszczynski, 2009:350; Schuurman, 2000:585). In answer to this debate, Goodchild and others coined the term GIScience (Raper, 2009:2; Schuurman, 2000:583; Wright, Goodchild & Proctor, 1997:346) when they raised the question whether GIS is a tool or a science. More scholars added to this debate, advocating a continuum GIS as tool, through GIS as toolmaker towards GIS as a science (Summerby-Murray, 2001:38). However, some scholars highlights the fact that the underlying metaphysical tensions within GIS activities question the extent to which qualitative methods can be seamlessly hybridised with the quantitative architectures of GIS (Leszczynski, 2009:350).

The fundamental question of what GIS really is, influenced the way of thinking concerning GIS learning. Because GIS was used as a tool through which to teach sciences, GIScience, became a theoretical underpinning for GIS instruction (Kerski, 2008:330; Tate, Jarvis & Moore, 2002:87). This latter approach of GIScience does not focus on the use of GIS technologies as a tool, but focuses on the measurement, generalisation, analysis and representation of a geographic phenomenon through scientific inquiry processes (Summerby-

Murray, 2001:38). Within this time-frame - from 1990 until the early 21st century - the need for GIS curricula accordingly emerged (Yu *et al.*, 2011:193).

After 2000, spatial thinking came to the fore, emphasising the need for the development of this neglected skill (Black, 2005:402; National Research Council, 2006:4). During this time frame, web-based GIS (Bodzin & Anastasio, 2006:295; Clark, Monk & Yool, 2007:225; Songer, 2010:414), virtual globes such as Google Earth (Schultz, Kerski & Patterson, 2008:28) and 3-dimensional (3D) GIS (Schultz *et al.*, 2008:27; Sinton, 2009:S7; Yin, 2010:423) greatly increased the arsenal of geospatial tools available to the educator. By this time Foote (1997:137) already referred to the Geographer's Craft, a two-semester course introducing GIS and geographic research methods using active-learning, problem-solving technique on the web.

By 2008, GIS modules included in degree and certificate courses were obtainable at virtually every main university and technical college across the globe, as well as in hundreds of online programs (Kerski, 2008:330). While teaching *about* GIS dominated higher education during this period, GIS courses were increasingly appearing at the secondary level and informal educational programmes (Kerski, 2008:330). This paved the way for the shifting of the landscape of secondary and tertiary Geography education towards an increasing use of digital and technical aspects (Yu *et al.*, 2011:191).

During the 21st century information increased rapidly, popularizing GIS in many disciplines (Bian & Wang, 2008:269). With the availability of information, teaching approaches shifted from the knowing towards the access, use and production skills of information (Ugurlu, 2008:81).

Although many scholars, since the 1994 First National Conference on the Educational Application of Geographic Information Systems, have repeatedly identified the advantages and barriers of including GIS in classrooms (Baker & Bednarz, 2003:231), adoption of GIS applications within secondary schools has been minimal and the majority of users during this time is still in the early adopter phase (Kerski, 2003:129). Consequently, early adopters of GIS teaching describe the experience as both vastly rewarding and overwhelmingly frustrating (Sinton, 2009:S13).

2.4 EDUCATIONAL GIS PRACTICE AND MODELS

The following discussion highlights various factors influencing the implementation of technology within education, and therefore GIS educational applications.

2.4.1 The innovation adoption curve of GIS

Roger's Innovation Adoption Curve of GIS, represented and discussed below, can be used to describe the change in innovation adoption rate, with time. Developing countries lag behind in their adoption of the latest innovations of the developed world. This lag should be reduced by the benefit of research from the developed world.

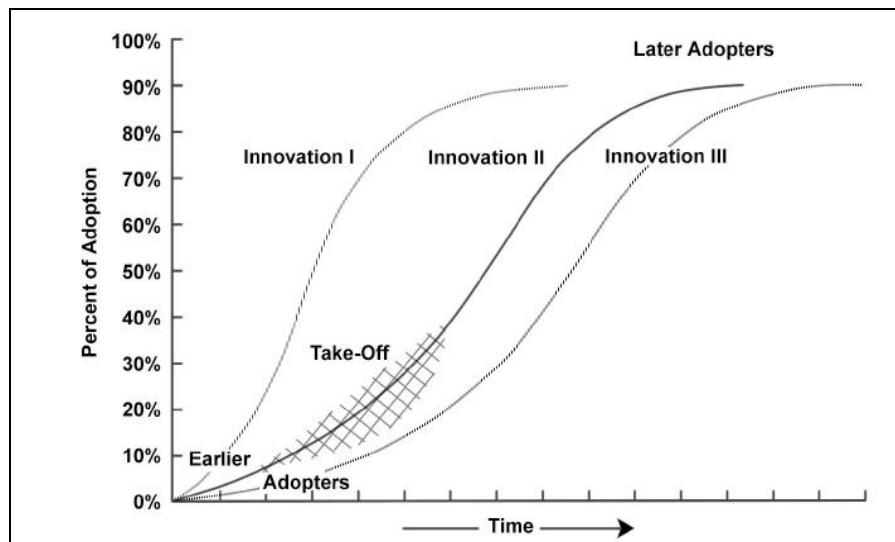


Figure 2.1 Roger's innovation adoption curve (Rogers, 1995:11; White, 2005:42)

According to Roger's innovation adoption curve (Figure 2.1), the adoption of an innovation is dependent on time. At first, only some individuals adopt the innovation, but as soon the diffusion curve begins to ascend, additional individuals cumulatively start to adopt the innovation when interpersonal networks become activated (Rogers, 1995:12). This tendency of adopters to model their closest peers, who have adopted and experienced the innovation, is essential within the diffusion process. A critical mass transpires at the point where sufficient individuals have adopted an innovation to enhance further rate of adoption in a self-sustaining way (Rogers, 1995:333).

The adoption rate may also differ depending on factors such as costs, difficulty of mastering the innovation, time constraints, etc. These different possible rates are represented by the three curves shown in Figure 2.1 (Innovations I-III). Note that the S-curved adoption rate of

innovation III is much slower than that of innovation II and innovation I. When this model is used to understand the process of adoption of GIS software, as advised Kerski (2009:181), we find that Innovation curve III applies. In other words, there is only a 5% GIS adoption rate in education (White, 2005:55).

It should be noted, however, that there is always a need for earlier adopters and research, before others can realise the need for that specific innovation. By comparison, South Africa is still trapped in the early phase of GIS adoption where GIS users are mainly municipalities, water and electricity suppliers and Environmental Management sectors (Innes, 2011:1). Therefore, GIS adoption in SA education might trail behind the dawdling international adoption rate. However, through matching the characteristics of the innovation with the educational needs within FET phase, the GIS s-curve may enhance its aligning with the s-curve of Innovation II, that represents instructional technology (White, 2005:56).

Moreover, according to Rogers (1995:15), the following characteristics of innovations, as perceived by individuals, influence their adoption rate:

- Relative advantage – extent to which the innovation is perceived superior to other innovations.
- Compatibility – extent to which innovation is perceived as consistent with needs of potential adopters.
- Complexity – extent to which an innovation is perceived as difficult in understanding and usage.
- Trial ability – extent to which an innovation may be experimented on a limited basis.
- Observability – extent to which the results of an innovation are visible to others.

Therefore, through the careful study of these characteristics within SA's unique educational context, the adoption of the I-GIS-T innovation can be predicted.

2.4.2 The technology acceptance model (TAM)

The technology acceptance model (TAM) highlights the perceived ease and usefulness of innovations/applications whilst influencing the attitude and intention to use. The technology acceptance model (TAM) as introduced by Davis in 1986, was tailored for modelling user acceptance of information systems (Davis, Bagozzo & Warshaw, 1989:985). Within the TAM, perceived usefulness and perceived ease of use are of crucial significance within computer-acceptance behaviours. Furthermore, the attitude towards the use of the application serves as an indicator towards the intentional use of the application. Consequently, as seen in Figure 2.2, TAM postulates that computer usage is determined by BI, whereas $BI = A + U$ (Davis *et al.*, 1989:985).

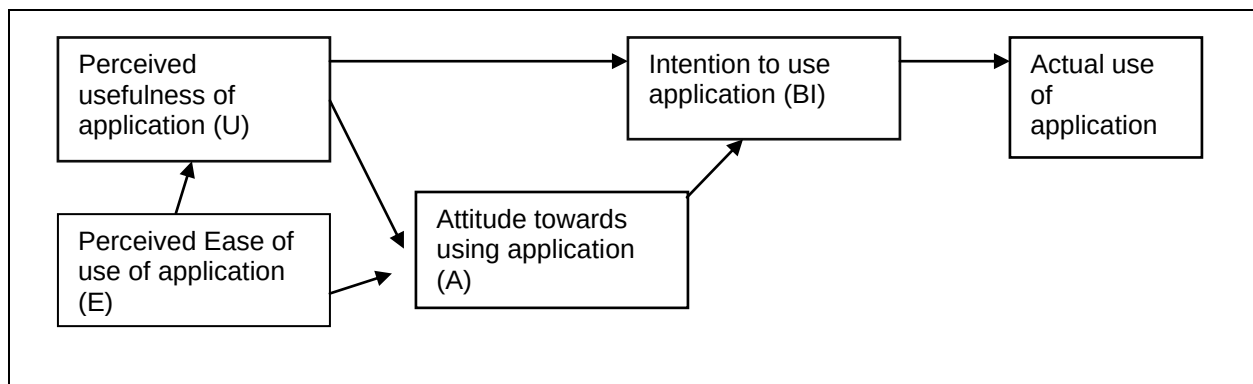


Figure 2.2 Technology acceptance model (TAM) (Davis *et al.*, 1989:985)

In this study the TAM model provides codes that may project the actual use and viability of an educational GIS software such as the I-GIS-T.

2.4.3 Model for understanding the value of Information Communication Technology (ICT) and use thereof in developing countries

As developing countries differ in their context regarding the use of ICT within education, a second model was reviewed. Figure 2.3 depicts an educational ICT model for developing countries designed by Draper (2010:208). Within this model the following components play major roles in the pedagogical use of ICT in teaching/learning: The teachers' personal vision, Technological Pedagogical Content Knowledge (TPCK), digital learning materials, and the ICT infrastructure in the school. Furthermore, Draper (2010:208) suggests that collaboration and support, and leadership also influence the pedagogical use of ICT within the classroom.

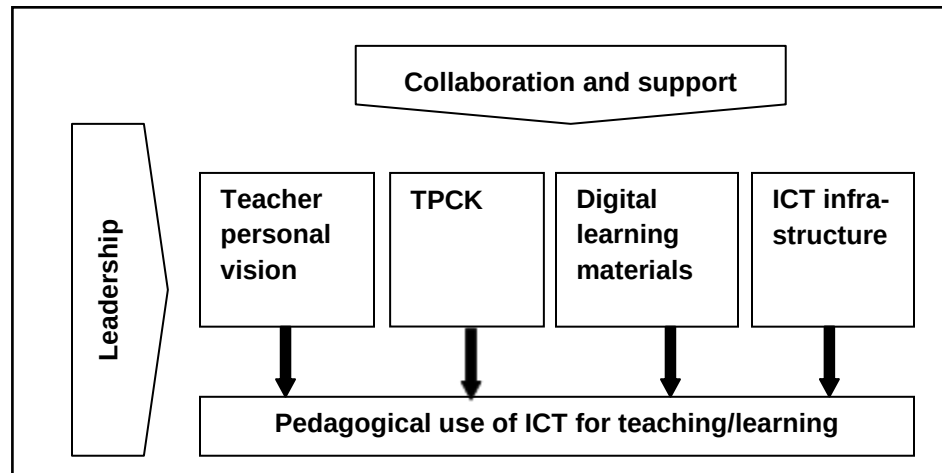


Figure 2.3 Model for understanding the value of ICT and use for developing countries
(Draper, 2010:208)

TPCK within Figure 2.3 depicts the summative qualities and complexity of teacher knowledge required to integrate ICT in teaching (Draper, 2010:57). In fact, Draper (2010:204) suggests that TPCK might be a key factor for using ICT effectively.

These factors might in fact also have an effect on educational GIS practice.

2.5 GIS EDUCATION

The National Research Council summarised GIS practice within education as follows (National Research Council, 2006:217, 233):

- The *power* of GIS lies in its ability to support scientific research processes and solve authentic problems.
- The *request* for GIS lies in the need for a GIS workforce.
- The *potential* of GIS lies in its ability to accommodate learner differences.

This section will now serve as a review regarding the advantages of GIS practice as noticed in literature globally.

2.5.1 General advantages of GIS education

A rising number of research studies and application reports allude to the potential of GIS within education (Kerski, 2009:86). In brief, GIS acts as catalyst for comprehending the world and geographic phenomena in their complexity (Kerski, 2009:318).

2.5.2. Geography's position within the school curriculum

GIS teaching boosts the overall position of Geography within a school's curriculum (Rød, Larsen & Nilsen, 2010:27; West, 2003:269; Tuna, 2012:217) and re-positions Geography in serving a renewed role within academe (Oberle, Joseph & May, 2010:490; Wheeler, Gordon-Brown, Peterson & Ward, 2010:168; Yano, 2001:173) as well as a future geospatial technology labelled *neo-geography* (Papadimitriou, 2010:73). The swift ability of GIS to dynamically re-represent the globe on a variety of themes expands the scope of topics students can explore. The miscellaneous subject themes of Geography lends itself well to various teaching techniques (Kerski, 2009:82). Obviously, the highly interactive, creative, and hands-on nature of GIS can generate powerful learning experiences over a large range of Geography themes (Baker & White, 2003:243; Broda & Baxter, 2002:49; Goldstein, 2010:30).

GIS indeed revolutionised the educational landscape infusing an "air of authenticity" to what learners can study, providing "real data" (Chun, 2008:3; Drennon, 2005:385; Goldstein, 2010:4; Hagevik, 2011:35; Henry & Semple, 2012:3), promoting multidisciplinary integration within learning (Audet & Abegg, 1996:22; Audet & Paris, 1997:300; Goodchild & Janelle, 2010:8; Henry & Semple, 2012:3; Kawabata, Thapa, Oguchi & Tsou, 2010:493; Kerski, 2009:350; Schubert & Uphues, 2009:279; Yap, Tan, Zhu & Wettasinghe, 2008:52).

The foremost aim of teaching *through* GIS education is to develop learners' geospatial skills, which improves Earth Science conceptual understanding (Black, 2005:402). For instance, Black points out that difficulties in handling mental rotation (a type of spatial ability) is associated with a number of Earth Science misconceptions and conceptual difficulties (Black, 2005:402). In order for learners to be taught *through* GIS, learners require a basic knowledge *about* GIS. A viable educational GIS application should therefore start with basic knowledge *about* GIS and then be a GIS teaching learning tool *about* Geography themes.

2.5.3 Spatial thinking skills

Spatial thinking is a form of thinking that consists of a variety of cognitive skills and involves knowledge about space, representation and reasoning (National Research Council, 2006:12). Moreover, the National Research Council has broadly identified three types of spatial thinking namely, cognition *in* space, cognition *about* space and cognition *through* or with the medium of space (Bednarz & Bednarz, 2008a:322). The main purpose of spatial thinking is description, analyses and inference in order to provide an understanding of structure (order, arrangement, relation and pattern) and function (how and why something works) in order to solve real-world problems and support decision making (National Research Council, 2006:33).

The foremost argument for including GIS into the Geography curriculum is to enhance spatial thinking skills (Bednarz, 2004:129). Although GIS educational research does suggest the development of spatial thinking abilities (Battersby, Golledge & Marsh, 2006:140; Gryl *et al.*, 2010; Hall-Wallace & McAuliffe, 2002:12; Lee & Bednarz, 2009:194; National Research Council, 2006:168,221) promoting spatial citizenship (Bednarz,2004:191, Gryl, 2010:7, Madsen & Rump, 2012:98), it was observed that scholars in fact struggle to clearly indicate that GIS does have a positive effect on the development of spatial thinking and reasoning. However, in order to explain these conflicting results, analyses do suggest “that spatial thinking is almost certainly not a single ability but comprised of a collection of different skills” (Bednarz & Lee, 2011:103).

Based on the clusters identified and analysed during this latter study, the following spatial thinking components emerged during the STAT tests: map visualisation and overlay, identification and classification of map symbols (point, line, area), generalised or abstract Boolean operations, map navigation or way-finding, and recognition of positive spatial correlation (Bednarz & Lee, 2011:103; Lee & Bednarz, 2012:24). A spatial skills taxonomy was created by Jo (2007:72) in evaluation of spatial skills within textbook questions through posing the three dimensions, namely cognitive processes, concepts and representations.

2.5.4 Attitudes, values and motivation

Learners taught *through* GIS foster positive attitudes, values (Artvinli, 2010:1286; Hall-Wallace & McAuliffe, 2002:9; West, 2003:273) and motivation (Aladağ, 2010:22; Chun, 2008:24; Kerski, 2009:277). Furthermore, scholars highlight the statement that the use of GIS in schools enhances learner’s intrinsic motivation (West, 2003:267) and *attitude* (Kaya, 2011:404) required

for optimal learning (Kerski, 2009:172). West (2003:270) suggests that the reason why GIS enhances intrinsic motivation, is firstly, that GIS increases the relevance of the geographical study and secondly, GIS enhances focal thought. Critique to the study of West is though, that it remains unclear whether it was GIS or the computer work that enhanced the attitudes of learners. However, learning within the learner's native digital language (digital natives that they are) does promote overall motivation (Artvinli, 2010:1283; Goldstein, 2010:2). On the contrary, difficult and complex GIS software do have a negative effect on learner attitude (West, 2003:272) and motivation.

2.5.5 Higher order thinking skills

A growing body of evidence suggests that GIS education fosters the development of higher-order thinking skills, such as critical thinking (Baker, 2005:48; Fitzpatrick & Maguire, 2001:70; Goldstein, 2010:30) and problem solving (Audet & Abegg, 1996:28; Drennon, 2005:385; Hall-Wallace & McAuliffe, 2002:5; Hespanha, Goodchild & Janelle, 2009:S20; Kerski, 2003:135; West, 2003:269). GIS stimulates learners to actively conduct geographic analysis, thereby minimising the passive reading of text (Broda & Baxter, 2003:49; Fitzpatrick & Maguire, 2001:62).

In addition, scholars apply Bloom's taxonomy in developing GIS applications and lessons implementing multiple levels of coding (Arleth, 2004:786; DeMers, 2009:S71; DeMers & Vincent, 2007:227; Kinzel & Wright, 2008:6; West, 2003:268). However, Bloom's taxonomy has been profoundly criticised in recent educational literature (Booker, 2007:348; Krathwohl, 2002:218; Liu, & Zhu, 2010:151; Wineburg & Schneider, 2009:57), leaving an educational research gap regarding the teaching and learning of GIS in this discourse.

2.6 MULTIMEDIA LEARNING THEORIES GUIDING I-GIS-T DEVELOPMENT

Passive learners staring vacantly at computer screens have become worrisome for many educators. Teaching *through* GIS, unlocks various pedagogic opportunities and places the educator in the position to make the paradigm shift towards a technology-rich, constructivist environment (Henry & Semple, 2012:3; Johansson, 2003:2; Kinniburgh, 2010:77; Liu & Zhu, 2008:14; Zerger *et al.*, 2002:68). In addition, Zerger and others advocate that GIS places educators in the position to

“make a paradigm shift from the didacticism of the traditional lecture hall to the technology-rich, constructivist environment partly by encouraging many local experiments in teaching practice with information rich technologies” (Zerger *et al.*, 2002:68).

Moreover, the use of multimedia within this technology-rich environment has the capacity to enhance learning.

Within Interactive Multimedia Instruction (IMI) systems, each of three main theories (cognitivist, behaviourist and constructivist) place a different emphasis on the design within educational multimedia (Kettanurak, Ramamurthy & Haseman, 2001:543).

2.6.1 Cognitivist theory of multimedia

The cognitive theory of multimedia is based on the following three assumptions:

- Dual-Channel Assumption
- Limited-Capacity Assumption
- Active-Processing Assumption

2.6.1.1 Dual-Channel Assumption (dual encoding)

Computer education research suggests that dual encoding (verbal and visual remembrance), shows significant improvements in student achievements (Alty, 2002:5; Rutherford & Lloyd, 2001:353). Figure 2.4 depicts the process of dual encoding.

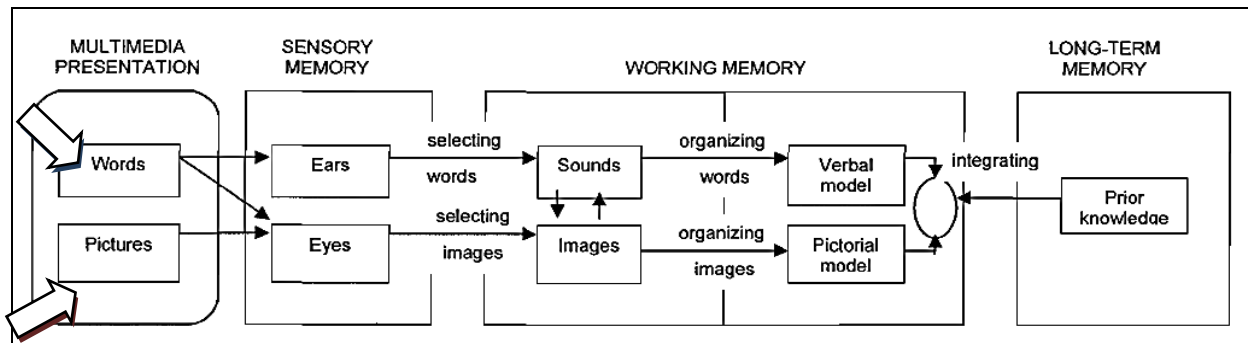


Figure 2.4 The dual-encoding cognitive theory of multimedia learning (Mayer, 2001:59)

Dual encoding (through use of GIS applications), improves learning as learners are encouraged to associate text with an iconic mode (images, graphs and maps) augmenting conceptualization and memorisation. Furthermore apart from dual coding, I-GIS-T also incorporates a third

dimension within an interactive component (Liu & Zhu, 2008:14), leading to an overall “*thrice*” *encoding* (words, pictures and doing).

These multiple representations, or levels of coding of the real world therefore enhance learning as learners explore and analyse the environment in a direct and engaging format within the Geography classroom (Broda & Baxter, 2002:158; Liu & Zhu, 2008:14).

2.6.1.2 Limited-Capacity Assumption

The second assumption is that learning is limited by the quantity of information that can be processed in each channel at a specific moment (Mayer, 2001:48). The learner is therefore only able to hold a few images in the working memory at a certain time and is therefore severely limited in the processing capacity, as seen in Figure 2.5 (Mayer, 2001:49).

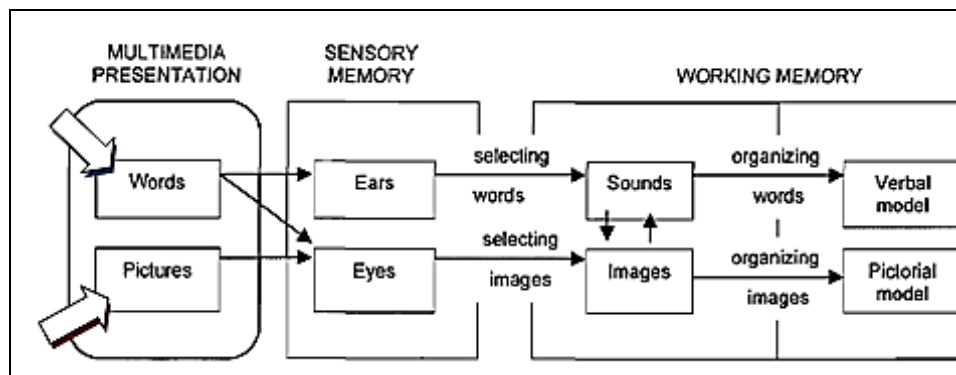


Figure 2.5 The dual-encoding cognitive theory (Mayer, 2001:59)

When visual working memory is not overloaded by animation and text processing, learners learn more deeply. Moreover, words such as printed text, compete with animation for processing resources in the visual working memory, lessening the prospect to construct understanding (Mayer & Moreno, 2002:117). However, words as spoken text do not overload the visual working memory, thus allowing for dual encoding and therefore stimulating a deeper understanding (Mayer & Moreno, 2002:117).

2.6.1.3 Active-Processing Assumption

Learners are active, cognitive processors who seek to make sense of multimedia presentations (Mayer, 2001:50). In addition, multimedia that contains a self-paced feature enhances learning (Mayer, 2003:303).

2.6.1.4 Cognitive affective model

The following model in Figure 2.6 portrays an expansion of the cognitive model (Moreno & Mayer, 2007:314).

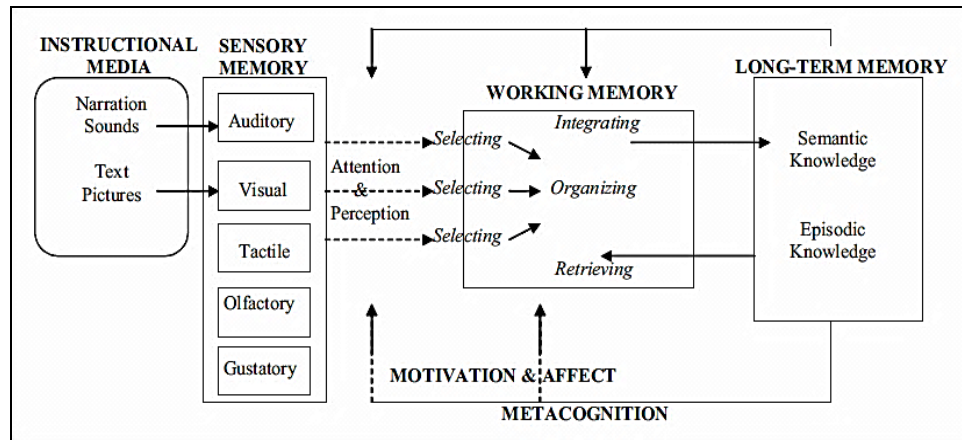


Figure 2.6 Cognitive affective model (Moreno & Mayer, 2007:314)

Within Figure 2.6 metacognition of the learner influences the motivation, which in turn influences attention and perception. The working memory supports integrating, organizing and retrieval of information. Moreover, the visualising of the rotation of an object in order to fit an opening, depends on the working memory, where both pieces are being held (National Research Council, 2006:107). Spatial thinking skills can therefore not be isolated from other cognitive skills within the working memory. Furthermore, semantic knowledge and episodic knowledge are found within the long-term memory.

2.6.1.5 Implication of the Cognitive theory on multimedia designing

In order for maximum learning to take place, the multimedia environment should engage the learner in the following five cognitive processes (Mayer, 2001:54):

- selecting relevant words for processing in verbal working memory
- selecting relevant images for processing in visual working memory
- organizing selected words into a verbal mental model
- organizing selected images into a visual mental model
- integrating verbal and visual representations as well as prior knowledge

A successful GIS educational multimedia should guide the learner to coordinate and monitor these five cognitive processes. Furthermore, scholars suggest the specific designing principles,

amongst others in Table 2.1 is the use of corresponding words and pictures as well as feedback within educational multimedia (Mayer, 2003:310; Moreno & Mayer, 2007:316).

Table 2.1 Multimedia design principles of enhanced learning (Mayer, 2003:310; Moreno & Mayer, 2007:316)

Design principles	Multimedia design explanation
Coherence	Avoid extraneous video and audio.
Contiguity	Present corresponding words and pictures at the same time.
Feedback	Quality of feedback is important. (Guidance).
Modality	Present the words in spoken form.
Multimedia	Use both words and pictures.
Pacing	Allow the learner to have control over the pace of presentation.
Personalisation	Present words in conventional style.
Signaling	Provide signaling for the narration.
Redundancy	Involving animation and narration, do not add redundant on-line text.

Within an educational GIS application, it is therefore advisable to include the above principles in Table 2.1, in order to enhance learning.

Although some researchers propose that GIS accommodates cognitivist-orientated Howard Gardner's multiple intelligence theory (Broda & Baxter, 2002:50; Fitzpatrick & Maguire, 2001:70; Goldstein, 2010:32) some scholars, due to of lack of evidence, question the authority of Gardner's theory (White, 2006:83).

2.6.2 Constructivist theory

Learning GIS through hands-on experience fits into John Dewey's model (Bednarz, 2004:193; Whyatt, Clark & Davies, 2010:235) that suggests that active, experiential learning, or learning-by-doing) is a more effective way for attaining understanding. However, reviews of empirical studies have provided a solid research-based argument against the minimal use of guidance within instruction as promoted within the constructivist theory (Kirschner, Sweller & Clark, 2006:79). For example, as most learners know how to construct a network of knowledge, there is no evidence that by providing only part of the information will enhance the constructing of a representation (Kirschner *et al.*, 2006:78). This finding implies that learning, by using multimedia, should provide a measurement of guidance within the instruction (Moreno & Mayer, 2007:316).

2.6.3 Behaviourist theory

Within the multimedia environment some computer-aided learning (CAL) programmes are based on Skinnerian teaching mechanisms (Kennewell, 2004:90). These teaching mechanisms include repetitive knowledge tests and exercises, or drills. Furthermore, behaviourist principles also include the use of small fragments of self-paced sequential exercises combined with clear feedback notices. Within such an exercise, assessments or feedback are based upon learner actions in order to reinforce correct behaviour (Kettanurak *et al.*, 2001:543). In other words, according to Skinner's view, learning is shaped by selective reinforcement within motivational and/or correctional feedback in order to enhance the likelihood of target behaviours.

The main criticism of this theory is that it fails to entirely explain the complexities of human learning (Kettanurak *et al.*, 2001:543).

2.6.4 Constructivist and behaviourism merged within interactivity

Multimedia interactive learning can be viewed in the following three ways as seen in Figure 2.7 (Kettanurak *et al.*, 2001:546):

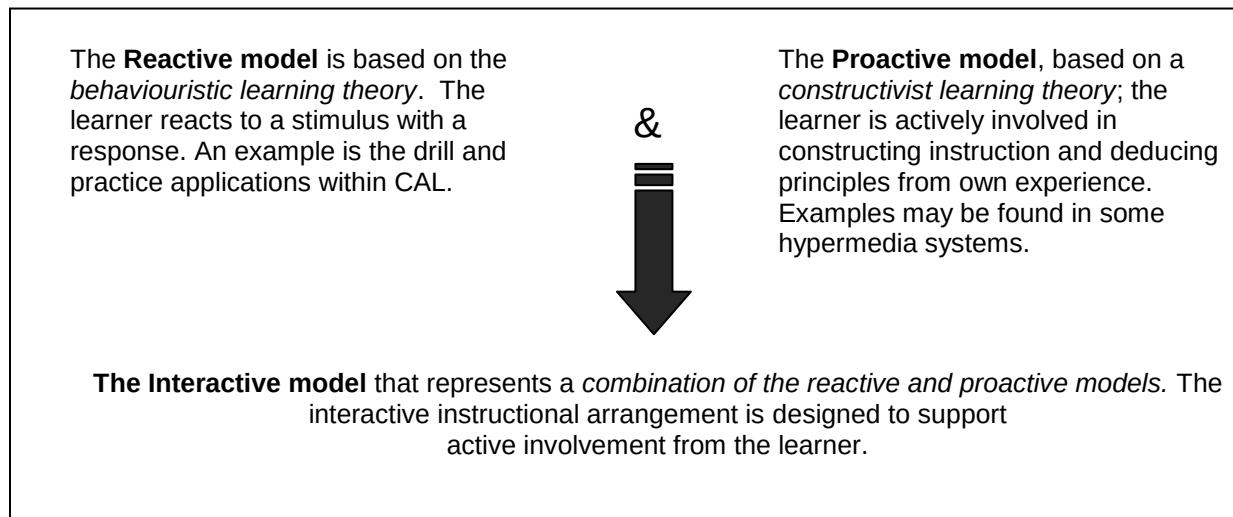


Figure 2.7 Reactive and proactive model (Kettanurak *et al.*, 2001:546)

Within Figure 2.7, it is important to note that the use of both the Reactive model (behaviouristic) and Proactive model (constructivist) are employed within the Interactive model. Consequently, active involvement from the learner further enhances the learning process. The interactive model should therefore be the most suitable learning application within the multimedia environment.

2.6.5 Various teaching learning strategies within GIS practice

The usage and demonstration of GIS also present a great pedagogical difference (Kerski, 2009:279). In other words, GIS practice unlocks various teaching learning strategies. As depicted in Table 2.2, activity-based learning and project-based learning appear to be amongst others of the most recent focus.

Table 2.2 Summary of GIS teaching learning strategies

GIS teaching learning strategies	Sources
Activity based learning	(Srivastava & Tait, 2012:527)
Experimental learning	(Bednarz, 2004:193; Whyatt <i>et al.</i> , 2010:235)
Fieldwork	(Kerski, 2008:332)
Gardner's multiple intelligence theory	(Broda & Baxter, 2002:50; Fitzpatrick & Maguire, 2001:70; Goldstein, 2010:32)
Inquiry-oriented	(Favier & Van der Schee, 2012:667; Hall-Wallace & McAuliffe, 2002:6; Liu & Zhu, 2008:13; West, 2003:269)
Learner-centered	(Aladağ, 2010:12; Beeson, 2006:277)
Participatory action research (PAR)	(Elwood, 2009:57)
Problem-based (PBL)	(Baker & White, 2003:243; Drennon, 2005:386; King, 2008:50; Kinniburgh, 2010:79; Liu <i>et al.</i> , 2010:150)
Project-based	(Baker & White, 2003:251; Barcus & Muehlenhaus, 2010:368; Bednarz, 2004:191; Chen, 1997:262; Henry & Semple, 2012:4)
Standards-based	(Baker, 2005:44)

2.6.6 GIS learning models and a research gap

However, it should be noted that the constructive approach remains valuable as constructivist approaches assume prior knowledge and research addressing the model for GIS focused learning which is still largely lacking (Zerger *et al.*, 2002:70). The lacking of educationally sound GIS methodological research regarding GIS learning models and applications is also broadly emphasised within academic literature (Bednarz & Witham, 2003:233; Zerger *et al.*, 2002:70). In addition, Kerski (2009:64) pointed out that within the growing amount of GIS literature, a consistent pedagogical framework for the teaching of or through GIS is still largely lacking.

In conclusion, the adaptation and impacts of computing technologies' latest developments on education, have been difficult to manage (Deadman, Hall, Bain & Elliot, 2000:366). Therefore, to the surprise of many, the diffusion of GIS through education has been lagging behind the use of GIS within the industry (Baker & Bednarz, 2003:231; Demirci, 2008:170; Kerski, 2003:128).

2.7 CONCLUSION

This chapter attempted to situate this case study within the existing understanding of GIS development and learning by means of a literature-based theoretical framework. This framework consisted of an overview regarding the global development of GIS, GIS education and various models such as the innovation adoption curve of Davies, the technology acceptance model (TAM) and a model for understanding the value of ICT in developing countries as well as GIS practice advantages and multimedia learning theories.

With regard to the first secondary research question posed in chapter 1, this chapter answered the first section of the first secondary question related to advantages of GIS practice.

The main advantages of GIS practice within schools globally, include:

- GIS practice is a catalyst for comprehending the world and geographic phenomena in their complexity (Kerski, 2009:318) as well as boosting Geography's position within the school curriculum (Rød *et al.*, 2010:27; West, 2003:269) while unlocking an array of teaching and learning strategies as depicted in Table 2.2.
- GIS practice develops geospatial skills, which improves Earth Science conceptual understanding (Black, 2005:402) in order to solve real-world problems and support decision-making (National Research Council, 2006:33).
- GIS practice enhances attitudes, values and motivation as required for optimal learning (Kerski, 2009:172).
- GIS practice enhances higher order thinking skills, such as critical thinking (Baker, 2005:48; Fitzpatrick & Maguire, 2001:70; Goldstein, 2010:30) and problem solving (Audet & Abegg, 1996:28; Drennon, 2005:385; Hall-Wallace & McAuliffe, 2002:5; Hespanha *et al.*, 2009:S20; Kerski, 2003:135; West, 2003:269).

These advantages of GIS practice caused great optimism globally amongst Geography teachers regarding the usefulness of GIS practice.

CHAPTER 3

GIS EDUCATION PRACTICE: GLOBAL AND LOCAL

3.1 INTRODUCTION

Teachers are, on average, optimistic regarding the potential of GIS, but globally face similar barriers that outweigh their optimism. This is evident in the fact that less than 2% of high schools in the USA employ GIS technology (Kerski, 2003:128). Within Singapore, only 10% of Geography teachers have adopted GIS in their teaching (Liu & Zhu, 2008:13).

This chapter attempts to answer the second section of the first secondary research question. GIS practice barriers, suggestions of scholars to circumvent these barriers, South African GIS teaching and learning support material and the evaluation of multimedia GIS packages are discussed.

3.2 GIS EDUCATIONAL BARRIERS: A GLOBAL PHENOMENON

Although it may seem naïve to suggest that diverse global education systems experience identical barriers of the same priority (Demirci, 2011:57), Table 3.1 does imply similarity in educational barriers regarding GIS implementation.

Table 3.1 GIS and global educational challenges

Country	Key GIS practice barriers	Sources
Australia	Lack of teacher GIS knowledge/education/training, time constraints in developing GIS-based units, accessing computer laboratories, bottom-up and top-down resistance	(Kidman & Palmer, 2006:293; Wheeler <i>et al.</i> , 2010:166)
Finland	Lack of hardware, lack of teacher training, lack of funds, lack of software, lack of time	(Johansson, 2003:3)
Hong Kong	Availability of computer lab, outdated GIS software, funds, availability of data, lack of time, lack of teacher training	(Lam <i>et al.</i> , 2009:64)
Malaysia	High price of GIS software, GIS software complexity	(Lateh & Muniandy, 2011:72)
Netherlands	Availability of GIS data and software (schools had to buy their own), lack of hardware, lack of knowledge	(Bednarz & van der Schee, 2006:193)
New Zealand	Mostly lack of time	(Chalmers, 2006:270)

Norway	Main constraint: how to teach GIS	(Rød <i>et al.</i> , 2010:34)
Singapore	Insufficient curriculum time, perceived irrelevance of the materials to meet learning objectives, complexity of GIS software	(Liu & Zhu, 2008:13; Yap <i>et al.</i> , 2008:55)
South Korea	Lack of GIS educational material, lack of in-service GIS training for teachers, lack of GIS content in curriculum, need for computers and GIS software	(Kim <i>et al.</i> , 2011:392)
Thailand	Teacher: lack of technology knowledge, high teaching load, inability to participate in workshops, budgets insufficient, limited teaching methods, lack in content knowledge and skills	(Suwanlee, 2012:30)
Turkey	Lacking sufficient hardware and software, attitudes of public, school administration and teachers	(Demirci, 2011:50)
USA	Lack of time to develop lessons incorporating GIS and complexity of software and lack in availability of hardware, little administrative support for training	(Baker, 2005:44; Baker <i>et al.</i> , 2009:181; Kerski, 2003:131; Kerski, 2009:163)

Within this table, the key GIS practice barriers as found in the USA, such as lack of time, lack of appropriate GIS software and hardware as well as little support seem to summarise the prominent barriers found globally.

Equipping (tooling up) schools for GIS teaching is indeed costly, not only regarding hard and software, but also in terms of time, acquisition of spatial data and expertise in both GIS teaching and technical maintenance (Carver *et al.*, 2004:427). In addition, in order to meet the set curriculum outcomes, teachers struggle through teaching practices (Whyatt *et al.*, 2010:235) and technical strategies (Baker *et al.*, 2009:174). In other words, pedagogical issues of GIS teaching seem to remain a prominent barrier (Bednarz, 2004:198).

The body of scholarship thus broadly differentiates between **four sets of barriers** that hamper widespread integration of GIS into geographic education (Lloyd, 2001:162; Nielsen *et al.*, 2011:61).

Firstly, **technological aspects** of integrating GIS can be overwhelming. Teachers struggle within the set time constraints to assimilate the latest GIS technology innovations (Baker, 2005:44; West, 2006:256), while low access to appropriate hardware remains a critical barrier (Breetzke *et al.*, 2011:2; Meyer *et al.*, 1999:572; Sanders *et al.*, 2002:126). In addition, numerous possible collapse points and technical diversity in school computers, networks and software, impede educational GIS development further (Baker, 2005:47). Moreover, the range of “patchwork-style computing and network systems” is often unable to handle the robust desktop GIS requirements (Baker, 2005:44). In addition, off-the-shelf GIS software (GIS

desktop), developed for example by ESRI's ArcIMS or Intergraph's WebMap, tend to require high set-up costs and lack teaching functionality (Carver *et al.*, 2004:427). Indeed, the complex nature of desktop GIS (Baker, 2005:44; Kerski, 2009:161; Liu & Zhu, 2008:12) demands extensive professional teacher development, technical preparation (Baker, 2005:47) and extra instructional time (Meyer *et al.*, 1999:572), not to mention hardware and network barriers.

Secondly, there is a **lack of curriculum-orientated materials** (Chun, 2008:2) and teacher professional development (Goldstein, 2010:6). The educator often faces a blank screen, and therefore must decide on the software and data prior to implementation (Kerski, 2008:331).

Even though a myriad of GIS educational software possibilities do exist, teachers and learners find it complex because most GIS software was not primarily developed for educational purposes (Green, 2001:43; Kerski, 2003:130; Kerski, 2009:344; Liu & Zhu, 2008:13; National Research Council, 2006:167). Highly trained and qualified GIS instructors therefore recoil at pre-built GIS media comprising of data, learner materials and assessment tools (Baker *et al.*, 2009:184). Obviously, shortages in a geo-spatially capable work force delay future development of pre-built GIS curriculum- centred educational media.

However, the fundamental focus question is not how we get GIS into the curriculum (teaching *about* GIS), but how GIS can be optimised in attaining desired learning while meeting curricular outcomes (teaching *through* GIS). This dichotomy between teaching only *about* GIS (GISystems) and teaching *through* GIS (GIScience) is stressed throughout the literature of scholars (Audet & Paris, 1997:297; Baker, 2005:48; Chun, 2008:32; Hall-Wallace & McAuliffe, 2002:5; Lloyd, 2001:158; Rød *et al.*, 2010:22; Whyatt *et al.*, 2010:236; Wright *et al.*, 1997:347).

Although learning *about* GIS is the common approach found in Geography classrooms today (Chun, 2008:32), it pilots the learner away from the actual learning of geographic concepts to a type of "*buttonology*,"⁴ while focusing on the technological skills of GIS (Barcus & Muehlenhaus, 2010:364; Marsh *et al.*, 2007:697). In contrast to rote button-pushing, critical spatial thinking implies data manipulation processes, analysis, data mining and modelling, that provoke and require critical thinking (Goodchild & Janelle, 2010:8). Moreover, learning Geography *through/with* GIS directly enhances learning of geographic concepts, skills and content. Learning *through* GIS therefore augments deeper learning, by focusing on the process of spatial

⁴ "**Buttonology**" – hitting the right button at the right time

inquiry and learning to reason spatially within spatial problem solving (Chun, 2008:32), but at the cost of covering all the curriculum topics in time (broad learning) (Kerski, 2008:332). Therefore, the important curriculum question here is whether we seek scope or insight.

It is essential, when answering this question in practice, that GIS learning follows an incremental pattern (Whyatt *et al.*, 2010:236). The basic skills and concepts need to be understood in order to master more advanced techniques and ideas.

The key challenges to teach *through* GIS are summarised as inadequate professional development and support (Kerski, 2003:129; Kerski, 2008:334), the lack of teachers' time to study complex software which is mainly designed for industrial purposes, developing GIS-based lesson plans and low availability of hardware in rural schools (Kerski, 2009:83). The integration of GIS into curricula therefore requires careful thought and planning in order to circumvent these barriers.

Thirdly, **wide-ranging systemic issues** may encourage or discourage innovation. Wheeler refers to barriers faced in Australia, such as bottom-up resistance from Geography teachers and top-down failure of support within the curriculum (Wheeler *et al.*, 2010:158).

Within the SA context, veteran Geography teachers might be ICT-phobic while facing classes filled with digital natives who expect them to teach GIS in a high-tech way. Since for many decades teachers relied upon traditional mediums and styles of teaching and although digital media and GIS arrived on the scene, teaching methods remained basically unchanged. As a result, many Geography teachers experience GIS-based exercises in a computer lab as a nightmare (Demirci, 2011:50). This bottom-up resistance of teachers to new technology can be empathically met by means of a self-paced GIS tutorial.

Additionally, West (2006:257) argues that the time-lag between student teacher GIS training and the time when those students have developed an aptitude to influence GIS implementation decisions at their schools, is clearly too great. Top-down failure of support within the curriculum leaves the GIS teacher isolated within the midst of a maze of possibilities.

Fourthly, **spatial thinking concepts** within GIS still need clarification. Although the National Research Council of the USA highlights the importance of spatial thinking, they stress the deficiency of clearly identified and described operations of spatial thinking (National Research Council, 2006:15; Schultz *et al.*, 2008:28) making geospatial thinking (GST) much of a *terra incognita* (Golledge *et al.*, 2008:86). In addition, some scholars remark that the most prominent

barrier towards implementing GST is the lack of understanding of the term 'spatial thinking'(Bednarz & Bednarz, 2008b:251). This lack in defining spatial abilities might be the main reason why some studies do not differentiate between types of spatial ability (Black, 2005:402). Overall, there are few studies seeking empirically convincing categorisation of geospatial concepts according to their complexity (Marsh *et al.*, 2007:697). Geospatial skills are under-recognised, undervalued and under-appreciated due to lack of understanding (Schultz *et al.*, 2008:28) and therefore remain the worst taught element within some curricula (Comber *et al.*, 2008:2; National Research Council, 2006:15).

In light of the gap between the potential educational advantages of GIS technology and the barriers of GIS teaching, there is a recognised call for research and better approaches for the adoption of GIS within secondary education.

3.3 SUGGESTIONS OF SCHOLARS IN GIS EDUCATIONAL RESEARCH

The spatial nature and dynamics of GIS creates an ideal multimedia environment (Zerger *et al.*, 2002:70) as dynamic spatial perceptions are difficult to demonstrate in static textbooks (Zerger *et al.*, 2002:68). Integration of GIS within hypermedia in an interactive environment, exemplifies complex authentic relationships such as spatial, cultural and economic information through graphics, text, sound, animation and video materials. Hypermedia systems, through presenting multiple facets of a problem, enable learners to analyse information in several different contexts, increasing alternative approaches and solutions to authentic problems (Seong, 1996:206).

Wheeler and others support this line of thought by suggesting the inclusion of GIS-DVD within textbooks running parallel to the learning area (subject) that will enhance teaching and learning through GIS naturally (Wheeler *et al.*, 2010:168). This proposed DVD may alleviate the main barriers to GIS teaching and learning.

Scholars suggest that if GIS were a “plug-and-play” application, more teachers would make use of it, but at the cost of functionality and flexibility (Kerski, 2003:131; Kerski, 2009:189; Rød *et al.*, 2010:33).

Baker (2005:46), on the other hand, argues that reduced technical and cartographical complexity tends to lessen the requirement for “buttonology.” Songer and others agree with Baker and advocate the use of minimal GIS to intentionally teach spatial and geography concepts in a chronological and/or hierarchical approach, and thereby lessen numerous

obstacles currently impeding successful implementation of software versions of GIS (Baker, 2005:46; Battersby *et al.*, 2006:140; Carver *et al.*, 2004:428; Hall-Wallace & McAuliffe, 2002:7; Marsh *et al.*, 2007:196; Songer, 2010:402). In other words, if the number of operations needed to complete tasks is reduced, the learning curve of the software is shortened (Kerski, 2009:57), thus adding extra time to focus on applying spatial concepts to solve problems (Henry & Semple, 2012:4). Therefore, a central research question regarding GIS adoption within the FET phase is best to minimise the learning curve of this technology in the classroom, while simultaneously emphasising the analytical power of GIS (Henry & Semple, 2012:4).

There is thus a need to develop suitable user-friendly GIS curriculum materials (Artvinli, 2010:1288; Baker *et al.*, 2009:184; Bednarz & van der Schee, 2006:194; Lam *et al.*, 2009:64; Yap *et al.*, 2008:58) capable of executing robust spatial analysis and problem solving (Kerski, 2003:135). For this reason, a growing number of researchers are critically evaluating GIS in order to plan software systems that will support learner learning (Bednarz, 2004:191).

This coincides with the finding of the National Research Council (2006:219) that argues that because GIS software is designed largely for the expert user who is willing to spend a lot of time on learning GIS software, there is a need for the rapid development of software packages that are quick and intuitive for students and teachers to use and that are developmentally and educationally appropriate for learners. Moreover, scholars suggest that there is an obvious trend and need to use pre-built GIS applications that include data, learner materials, and assessment tools (Baker *et al.*, 2009:184). The development of such GIS applications lies mainly with academia and industry; this is critical to implement any GIS supported curricula in the classroom (Baker *et al.*, 2009:184).

Baker and Bednarz (2003:233), after conducting a thorough literature review, express concern regarding the use of appropriate research practices (sample collection, hypothesis formulation, data quality, statistical analysis, reporting requirements and research ethics) within educational GIS research. Other authors follow this vein of thought by identifying research papers as *thin* with no methodological or theoretical frameworks (Doering *et al.*, 2008:217; Songer, 2010:405).

Together with these concerns, Audet (1996:22) highlights the point that mere intuition and experience are not enough to ensure good education practice through the use of ICT. On the other hand, only GIS knowledge does not ensure optimal pedagogical conduction of a GIS lesson (Yap *et al.*, 2008:59). In conclusion, it should be noted that an ideal educational GIS

application should be workable in the classroom setting, which will enhance GIS knowledge, spatial skills and attitude while supporting optimal pedagogical models.

3.4 THE SOUTH AFRICAN GIS CURRICULUM CONTEXT

The geo-information industry in South Africa has trailed behind the global trend of rapid growth. The Department of Basic Education (DoBE) has not been ignorant regarding the rapid local demand and global development of GIS (Breetzke *et al.*, 2011). The first introduction of GIS within Geography at school level was with the National Curriculum Statement (NCS) of 2005. Within this curriculum GIS was added to the Geographical Skills and Techniques section. Many educators viewed GIS as a volatile connection between paper-based map study (which has long been neglected in numerous schools) and the information technology (IT) resources that are still not accessible for teaching in the mainstream of South African high schools (Innes, 2011:5).

Although GIS diffusion through the SA education system has been slow (Scheepers, 2009:40), GIS has been reintroduced in the South African Curriculum and Assessment Policy Statement (CAPS) (Department of Education, 2011:7).

Although the CAPS reveals an inclination towards teaching *about* GIS (GISystems as loose entity) in Grade 10, there is freedom in the Grade 11 and 12 curricula for teaching and learning relevant geographic topics *through* GIS. In order to meet the CAPS requirements, the integration of GIS within the Geography curriculum themes (grade 10 and 11) is necessary. Integration of GIS within Geography themes (GI-Science) supports and augments deeper learning of geographic themes and thereby saves overall teaching and learning time.

The CAPS requirements for the FET phase (Department of Education, 2011:12) are as follows:

Grade 10 includes use of GIS, remote sensing, GIS concepts such as spatial objects, lines, points, nodes and scales.

Grade 11 includes spatially referenced data, spatial and spectral resolution, different types of data – line, point, area, attribute, raster and vector data, application of GIS to all relevant topics in the grade, capturing different types of data from existing maps, photographs, fieldwork or other records on tracing paper.

Grade 12 includes GIS concepts – remote sensing, resolution, spatial and attribute data, vector and raster data; data standardisation, data sharing and data security; data manipulation – data integration, buffering, querying and statistical analysis; application of GIS by government and the private sector; relate to all topics in Grade 12. Develop a paper GIS from existing maps, photographs or other records on layers of tracing paper.

In practice though, teachers may often recoil from textbook GIS, because they are left to their own methods of assembling of resources and development of materials for integration with the existing curriculum. Teachers may also lack information communication knowledge, time to study software (Baker, 2005; Meyer *et al.*, 1999) or time to explore an appropriate teaching-learning approach. Additionally, insignificant GIS teaching-learning time within the CAPS, as well as the absence of a GIS practical on computers during grade 12 exams (Department of Education, 2011:46), because of the digital divide in SA, do not promote GIS teaching as a high priority.

Although the digital divide within SA presents major barriers with regards to educational developments (Department of Education, 2004:9), it can also be viewed as an opportunity for academia to meet these challenges and create, through innovation, solutions such as USB-GIS (the use of a GIS application as stored on a USB stick), I-GIS (Baker, 2005; Bodzin & Anastasio, 2006; Milson & Earle, 2007) and multimedia applications (Cartwright & Hunter, 2001:295; Deadman *et al.*, 2000; Hu, 2003; Seong, 1996; Zerger *et al.*, 2002:69). In fact, the Department of Education in SA has placed emphasis on “the collection and evaluation of existing digital, multimedia material that will stimulate all South African learners to seek and manipulate information in collaborative and creative ways” (Department of Education, 2004:27).

However, even the mainstream of schools of the USA tend to lag behind the cutting edge of computing technology and struggle to realise network connectivity as found in businesses (National Research Council, 2006:200). As new GIS technologies take advantage of the latest development, the considerable gap between the computer capacity available in the typical FET phase class and the system demands of the latest generation of professional GIS widens (National Research Council, 2006:200).

Having to face these barriers begs for the development of a customised, ready-to-use, curriculum-orientated GIS educational application tool (Bednarz & van der Schee, 2006:200) that is able to bridge constraints such as low availability of hardware and user-friendly GIS software and time. The National Research Council (2006:184) supports this notion by calling for a self-contained software application that includes data, documentation and assessment materials that can be easily accessed, installed and evaluated. Educational GIS designers need to address the needs of the learners.

The I-GIS-T application places GIS directly into the hands of learners, even to use at home, making learning possible at anytime, anywhere. Although ESRI's Paper-based-GIS alleviates

some immediate educational needs in SA (Breetzke *et al.*, 2011:8), GIS needs to be experienced through real interaction with software in order to gain the full advantages of GIS. Scholars suggest that interactive communication and multimedia enhances learner engagement (Liaw, 2008:869). Moreover, higher interactivity can lead to higher learner engagement and improved learning outcome.

A key assumption of the cognitive learning model is that a learner's attention is limited and therefore selective (Liaw, 2008:869). However, the self-directed and interactive learning style of the I-GIS-T application should provide supplementary flexibility to meet the individual needs of learners (Liaw, 2008:869). Based on this, we assume that an instructional GIS teaching method that provides a greater variety of interactions and richer media should be more effective.

The need therefore exists to teach Geography *through* GIS in South Africa, without weighty outlays of time, money (Breetzke *et al.*, 2011:9) and energy in the learning *of* GIS (Lloyd, 2001:158). GIS educational policy developments have outpaced academic educational GIS literature within the South African context. Furthermore, while education policies supporting spatial competence and GIS are in place, the number of trained teachers available to teach GIS has been dwindling (Innes, 2011:12). South African case studies suggest that GIS implementation is directly linked to the curriculum, which in turn is linked to expanding local capacity (Ramasubramanian, 1999:375).

Alternative teaching methodologies must therefore be investigated. In fact, Demirci (2008:171) advocates GIS education research within developing countries.

3.5 POSSIBLE GIS TEACHING-LEARNING SUPPORT MATERIAL

GIS is envisaged as an invaluable resource extending a learner's geography through visual illustrations and manipulation of central concepts of the discipline (Breetzke *et al.*, 2011:1).

As digital technology and Internet developments have soared during this last decade, additional alternative delivery methods and instructions proliferated (Zerger *et al.*, 2002) across global educational environments. Literature reveals the tendency of teachers to rely greatly on educational GIS resource packages. This reliance is to a certain extent due to the novelty of GIS technology and time constraints involved in mastering and personalising GIS teaching material (Comber *et al.*, 2008:2; Yap *et al.*, 2008:58). In order to curtail lesson preparation time, relevant and curriculum-aligned GIS-based resource packages need to be developed.

3.6 SOUTH AFRICA: AN UNIQUE DIGITAL DIVIDE CONTEXT

Evaluations of GIS endeavours in developing countries ought to recognise the uniqueness of their various country-specific problems (Ramasubramanian, 1999:378). The contrast of inequalities that still present itself in South African schools, can be seen by the fact that in 2005 less than 10% of South African schools had access to information and communication technologies (ICT) (Scheepers, 2009:42), whereas there was a minimum of 22% computer penetration in all public schools a few years later (Isaacs, 2007:2).

Furthermore, the scarcity of computer-literate Geography teachers or the large number of teachers who have no access to computers, results in GIS teaching remaining a problematic experience (Innes, 2011:13). In addition, currently there are only a limited number of local programmes and organisations committed to the development of digital content for use in South African schools (Isaacs, 2007:17).

On the brighter side, in the White Paper on E-education, the Department of Basic Education (DoBE) committed itself to “promote the generation of new electronic content that is aligned with outcomes-based education” (Department of Education, 2004:28). The DoBE also stresses that “the research and development community must continuously assess current practices, and explore and experiment with new technologies, methodologies and techniques that are reliable and will support teachers and administrators in e-Learning and e-Administration” (Department of Education, 2004:33).

However, even in the midst of the GIS drive from within the DoBE and the curriculum, GIS implementation in developing countries is more likely to benefit from and depend on the competence of empowered individuals than from organisational structures (Ramasubramanian, 1999:379).

3.6.1 Possible GIS solutions for the South African context

Possible GIS solutions for the South African context will now be briefly discussed.

3.6.1.1 Textbook GIS

The majority of GIS textbooks follow a typical way for the introduction and discussion of core GIS content. However, the use of traditional media such as textbooks within a technologically advantaged age creates discontentment within the teaching setting (Kerski, 2009:287). In

addition, the use of printed GIS text lacks interactivity and the demonstration of dynamic spatial concepts (Zerger *et al.*, 2002:69). As GIS technology moves progressively away from automated cartography to modelling and analysis, the inflexibility of textbook GIS constrains the learner from reaching higher levels of cognitive thinking and spatial reasoning (Jo, 2007:29; Zerger *et al.*, 2002:72).

3.6.1.2 Paper GIS

A paper-based GIS initiative, managed by ESRI South Africa (Pty) Ltd and supported by the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (UP) (Breetzke *et al.*, 2011:2) envisages the introduction of GIS in resource-poor schools in South Africa. According to this study, resource-poor schools included those that did not have electricity and/or computers available to learners. The paper-based GIS package contained a 1:50,000 topographic map, a 1:10,000 orthophotograph, tracing paper, a ruler, colour crayons, adhesive, an exercise book for learners, and a handbook for educators packed into a sealed A3 cardboard box, sold to schools. In terms of content, the handbook consists of seven practical lessons as well as an additional lesson on the method used in GIS. Approximately 93% of learners gave positive feedback during this study on the exercises (Breetzke *et al.*, 2011:8).

Battersby *et al.* (2006:251) concluded that when learners used collaborative GIS to support their investigations, positive and significant improvements were noted in science self-efficacy and technology attitudes, compared to students who used paper maps. While paper maps focus the learner's attention on the "where", GIS quickly move the learners' attention from the "where" to the "why".

Although, Paper-Based-GIS seems to be successful in resource-poor schools, the complete power of GIS will only be noticeable to learners who can experience the real thing (National Research Council, 2006:205). In addition, there are schools that have electricity and computers available to learners, but overall they still struggle with the implementation of GIS applications.

3.6.1.3 ArcView 3.3

ESRI's ArcView (ArcView 3.x, 2005) has made software available at heavily discounted educational prices (Chalmers, 2006:268). Although ArcView 3 has the ability to project, readily, decimal degree vector data, it cannot project raster data (National Research Council, 2006:223).

3.6.1.4 Web-based GIS

During the last decade, the proliferation of the Internet has influenced the educational environment greatly (Zerger *et al.*, 2002:69). Expanding access to learning materials eased findings of authentic educational material while the relatively flat learning curve of Web-based GIS reduced software cost, and the capacity to support constructivist-learning techniques which are the principal benefits (Henry & Semple, 2012:4). Songer (2010:403) agrees with Rød *et al.* (2010:32) that the learning curve is less steep with Web-based GIS as learners focus on geospatial thinking rather than learning how to use GIS software. Though Web-based GIS, extras and unused complexities of desktop GIS are minimised, it attenuated the ease of learning and use of software (Baker, 2005:46; Carver *et al.*, 2004:428). Furthermore, Web-based GIS applications are exceedingly versatile (Clark *et al.*, 2007:238), providing varying levels of user interaction, from viewing map layers to creating them (Songer, 2010:403). Browser-based GIS is therefore ideal for the mainstream classroom (Baker, 2005:46; Rød *et al.*, 2010:25).

An example of web-based GIS is virtual globes such as Google Earth (Schultz *et al.*, 2008:28) that became a popular gateway for information visualisation (Goodchild & Janelle, 2010:3). Virtual globes are 3D globes, generated by software and spatial data that is streamed, to create the “on the fly” effect through the use of satellite imagery, aerial photographs, elevation data together with points, lines and polygonal data (Schultz *et al.*, 2008:28). Google Earth, released during 2005 (Hagevik, 2011:34), stimulates and motivates learners to use geospatial technology outside the class as well (Doering & Veletsianos, 2007:223).

However, as the file sizes of these data sets are large, a fast broadband connection is essential (National Research Council, 2006:171). In addition, streaming data from web-based GIS is often slow and unreliable (Baker *et al.*, 2009:178; Songer, 2007:132). Internet-based mapping within a SA context will therefore not meet the analytical needs of every FET-phase classroom, but has immense potential for introducing every classroom, now and in the future, to learn Geography *through* GIS while supporting meaningful, authentic learning. It should be noted that as schools’ bandwidths and accessibility of the Internet (Clark *et al.*, 2007:237) and computer availability in future increase, the use of GIS Web sites may also expand. In the meantime Web-based technologies and Internet-based GIS do have the further potential to stimulate geographic and GIS awareness across higher education in SA (Baker, 2005:49).

3.6.2 Evaluation of educative multimedia GIS packages

Although multimedia has the benefit of being flexible, appealing and available to today's technology-savvy learners (Kinzel & Wright, 2008:6), evaluation of GIS multimedia packages needs close attention. As the richness of the multimedia environment may overcloud the evaluation of GIS applications, an effective evaluation procedure is needed (Cartwright & Hunter, 2001:301). Cartwright and Hunter (2001:302) argue that the operation of the package, as well as "intrinsic merit of content" and the interactions undertaken to "discover" information, need to be evaluated.

However, the practical problems of integrating GIS into the FET phase context are equally prominent and also need to be addressed. Furthermore, Cartwright and Hunter (2001:293) stress that experimental development of GIS applications unaccompanied with proper evaluation of effectiveness, creates numerous "initiatives" and "prototypes" devoid of proper validation and improvement efforts. In addition, scholars argue that much time is spent in the development of software, without rigorous evaluation of product effectiveness (Cartwright & Hunter, 2001:294). The overwhelming sights, sounds, colours and motion of new GIS initiatives may overpower sound judgement of the underlying content (Cartwright & Hunter, 2001:293).

3.7 CONCLUSION

In short, educational GIS practice has significant potential but faces various practice barriers. GIS practice barriers are broadly differentiated by the body of scholars into four sets of barriers, namely technological aspects, complex GIS software and lack of curriculum-orientated materials, wide ranging systemic issues and lack of understanding spatial thinking concepts (Lloyd, 2001:162; Nielsen *et al.*, 2011:61). With regard to the secondary research questions posted in chapter 1, this chapter answered the second section of the first secondary question related to barriers of GIS practice.

In fact, the aim of this study is to investigate the viability of the I-GIS-Tutor, *against GIS practice barriers* in a FET-phase school in South Africa. It is with these views about GIS practice barriers, the various educational GIS applications and recommendations for future research and developments, that we now approach the research of this study.

CHAPTER 4

METHODOLOGY

4.1 CHAPTER OVERVIEW

Methodology is the research strategy that describes how, why and what the researcher selects, collects and analyses in order to investigate a specific research problem (McMillan & Schumacher, 2010:8). In fact, the methodology of a case study is imperative as numerous case studies have fallen short as a result of methodological failure (Yin, 2012:6). This chapter therefore describes and motivates research activities carried out throughout the duration of this evaluative case study.

The methodology employed during this study is discussed under the following headings:

- Literature review
- Aim of the empirical investigation
- Rationale for qualitative approach
- Research design
 - A research design to fit the research question
 - Sample and site description
 - Data-collection procedure
 - Data analysis
 - Qualitative analysis
 - Supportive quantitative analysis
- Researchers role
- Validity and reliability
- Strengths and limitations
- Ethical considerations
- Conclusion

4.2 THE LITERATURE REVIEW

An extensive literature study that focused on most recent and relevant GIS educational literature was undertaken. This literature study was conducted in Google Scholar, checking for citations, in order to focus on the mainline arguments, debates and research of most prominent authors. These prominent authors and citations were traced through Web of Science (ISI) while checking the impact factor of the journal and further current developments in mainline arguments and debates. At least two key journals in Geography education were identified and content alerts set up. Citation alerts on the most relevant articles were also set up to keep pace with the latest developments. The focus during this research was as follows: current educational GIS applications, GIS pedagogy, global educational GIS practice advantages and barriers, as well as the influence of GIS on learner attitudes.

This literature review serves as answer to the first secondary research question regarding the advantages and barriers of GIS practice globally. The first secondary research question was therefore answered in chapters 2 and 3.

4.3 AIM OF THE EMPIRICAL INVESTIGATION

As the aim of this study is to investigate and evaluate the viability of the I-GIS-T within its natural setting, in this case a grade 11 class, a case study evaluation design was chosen. Case study evaluations fill a unique niche as an evaluation tool for the I-GIS-T application (Yin, 2012:167). Therefore, this study determines the extent to which the I-GIS-T application is able to surmount barriers of GIS teaching and learning within FET phase Geography. Furthermore, this study investigates whether the I-GIS-T assists FET phase learners, more specifically grade 11 learners, towards autonomous learning (working independently, on their own and with success) and to what extent this application will enhance students' attitudes toward GIS within Geography. Attitude is a pivotal element for technology acceptance as shown in the Technology Acceptance Model (TAM), already discussed in section 2.4.2. Finally, this study also investigates if the I-GIS-T project eases GIS practice for both learner and the teacher within the FET phase.

In the pursuit of the above, the need for a case study developed in order to understand the complex interaction and influences between the teacher, learners, GIS practice barriers and the I-GIST practice (Yin, 1994:3).

4.4 EPISTEMOLOGY AND ONTOLOGY

As epistemology influences the theoretical approach to research design, it is important to reflect the epistemological view of John Dewey connected to the pragmatic paradigm in contrast to views of the researcher. Moreover, Dewey's status as an influential humanist educator in modern public schools in America, calls for a deeper investigation into his atheistic epistemological views. The view of the researcher is that science does not threaten a theocentric approach, but rather that science supports the notion that God exists. For example, scientific theories such as the Second Law of Thermodynamics, the impossibility of spontaneous generation of life from non-life, genetic information theory (DNA), and the Anthropic Principle support this notion (Noebel, 1996:85). Therefore, the researcher regarded Christian realism (Noebel, 1996:87) as the relevant epistemology within this study.

The researcher noticed that GIS development and research discussed in chapter 2 highlight philosophical tensions, such as experienced in human sciences, which have drawn debates over the years. Indeed, GIS as information system, contains tension in itself as both qualitative and quantitative data are stored within. With this underlying tension in mind and in order to gain insight into the viability of the I-GIS-T application, pragmatism was employed (Creswell, 2009:10), whilst adopting a stance leaning towards realism as far as ontology and epistemology are concerned. Although this chosen research design was not a watertight design found within qualitative research, this proposed design does fit the view that the focus should be on the research question and the appropriateness of the research design to clarify the research purpose (De Vos *et al.*, 2011:323) which is influenced by pragmatism, even though pragmatism is mostly familiar within mixed methodology research (Maree, 2010:265). The argument for using pragmatism is that this qualitative design is supported by quantitative elements. The focus of this study is to employ the best methods to answer the research question.

This case study, therefore, adheres to the use of pragmatism, moving possibly within a post-paradigmatic moment where there is reasoned acknowledgement that case studies and statistical methods are indeed not in conflict but rather are complementary (Flyvbjerg, 2011:313).

4.5 RESEARCH DESIGN

Research designs are rarely purely qualitative or quantitative design, but lie within a continuum from quantitative to qualitative research (Creswell, 2008:46). Within this continuum, this case study evaluation consists mainly of qualitative evidence supported with quantitative data in order to answer the research question the best. This notion is also found within case study evaluations. Moreover, practically all case study evaluations begin with a set of evaluation questions regardless of the methodology used (Yin, 2012:171).

4.5.1 A research design to fit the research question

The action plan of this research is disclosed through the research question: To evaluate the viability of the I-GIS-T within the FET phase.

The best fit to answer the research question is that of a case study evaluation, as “the case study method fills a distinctive niche as an evaluation tool” (Yin, 2012:167). As a result of reaching the aim of this study, the focus of this case study evaluation will first of all be to identify the GIS teaching and learning barriers within the FET phase and evaluating the I-GIS-T application against these, investigate the development of attitude regarding GIS, then investigating the workability of this application within a class context and finally to make future GIS development recommendations. This case study evaluation design is therefore being used as an approach to evaluate the viability and ‘worthiness’ of the I-GIS-T (Rule & John, 2011:11).

As scholars confirm that the term case study has quite a few meanings, it was obligatory to define the term within the context of this study (Babby, 2011:301; Hesse-Biber & Leavy, 2011:255; Maree, 2010:75).

The case study investigated in this research, is a strategy of inquiry in order to gain in-depth insight through exploring the workability of the I-GIS-T activities against the backdrop of GIS practice barriers. Secondly, this case study increases insight and understanding regarding the dynamics of I-GIS-T practice (Leedy & Ormrod, 2010:137; Maree, 2010:76; Yin, 2012), while focusing on holistic description and explanation of GIS practice (Hesse-Biber & Leavy, 2011:256; Merriam, 2009:43).

A case study is bounded by time and activity (Creswell, 2009:13). Being bounded suggests being distinctive with regard to place, time and participant characteristics (McMillan &

Schumacher, 2010: 344). This case is therefore bounded for this research in terms of all the grade 11 Geography learners, as well as bounded by space, referring to the computer lab and interview classrooms (Creswell, 2008:476). This case study is also bounded within the I-GIS-T activity as well as interview time frames (Merriam, 2009:41). In conclusion, these descriptions of a case study correspond with the following definition for a case study in which McMillan and Schumacher (2010:24) highlight that a case study examines a bounded system, or a case, over time and in depth, utilising multiple sources of data found in the setting. Naturally, this case study is bounded in these ways, in order to narrow down the research to answer the research questions (Heck, 2011:206).

Lastly, this case study evaluation design makes it possible to answer the 'to what extent' questions and not the usual 'why' and 'how' questions familiar in explanatory case studies (Yin, 1994:7; Yin, 2012:45).

The strategy followed was a case study evaluation, with a qualitative approach to data collection and analysis, supported by quantitative data, since this was most suited to the research questions and context. In addition, a case study evaluation is "intended to document and analyse the workability and outcomes of the activity being evaluated" (Yin, 2012:169), in this case the I-GIS-T activities.

Traditional research methods do not lend themselves well to a wide array of educational situations (Anderson & Arsenault, 2000:152) as seen in the fact that a grade 11 Geography class within its natural setting cannot be randomly divided into groups due to educational regulations. On the other hand, another class with another teacher is not comparable as control, due to differences, for example the different teachers.

Because education is a process, educational research calls for a process-orientated, flexible and adaptable research method (Anderson & Arsenault, 2000:152). A case study design was therefore chosen to describe the dynamic class context. To support this, Yin (2012:169) argues that case study evaluations acknowledge the inability of the evaluator to control a fixed environment and therefore may be a better study method than quasi-experimental designs when dealing with unexpected educational situations within the natural class setting.

This case study focuses therefore on the describing and understanding of a phenomenon in all its complexity (Leedy & Ormrod, 2010:135), as well as in its natural environment (*in situ*) (Creswell, 2009:175; Leedy & Ormrod, 2010:135; Maree, 2010:51; McMillan & Schumacher, 2010:321). Through this case study, a theory was built regarding the workability of the I-GIS-T,

from observations and intuitive understanding gained from being in the field (Merriam, 2009:15). Rich narrative descriptions through the eyes of the learners and teachers (McMillan & Schumacher, 2010:322; Merriam, 2009:16) add to the quality and depth of information, revealing the nature of multiple perspectives (Babby & Mouton, 2004:281; Leedy & Ormrod, 2010:135).

This approach coincides with the philosophers of education, during the 1960s, who felt that the traditional quantitative approach within education relies too much on the researchers view and not on the research participant's view (Creswell, 2008:49). With this in mind, a qualitative approach has been chosen in order to gain a description of the natural GIS-class setting, interpretation of new insights regarding GIS teaching, verification of certain assumptions and evaluation of the I-GIS-T innovation from the research participant's view (Leedy & Ormrod, 2010:137).

This case study approach corresponds with Kerski who employed case studies in order to “more fully and accurately understand the effectiveness of GIS in education” (2009:258).

4.5.2 Sampling and site description

Sampling in this case study is non-random (Merriam, 2009:16) and all 12 learners from the grade 11 class as well as all three Geography FET phase teachers from a rural school in KZN were sampled through availability sampling.

The school started in the 1980s and is situated on a mission within KZN. The school caters for learners from different socio-economic and cultural backgrounds, both from the surrounding rural area and those who live on the premises. Most learners come from basic rural areas while some families have moved from cities and other countries to support the mission. The majority of learners, therefore, come from poor families with little or no formal education background. The school can accommodate approximately 400 learners, mostly incorporated within the secondary school. Boarding facilities cater for most of the secondary school scholars. The learners within the grade 11 Geography class are, therefore, multicultural with a variety of home languages such as Afrikaans English, German, Korean and Zulu. This class consists of both weak and strong academic achievers. Some learners from this class are accommodated within a hostel, while others are day students. The grade 11 Geography teacher, Teacher 1, is in her first year of teaching, is computer literate, proactive but lacks GIS teaching experience.

The school is equipped with running water, regular and consistent electricity (supplied by a generator, in case of an electricity failure) and well-maintained classrooms. Sections of the school are continuously upgraded as finances are available. This accounts for the relatively new computer lab, consisting of two adjoining computer classes. The I-GIS-T activity took place in one of two adjoining computer lab classes of the school. More details regarding the I-GIS-T are further discussed in chapter 5.

Since Teacher 1 is in her first year of teaching and has not taught GIS before, additional interviews with two other FET phase Geography teachers, Teacher 2, the grade 10 Geography teacher, and Teacher 3, the grade 12 Geography teacher, from the same school had to be conducted. Although both Teacher 2 and Teacher 3 have numerous years of experience of teaching GIS in the FET phase, they make use of textbook GIS. These interviews provided an in-depth description of the barriers teachers experience in implementing GIS within the FET phase.

4.5.3 Data collection procedure

The following procedures were used in collecting data.

4.5.3.1 Gatekeepers

A gatekeeper is a person with either formal or informal authority to give approval for admission to the setting and participants (McMillan & Schumacher, 2010:351). The KZN DoBE (Addendum 4.1) and the school governing body (Addendum 4.2) gave permission to conduct the study at the school. Information letters were given to the Principal and the Geography teacher (Addenda 4.3 and 4.4).

Parental letters of consent were signed by all 12 of the participants, as well as by their parents/guardians. This letter indicated that this study is voluntary and that the learner could leave the study at any time (Addendum 4.5).

4.5.3.2 Data-collection tools

In this case study, evaluation relies on several sources of field-based data (Yin, 2012:172) such as details about the physical environment, interviews (semi-structured one-on-one interviews and focus groups), audio and video recordings (Heck, 2011:205; Leedy & Ormrod, 2010:137) as well as a quantitative questionnaire to support attitude analysis of the I-GIS-T

(Maree, 2010:76; McMillan & Schumacher, 2010:345), making triangulation possible (Maree, 2010:39). In fact within case study evaluations, qualitative and quantitative data are important (Yin, 2012:173). Tools used in this study were also employed during the evaluation of multimedia teaching packages in literature (Cartwright & Hunter, 2001:301).

A variety of qualitative forms of data are grouped under qualitative data (Creswell, 2008:222; Heck, 2011:205; Leedy & Ormrod, 2010:145). This study consists of the following qualitative and supportive quantitative data collection categories:

- *Observations*: unstructured text data including field notes, both descriptive and reflective, and photos taken during site visits as well as the I-GIS-T activities.
- *Interviews*: semi-structured one-on-one and focus group interviews, audio recorded and transcribed.
- *Questionnaires*: which also included open-ended questions regarding the workability of the I-GIS-T together with Likert scale questions.
- *Pre- and Post-attitudinal tests* in order to support qualitative data in answering secondary research question three.
- *Audio-visual materials*: video recording of the I-GIS-T activities, photos of the GIS lesson.

4.5.3.2.1 Observations

Observation is a research tool, where the researcher sees, listens and takes notes of what is occurring naturally within the research site (McMillan & Schumacher, 2010:350). Observations were employed to address the research question and were subjected to checks and balances in order to construct trustworthy results (Merriam, 2009:118). The main advantage of observations during this study was the gathering of first-hand information at the research site (Creswell, 2008:222). In addition, it afforded the opportunity to record information as it occurs in its natural setting, and capture the actual behaviour during the I-GIS-T activity. Observational notes and video recordings taken throughout the I-GIS-T activity formed an integral part during the empirical process of triangulation of learners response during the interviews that followed (Heck, 2011:207; Merriam, 2009:119). The main disadvantage, however, of observations is that they are highly subjective, and selective (Merriam, 2009:118). Learners may also feel uncomfortable being observed and might not behave naturally. Through conducting multiple observations over time (Creswell, 2008:223) however, the effect of the latter disadvantage can be minimised.

The following observational checklist (Flick, 2006:220; Merriam, 2009:121) was compiled for this study:

Descriptive observation provides orientation to the research site:

- Physical setting and environment: computers, outlay.
- Participants: how many learners, what culture and or home language groups, ages, genders.
- Focused observation: narrowing the focus to the process and problems in order to answer the research question.
 - I-GIS-T activity: do they struggle to go through the activity? Do they need support from the teacher? Are some activities not clear or too difficult, and if so, which activities?
- Selective observation: towards the end of the I-GIS-T activity.
 - Conversations: who speaks with whom, do they help one another, and do they ask the teacher? What is the non-verbal behaviour?
- What is my role during this activity?

4.5.3.2.2 Interviews

Using interviews are just as popular as observation within qualitative research (Creswell, 2008:225) and a primary source of case study information (Heck, 2011:207). Moreover, Hesse-Biber (2011:105) defines qualitative interviews as a “special kind of knowledge-producing conversation that occurs between two parties.” As verbatim transcription of the recorded interviews presents the best database for analysis (Merriam, 2009:110), and even though this method is time consuming, it was employed.

The reason why *semi-structured interviews* were chosen for this study is fourfold. Firstly, semi-structured interviews are used in order to gain a detailed picture of a participant’s perception or accounts of the I-GIS-T activity (De Vos *et al.*, 2011:351). Secondly, this method allows greater flexibility for the interviewer and respondent. In other words, both the researcher and participant can follow up on avenues that emerge from the interview (De Vos *et al.*, 2011:351; Hesse-Biber & Leavy, 2011:102) as the interviewees may frequently have information not yet considered by the researcher. This method therefore added to the richness of themes emerging from the

conversation during this study. Thirdly, by allowing the participant to choose which question to answer at specific stages, the participants played a strong role in the procedure of the interview (De Vos *et al.*, 2011:353). Fourthly, this method also maintained some structure to guide the interview and so keep the focus in answering the research question. These interviews were recorded in order to gain a fuller record of the interview and to be transcribed for closer analysis afterwards. Although recording added to the richness of data, recordings could also intimidate the participant.

The semi-structured interviews included questions encouraging participants to voice their experiences uninfluenced by any perspectives of the researcher. Semi-structured interviews allow probing and clarification of answers (Maree, 2010:87). The main disadvantage however, is that data could be filtered through the views of the researcher (Creswell, 2008:226). Another disadvantage is that the participant might provide data that the researcher *wants* to hear. (See semi-structured interview schedules in Addenda 4.6, 4.7 and 4.8). Sound files of these interviews are found in Addenda 4.10 to 4.16.

A critique of semi-structured one-on-one interviews is that they are artificial, as the participant is separated from a natural setting (Flick, 2006:189). To gain in-depth insight within the natural setting, focus-group interviews have also been employed.

4.5.3.2.3 *Focus group interviews*

A focus-group interview is a method of obtaining qualitative data from a selected group of individuals (McMillan & Schumacher, 2010:440). Two focus-group learner interviews were additionally employed, of five and seven members in order to shun pairing and to instil group dynamics. The two focus groups included all the learners of the grade 11 Geography class. Although focus groups usually include six to ten participants, a compromise of one group of five was made in order to preserve group dynamics. In fact, in this case study, the smaller group of five learners did share valuable insights.

The main advantage of the focus group interviews was that they generated rich, concentrated data on the topic of interest whilst stimulating the participants to remember events, thereby expanding the one-on-one interviews (Flick, 2006:190). The focus-group interviews disclosed multiple viewpoints regarding the I-GIS-T learning experience, within a relative short time span. (See questions of focus group interviews in Addendum 4.9)

In addition, these two focus group interviews followed after a gap period of approximately four weeks. The rationale behind these interviews was to ascertain whether the attitude towards the I-GIS-T was still positive, after the initial 'overwhelmingness' of the multimedia.

These focus group interviews also generated new codes that were merged with the I-GIS-T networks as taken up in chapter 6. In addition, these interviews generated in-depth insight regarding the learners' perspectives of the I-GIS-T. (Sound files for focus group interviews are found in Addenda 4.17 and 4.18.)

4.5.3.2.4 *Questionnaires*

The questionnaires consist of open-ended questions, combined with Likert scale questions to support qualitative data in answering the fourth secondary research question (Addendum 4.19).

Through the inclusion of open ended questions within the questionnaires, there is an allowance for the participant's perspectives to emerge, creating new lines of inquiry directly related to the phenomenon being studied (Maree, 2010:87). In addition, Likert scales have been employed by other scholars to evaluate the GIS software and GIS-based resource packages (Yap *et al.*, 2008:57).

4.5.3.2.5 *Pre- and Post-attitudinal tests*

Pre- and post-attitudinal tests were utilised to measure the development of learner attitudes towards GIS (Addendum 4.20). The same test was used before and after the I-GIS-T activity. As this test has been used in previous studies to measure the attitudes towards computers, the word computer(s) was changed to GIS, in order to measure attitudes towards GIS and therefore adding quantitative support to the third secondary research question.

4.5.3.2.6 *Audio-visual material*

Audio-visual materials in this study consists of images or sounds collected in order to comprehend the central phenomenon under study (Creswell, 2008:232), in this case the viability of the I-GIS-T application. Although this category provides a richness of data, there are also a few drawbacks. The researcher, for one, may influence the data collected or may impose his/her perception of the phenomenon on the participants, rather than obtaining the participants view (Creswell, 2008:232). Another drawback is the selectivity of the camera's focus (Flick, 2006:242). In order to alleviate this major drawback, interviews were included in order to include the participants' perspectives and in that way added to a multi-focal research (Flick, 2006:243).

Analyses of video-taped GIS sessions of the learners produced evidence to document the effectiveness of GIS in the class in other studies as well (Baker & Bednarz, 2003:233).

4.5.4 Data analysis

Qualitative and supportive quantitative data analysis will now be described.

4.5.4.1 Qualitative analysis

Within this data analysis, sense was made from data through consolidation, reducing and interpreting the participants' comments and what was seen and read (Merriam, 2009:175). Rigor and insight were added within this study by employing a few levels of data analysis (Creswell, 2008:258; Merriam, 2009:188). In fact, data analysis is a complex process that involves the moving back and forth between the data and abstract concepts, inductive and deductive reasoning, descriptive and interpretative data (Merriam, 2009:176). In this study data analysis was used as the process to answer the research question.

For example, in order to answer the first research question regarding the barriers, the following data was analysed:

Within the semi-structured interviews with the teachers, inductive coding was used to grasp the barriers teachers experience regarding GIS learning and teaching.

Through the post-interview with the teacher, the codes that surfaced within the teacher's pre-interview were used. The insight gained was used to answer the first secondary research question. Further insight was also gained to answer the second secondary research question regarding the workability of the I-GIS-T from the teacher's perspective.

The learners' post-interviews were analysed to give insight from the learners' perspective regarding the workability of the I-GIS-T.

4.5.4.1.1 Coding

In this study, both inductive and deductive coding were employed. While an extensive literature review guided the focus of interview questions asked during the interview, new codes emerged from open questions answered, that lead to new insights. In other words, within this study, deductive coding through predetermined codes was gained from Meyer *et al.* (1999:574),

whereas inductive coding was also employed as new codes emerged from the data relevant to the unique South African context.

For example, in order to answer the first secondary research question on barriers teachers face while implementing GIS practice, the following categories of GIS implementation barriers, as retrieved from Meyer *et al.* (1999:574), as depicted in Table 4.1 were used.

Table 4.1 **Predetermined barrier factors hindering GIS implementation** (Meyer *et al.* 1999)

Predetermined barrier factors when implementing GIS practice in Secondary Schools.	Barrier
	Hardware barrier
	Software barrier
	Time of teacher barrier
	Time constraints of curriculum
	GIS support barrier
	Lack of curricular connections
	Lack of skills from teacher

Draper's model (discussed in sections 2.4.3), was used to understand barriers to GIS practice barriers. This assisted the researcher to gain insight into ICT challenges that may also reflect GIS practice challenges experienced within the South African classroom.

The overall process of data analysis relevant to the secondary research question on barriers was used by identifying segments in the data sets. These data sets included short comments of teachers that described their constraints in implementing GIS practice. After this initial step, these units of segments were compared for recurring regularities, assigning them to the pre-determined classes or categories and coding them accordingly. In order to give further insight within the South African context, inductive coding was employed, constructing further barrier categories through reading the first interview transcript, the first set of field notes and observational notes. Comments and observations were made in the form of memos within ATLAS.tiTM. These memos were then classified when considered important, potentially relevant or interesting regarding this study. In this latter inductive classification, open coding, axial coding and selective coding (Flick, 2006:358) were used. As noted, both deductive and inductive coding were employed as depicted in Figure 4.1.

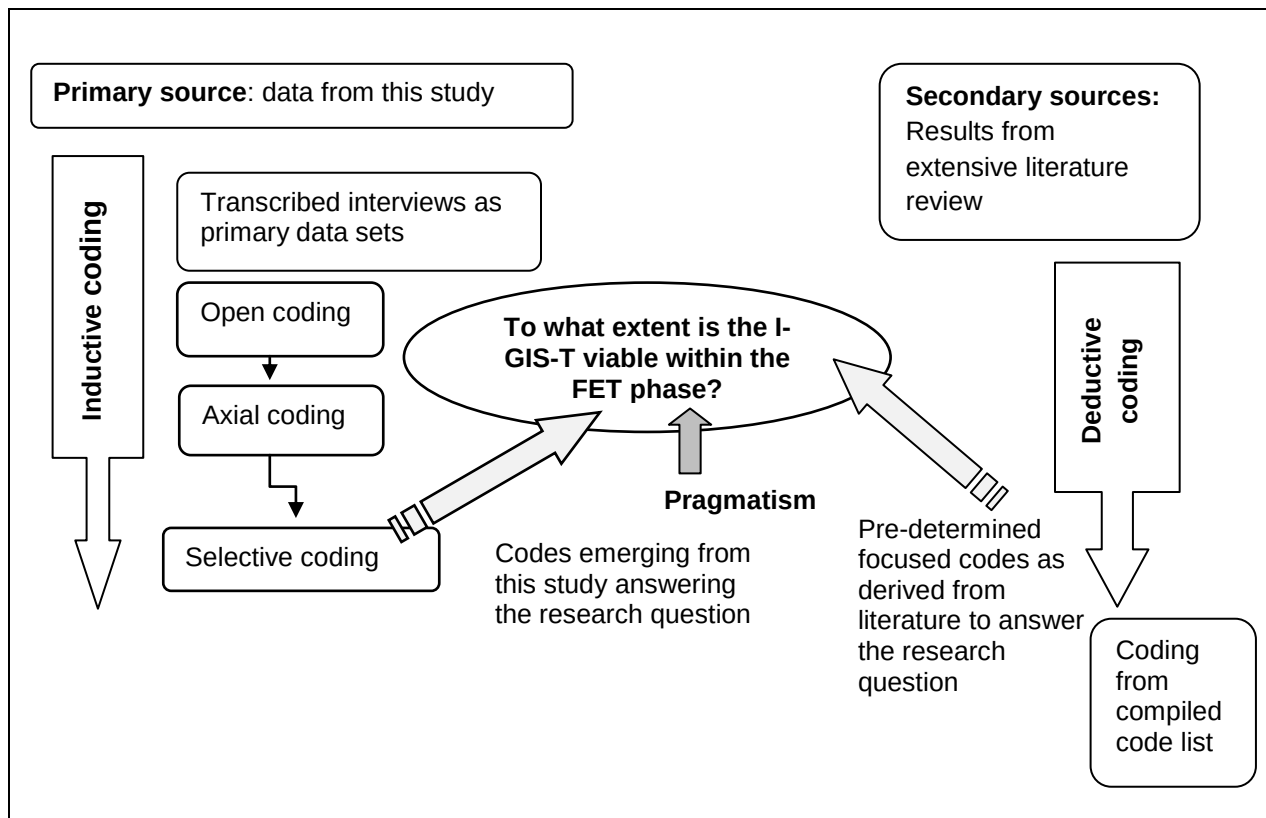


Figure 4. 1 Representation of pragmatic inductive and deductive code merging

The reason for applying both inductive and deductive coding as seen in Figure 4.1, is that although the literature describes educational GIS practice barriers (deductive coding), literature within the South African context is scarce. While coding the transcripts, the text was continuously scanned for barriers known from literature (secondary sources) deductively, while searching for emerging barriers from this case study (primary source) used the inductive method.

Open coding was used, identifying any segment of data that might prove to be useful (Babby, 2011:399). These codes were then grouped together according to characteristics and referred to as *analytical or axial coding* (Babby, 2011:399; Flick, 2006:301; Merriam, 2009:180).

As Figure 4.1 and Figure 4.2 illustrate, analytical coding was used in order to capture interpretation and reflection on meaning (Merriam, 2009:180). While continuing to scan other sets of data, this outline is also being used, and separate comments are being made, comparing this with the first list gathered from the first transcript. These lists then merged into one master list that includes the concepts from both sets of data. This master list consists of a primitive outline, reflecting recurring regularities and patterns that evolve into categories and themes. By definition, these categories are abstractions derived from the data, that is “conceptual elements

that cover or span many individual examples or bits/units of the data” previously identified (Merriam, 2009:181). These categories should be conceptually congruent (Merriam, 2009:186) and aimed at answering the research question(s). During selective coding, a core category, or pattern was developed. Selective coding follows a higher level of abstraction, conveying the story of the case (Flick, 2006:302). The xxxs represent the number of quotations gained from the transcribed interviews.

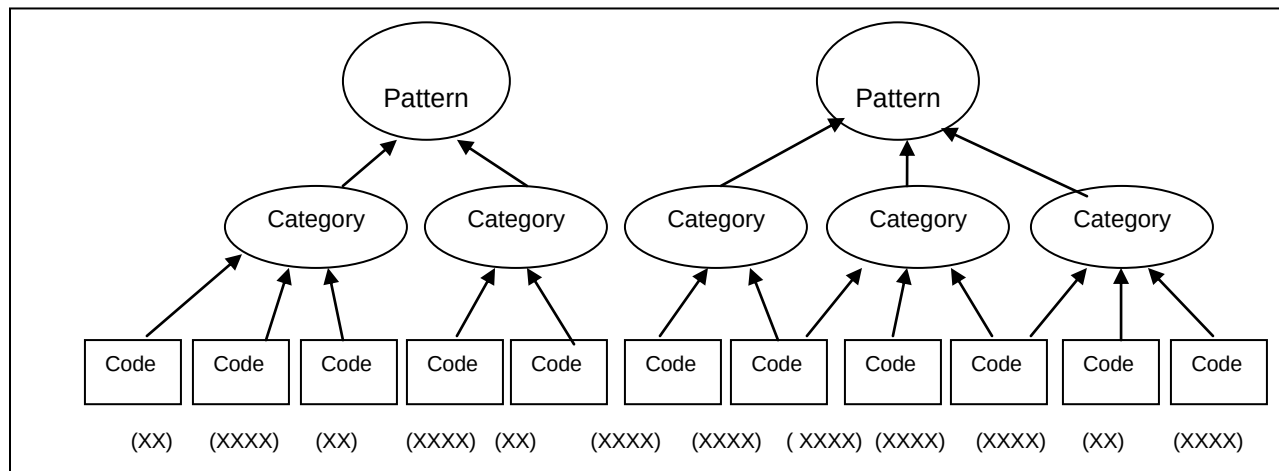


Figure 4. 2 Building patterns of meaning. McMillan and Schumacher (2010:378)

4.5.4.1.2 *ATLAS.tiTM as qualitative data analysis (QDA) programme*

Computers and software, according to Flick are “pragmatic tools that support qualitative research” (Flick, 2006:354). The qualitative data analysis (QDA) program, ATLAS.tiTM was employed for theoretical coding (Flick, 2006:349) and analysis of the transcribed interviews with the teachers and learners. This software enables the organisation of text, graphic, audio and video data files, along with codes, notes and findings into a project (Creswell, 2009:188; Hesse-Biber & Leavy, 2011:266), easing the retrieval of comparing segments of information, notes and building unique networks into a concept map (Creswell, 2008:249; Friese, 2012:210). Moreover, ATLAS.tiTM software has capacity to sustain the construction of complex networks and structures in developing the category framework (Merriam, 2009:195). Qualitative data is typically coded by means of inductive or deductive coding or a combination of both. Figure 4.3 illustrates the procedure followed during the data analysis with ATLAS.tiTM.

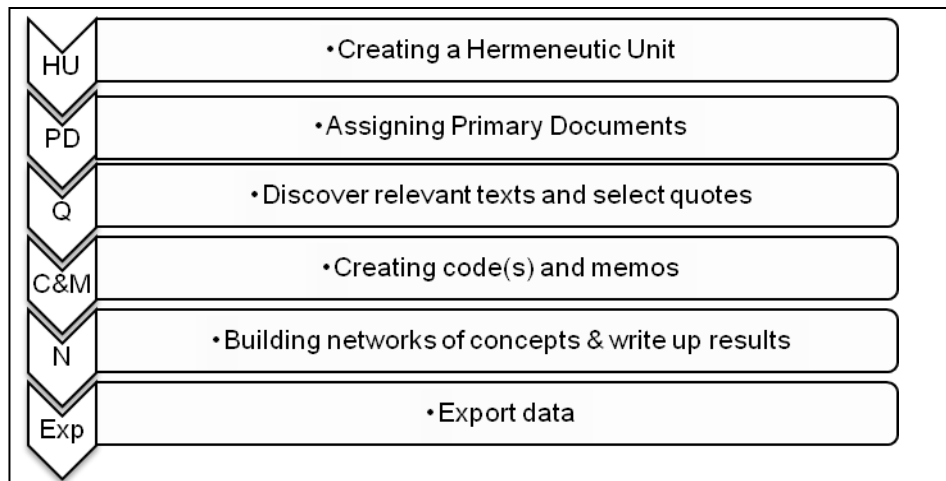


Figure 4.3 Workflow as with ATLAS.ti™ software

The ATLAS.ti™ analysis workflow as illustrated in Figure 4.3 consisted of the following steps:

- **Creating a hermeneutic unit (HU):** The HU was named “MED GIS PROJECT”.
- **Assigning of primary documents (PD):** Seven transcribed interviews and two transcribed focus group interviews were assigned. The focus group transcriptions were created only after the networks, in order to investigate the gaps from the previous interviews and also to provide opportunity for new nuances to arise. Each of the primary documents have been identified within brackets that include further quotation identification, for example (P16,34:34).
- **Discovering of relevant texts and quote selection:** After reading through the transcribed interviews a few times, quotes were selected that in some way reveal information regarding the research questions.
- **Creating codes and memos:** During this process word-codes were created which described the quote the best. After going through the transcriptions, these word-codes were reviewed and merged with those that have the same meaning into a one-word code.
- **Building theory:** After careful reflection on the codes, a number of categories (*) were clustered and then grouped under three themes or patterns (**) as noted in some labels within the networks.
- **Writing up of results:** After creating visual networks, corresponding relationships within the networks were chosen. These networks guided the writing of the findings.

The use of networks diminishes the cognitive load while handling complex relationships laid down in patterns.

It is important to note that ATLAS.ti™ software was not used to automatically generate the codes. Code generation was handled manually and required continuous metacognitive reflection. Moreover, ATLAS.ti™ provides rich contextual information, such as source information, linked lists of codes, documents and text segments, while enhancing swift transitions between text, codes and networks (Weitzman, 2003). A network schema was created while exercising complete and swift management of data.

4.5.4.2 Quantitative analysis

Because this case study is mainly research-problem focused and not methodology focused, supportive quantitative analysis was included in this case study evaluation. A case study and statistical methods are complementary in the pursuit to best answer the research question. The use of supportive statistical methods within this case study coincides with the argument that the case study which includes statistical methods adds supplementary scientific progress (Flyvbjerg, 2011:315).

Quantitative analysis of data consisted of descriptive statistics, such as frequencies, means, standard deviations and effect sizes. The dependent t-test and Wilcoxin ranked sign test were employed to determine the change in attitude between the pre- and post-test. Effect sizes, reflecting the importance of the observed effect in practice, were also calculated.

After analysis and discussion of qualitative and supportive quantitative data, knowledge claims were made that correspond to each of the research questions (Chapter 6).

4.5.5 Researchers role

As the epistemology of pragmatism relies on ‘what works’ in addressing the research question (Creswell & Plano Clark, 2011), a closer look at the different roles of the researcher is necessary.

Although the literature may suggest either an outsider or insider role within a study, Babby (2011:290), quoted in Marshall and Gretchen Rossman (1995), points out that the role of the researcher may entail varying degrees of “participantness.” Creswell (2008:223) also refers to this changing role. In other words, the researcher might change roles within a study in varying

degrees. Obviously, the qualitative researcher's role may be found on a continuum of participation (Hesse-Biber & Leavy, 2011:204; Merriam, 2009:125; White, 2005:104). Scholars further distinguish between a complete observer, observer as participant, participant as observer and complete participant within this continuum. Indeed, during this case study, the researcher had varying roles.

Within this case study, the researcher therefore pragmatically adapts his/her role to the situation. The researcher enters as an observer as participant. This role requires the researcher to reveal his/her identity within the setting, while remaining mainly uninvolved in the setting (Hesse-Biber & Leavy, 2011:204). However, during the interviews, the researcher switches to participant insider (participant as observer) in order to gain insider information:

- As outsider (observer as participant) during the completion of questionnaires. This position will be held in order to retrieve unbiased data as the dynamics of the setting are not influenced (Maree, 2010:85).
- As insider (participant as observer) during the semi-structured interviews in order to gain a thick description regarding the feasibility of the I-GIS-T application as well as the facilitation during the I-GIS-T activity. Here the participants are aware of the researcher's observer activities while conducting the interviews (Merriam, 2009:124).

During this study, the researcher begins as a spectator, or observer as participant, and then gradually becomes more involved during the interviews to become a participant as observer. The challenge, however, is to merge participation and observation in such a way as to understand the setting as an insider, and yet describing it to and for outsiders (Merriam, 2009:126). Consequently, the ethics of the researcher have a large role to play in the validity and reliability of this qualitative study to which I now turn (Merriam, 2009:228).

4.5.6 Trustworthiness

As every case is in a certain way similar to other cases and in some ways like no other case, a description of the grade 11 class, their teacher and the GIS teaching learning environment will be discussed in detail in order to enhance rigour and the trustworthiness (Merriam, 2009:228) of this study.

4.5.6.1 Strategies employed to establish trustworthiness

In order to establish trustworthiness of this case study, the following four design test tactics, as portrayed in Table 4.2, have been utilised throughout the study.

Table 4.2 Case study tactics four design tests as adopted from Yin (1994:33)

Tests	Case study tactic	Phase of research in which tactic occurs	Strategy used during this case study	Checked within this study
Construct validity (correct operational measures)	Use multiple sources of evidence	Data collection	Used interviews, field notes, video, questionnaires	☒
	Establish chain of evidence	Data collection	Stored data collections within ATLAS.ti TM	☒
	Have key participants review draft case study report	Composition	Did member checking	☒
Internal validity (establishing causal relationships)	Do pattern-matching	Data analysis	within ATLAS.ti TM	☒
	Do explanation-building	Data analysis	within ATLAS.ti TM	☒
	Do time-series analysis	Data analysis	“wash out” period before focus group interviews	☒
External validity (establish domain to which this study's findings can be generalised)	Use replication logic in multiple-case studies	Research design	X	Limitation – however analytic generalisable
Reliability (data collection procedures can be repeated, with same results)	Use case study protocol	Data collection	Only the researcher did the data collection	Limitation
	Develop case study data base	Data collection	Database within ATLAS.ti TM	☒

In order to enhance the *construct validity* (logical relationships amongst variables), multiple sources of evidence were employed, establishing a chain of evidence and member checking (Babby & Mouton, 2004:123; Flick, 2006:376; Yin, 1994:33). *Content validity* (if measure covers the variety of meanings within a concept) was verified by the Head of the project and NWU Statistical Consultation Services checked questionnaires for *face validity*. Member checks, the taking of data and tentative interpretations of their interview back to the respondents for their verification (Creswell, 2008:267; Creswell, 2009:191; Heck, 2011:207; Maree, 2010:86) promoted validity and reliability (McMillan & Schumacher, 2010:331; Merriam, 2009:229).

Time spent with respondents was adequate (McMillan & Schumacher, 2010:331) in that the data became saturated (Merriam, 2009:229). As this particular grade 11 class showed academic and cultural diversity, it allowed a greater range of application of the findings (Merriam, 2009:229) by the reader.

An integrated dataset was developed within ATLAS.ti™ in order to enhance reliability (Yin, 1994:33). Data collection included: questionnaires, interviews, audio and video recordings as well as quantitative pre- and post-tests. Quotes and excerpts added in the open ended questions of the quantitative questionnaire added to the descriptive character of qualitative research (Merriam, 2009:16) and promoted triangulation possibilities of data sets, that in turn strengthened the accuracy of the study (Creswell, 2008:266; Hesse-Biber & Leavy, 2011:256; McMillan & Schumacher, 2010).

As questions regarding the viability of a GIS software application and GIS teaching learning barriers in the FET phase within SA have not yet been researched, the questionnaire needed to be validated. The interviews (one to one and focus groups) followed a semi-structured protocol, and questions were scrutinised by NWU Statistical Consultation Services.

The validations of the questionnaires were as follows:

Although much has been done to ensure trustworthiness and validity, pragmatism moves the emphasis rather towards questions regarding usefulness of knowledge gained during the interviews leading to the issue of ethics (Kvale & Brinkmann, 2009:304).

As this study explores the viability of the I-GIS-T application, qualitative data will provide a thick description on the workability of this application. Quantitative data will provide triangulation possibilities.

4.5.7 Strengths and limitations

All research designs have their strengths and limitations. The merit of this particular evaluative case study design is related to the underlying principle for selecting the most appropriate research design for addressing the nature of the research problem and research questions (Merriam, 2009:50). The aim of this study is to test the workability of the I-GIS-T - *whether the I-GIS-T will work in the FET phase class situation*. To answer this research problem, the researcher chose a pragmatic framework. The strength of a qualitative approach is that it

accounts for and includes differences in ideology, epistemology and methodology (Merriam, 2009:52), therefore including paradoxes and acknowledging that there are no simple answers.

The advantage of this case study evaluation is that it supports a multi-perspective analysis in which the researcher considers more than only the voice and viewpoint of one or two participants in a situation (Maree, 2010:75), augmenting a deep, rich and comprehensive insight regarding the dynamics of the situation. The key strength of this case study is the drawing on a variety of sources and techniques within the data-gathering process (Creswell, 2008:477; Maree, 2010:76). The data and analysis methods to use in order to answer the research question were therefore chosen in advance. Methods of data collection within this case study include interviews, audio and video recordings, field notes and a supportive quantitative questionnaire regarding the I-GIS-T application. This case study therefore expands the readers' experience and plays an important role in advancing the GIS-education knowledge base (Merriam, 2009:51). In addition, Merriam (2009:51) points out that the "case study has proven particularly useful for studying educational innovations, evaluating programmes and informing policy." Evaluative case studies involve description, explanation and judgment (Merriam, 2009:49). The information is thus weighed to produce judgment, whereas the judgment is the final and ultimate act of the evaluation (Merriam, 2009:49) of the I-GIS-T application.

In spite of cautious planning and executing of research methods, all studies inherently have limitations. The main limitation of this case study methodology is the dependence on one class, 12 learners and three FET phase teachers only (Maree, 2010:76). In other words, there is a lack of generalisability of results (De Vos *et al.*, 2011:322; Leedy & Ormrod, 2010:137; Maree, 2010:76; Mouton, 2011:150) to all grade 11 Geography classes of South Africa. Secondly, data collection and analysis are time consuming (Babby, 2011:402; Merriam, 2009:51; Mouton, 2011:150) and may prove to be too lengthy for busy policy makers or teachers to read and use. Thirdly, qualitative orientated case studies are also limited by sensitivity and integrity of the researcher, being the primary instrument of data collection and analysis (Merriam, 2009:52). Ethical considerations are therefore deemed important.

4.5.8 Ethical considerations

Although policies, guidelines and codes of ethics have been developed by the NWU and DoBE of KZN, the actual ethical practice depends on the researcher's own individual values and ethics (Merriam, 2009:230).

4.5.8.1 Permission

The NWU Ethical committee scrutinised the proposed study regarding protection of subjects from harm, right to privacy of participants and the notion of informed consent. After the assessment, the Ethical committee of NWU granted permission for this study to commence under the ethical number NWU-00006-12-S2 Fleishmann. A letter was written to the DoBE of KZN including the completion of DoBE of KZN documents regarding the research design, letters of consent and questionnaires. After a 3-month prescribed waiting period, the DoE of KZN granted permission to conduct this study (Addendum 4.1). This was granted on 11 June 2012, with reference number 2/4/8/204.

4.5.8.2 Informed consent

Research participants (learners as well as teachers) were informed regarding the aims and methodology of the research. The teachers, as well as the learners and their parents/guardians, signed a consent form (Addendum 4.5).

4.5.8.3 Privacy and confidentiality

Because the researcher was a guest in a private space (Merriam, 2009:231), in this case in the grade 11 GIS class, utmost care was taken to protect the participants from possible embarrassment. To put the learner and teacher at ease, the interview monologue stressed that this interview aimed to evaluate the workability of the I-GIS-T and not to evaluate the learners, their teacher or their school. As most interviewees enjoy sharing their knowledge, opinions and experiences (Merriam, 2009:231), there were no questions that could lead to possible embarrassment. The video-recording of the I-GIS-T activity might raise ethical questions, as the participants might change behaviour knowing they are recorded. In order to ensure the confidentiality of the participants, their identity and that of the school were masked.

Another ethical consideration is that the researcher acts as primary instrument for the data collection and filtering (Merriam, 2009:233).

In order to uphold the ethics within this study, the purpose of the inquiry and methods used were explained to the participants, confidentiality stressed and informed consent obtained from the participants and parents/guardians' of minors.

4.6 CONCLUSION

This chapter dealt with the research design and methodology within this case study evaluation. Strategies to ascertain trustworthiness were described. The data analysis process and the use of ATLAS.tiTM were summarised. Various measuring instruments were discussed, motivated and described within the research process. The preliminary theory and codes were given. Supporting quantitative data such as means, standard deviations and effect sizes that were utilised in this study were explained briefly. The ethical considerations were considered and the limitations of this study were outlined.

CHAPTER 5

DESCRIPTION OF THE I-GIS-T ACTIVITIES

5.1 INTRODUCTION

This chapter describes the creation, compilation of the information on the I-GIS-T and routing through it. This includes the functionality of the I-GIS-T, unpacking of the I-GIS-Tin activities, including tutorials, exercises and tests. A description of the learners' interaction with the I-GIS-T application follows. It also describes the filling-in process of questionnaires, the conducting of interviews and briefly summarise some of the interviews themselves against the backdrop and physical environment of this case study. This chapter therefore adds to the thickness of description, characteristic of qualitative studies.

5.2 THE I-GIS-T APPLICATION

As GIS teaching is a relatively recent introduction to the FET curriculum, teachers experience pedagogical difficulty. The I-GIS-Tutor is a USB plug-and-play interactive multimedia tutorial that is intended to support the FET-phase Geography teacher faced with time constraints and pedagogical issues, thus streamlining standardised curriculum-aligned GIS teaching and learning. The I-GIS-T therefore includes both the teaching about and through GIS. The I-GIS-T furthermore makes use of ArcGIS and ArcMap GIS as developed by ESRI as a basis.

I-GIS-T was developed using Adobe Captivate 5.5. The Captivate software allows users to create software simulations that can act as tutorials as well as assessment tools. To create a simulation, the developer executes a process in the actual software, while in the background Captivate creates screenshots of each of the different steps being taken. These steps are then compiled into an executable (*.exe) file format which can be opened on almost any computer. Once opened, the initial process, which was done on the actual software, can then be repeated using the screenshots as the graphical user interface. It is important to note that the user will only be able to use the simulated features - the demonstrated process - and not the actual GIS software.

The first edition of the I-GIS-T consists of three tutorials with multi-choice assessments. After the I-GIS-T was peer reviewed, minor changes were made and exercises were included. The current I-GIS-Tutor application aims at user-friendliness, while enhancing active learning through interactivity, guiding learners through the myriad options that are exposed on standard user interfaces. When opening the memory stick, the screen shown in Figure 5.1 appears. As shown in Figure 5.1, the I-GIS-T activities start with an introduction, followed by various tutorials and exercises.

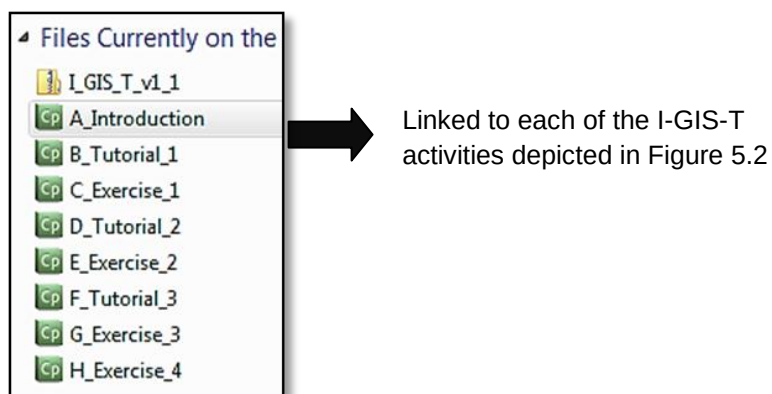
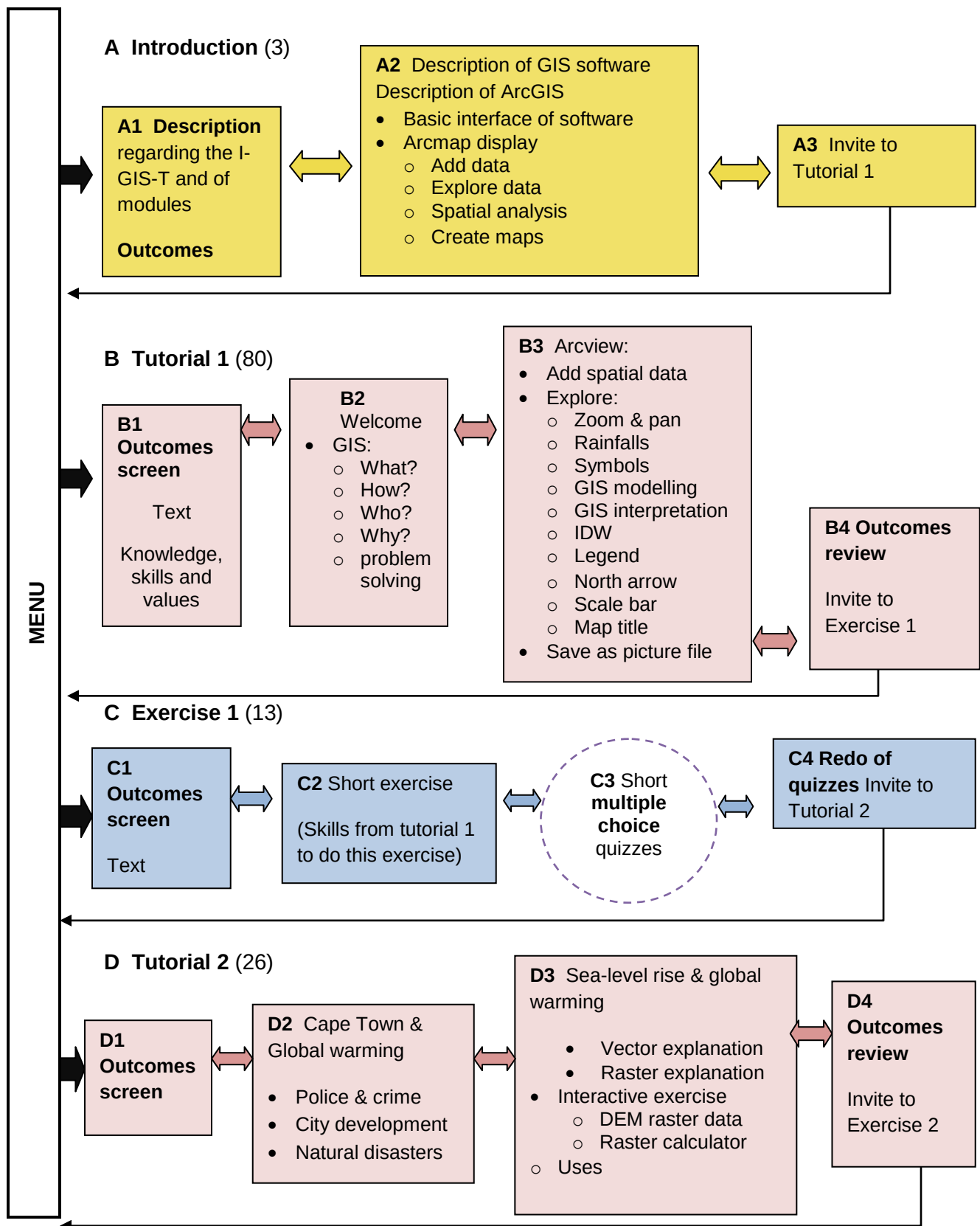


Figure 5.1 I-GIS-T activities as viewed from USB stick

This second edition of the I-GIS-T application consists of an introduction, three tutorials, four exercises and two multiple-choice assessments. The I-GIS-T is a self-paced application that takes approximately 90 minutes for a learner to complete in one sitting. However, the I-GIS-T activities can also be done in sections, integrated over three or four periods in order to accommodate slow learners and acquire more in-depth learning. Therefore the I-GIS-T can be used flexibly, fitting the time constraints of the curriculum.

Figure 5.2 depicts a summative framework of the I-GIS-T activities. Colour coding was employed in order to differentiate between tutorials and exercises. The numbers given in brackets represent the number of snippets within that specific activity. These snippets are linked to the rewind feature within the I-GIS-T, where the learner can review that specific snippet of the tutorial by following the return arrows. Each block represents the main theme of each section as well as the information sequence. The assessment section (multiple choice sections) is depicted by dotted circles as the learner has the choice to redo the assessment. Each of the different activities, tutorials and exercises is directly linked to the menu, as seen in Figure 5.1, allowing access to other activities at any time. The I-GIS-T demo is included within Addendum 5.1.



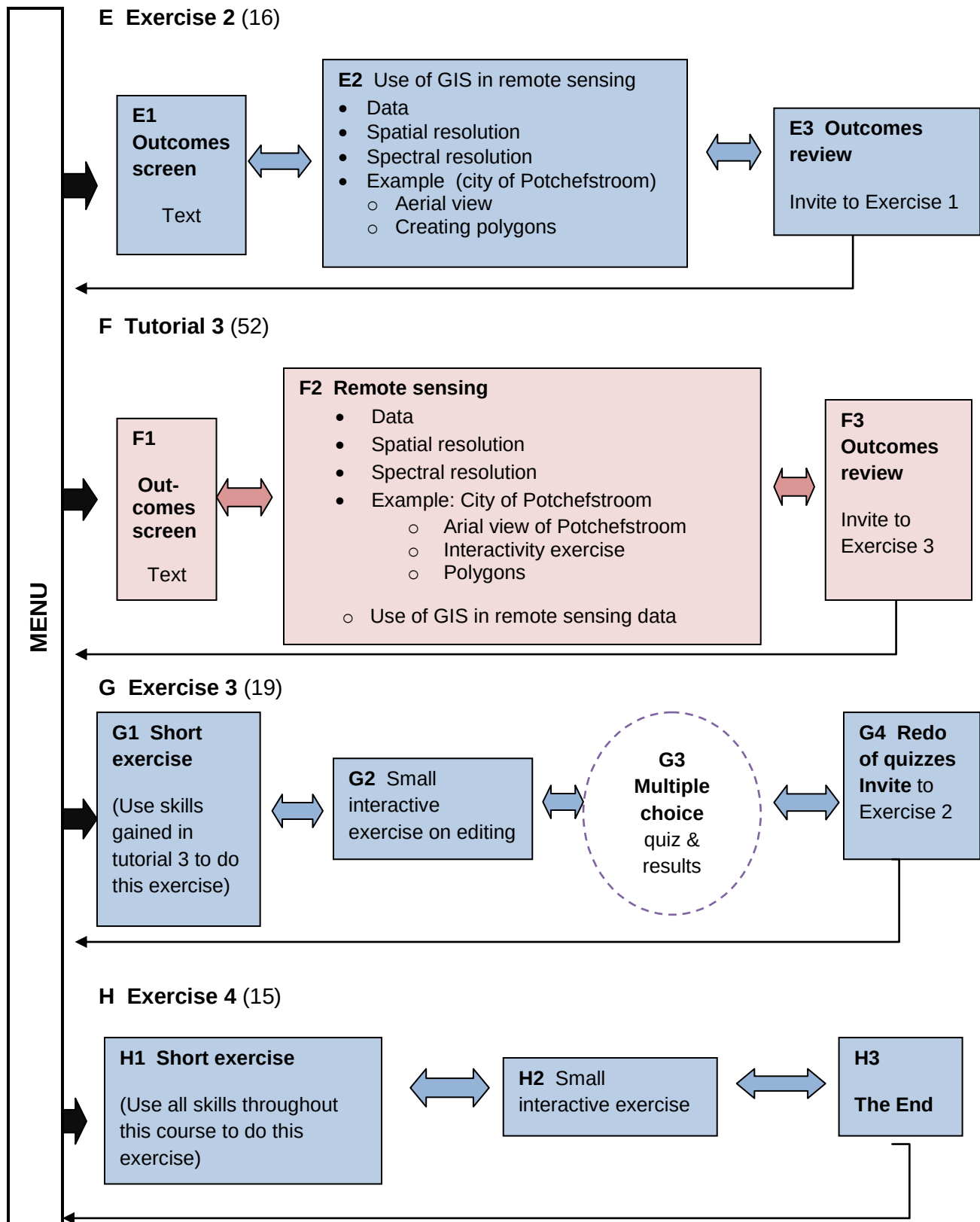


Figure 5.2 Summative framework of I-GIS-T activities

Section 5.2.1 describes and discusses the summative framework of the I-GIS-T activities as depicted in Figure 5.2. Each I-GIS-T activity will now be briefly described as routed in Figure 5.2.

5.2.1 Compilation of information on the I-GIS-T and routing through it

This section unpacks the various I-GIS-T activities and the routing through it as depicted in Figure 5.2. The labels (e.g. A2) used in this discussion refer to the labels used in Figure 5.2.

5.2.1.1 A: Introduction

The introductory description of the I-GIS-T application orientates the learner towards the I-GIS-T application and the outcomes of the activities (A1). Next, this activity comprises a description of GIS software and ArcGIS. This description includes the basic software interface and the Arcmap display buttons (A2). Following this description, the learner is invited to replay this part, or to close this introduction (A3) and open Tutorial 1 from the main menu (Figure 5.1). This introduction consists of three snippets that can be reviewed individually by following the rewind button.

5.2.1.2 B: Tutorial 1

Tutorial 1 is divided into 80 snippets, where each snippet can be reviewed by the learner, if the learner should so choose. This tutorial starts with the outcomes of the tutorial (B1). Thereafter, an explanation of the what, where, how, who, and why questions regarding GIS, as well as problem solving (B2) follows. The features of ArcView software used in this tutorial, as well as how to save a map, are explained (B3). Lastly, the outcomes are refreshed with an invitation to either review this tutorial or go on to Exercise 1, as selected from the main menu (B4).

5.2.1.3 C: Exercise 1

Exercise 1 is relatively short in comparison to the other I-GIS-T activities. This exercise starts with the outcomes screen (C1). Skills learned during Tutorial 1 are exercised (C2). This exercise also includes multiple-choice quizzes as well as multiple opportunities to redo this quiz (C3). The software provides immediate feedback to learners' responses to these questions. These multiple-choice quizzes are designed to accommodate various academic levels. The entire exercise consists of 13 reviewable snippets that conclude with an invitation to the learner to re-do the exercise or go on to the tutorial, as displayed in the main menu (C4).

5.2.1.4 D: Tutorial 2

Tutorial 2 starts with an opening scene including the outcomes screen (text) of this tutorial (D1). Thereafter, various uses of GIS are mentioned (D2). Following this, the influence of global warming (climate change) on sea levels rising is investigated through spatial analysis (D3). The differences between spatial and vector data are highlighted and both are used within this investigation. A raster calculator is also employed in this investigation. This investigation has interactive features, where the learner follows step-by-step narration and animated guidance. Tutorial 2 is divided into 26 snippets that can be reviewed in order to allow self-paced learning. This activity ends with a review of the outcomes and an invitation to redo this tutorial or to continue to Exercise 1 (D4).

5.2.1.5 E: Exercise 2

Exercise 2 starts with the outcomes for this activity (E1). Hereafter, skills learned in tutorial 2 are employed within an exercise (E2). Exercise 2 is divided into 16 snippets each with a rewind option. An invitation to redo this exercise or to continue to Tutorial 3 follows (E3).

5.2.1.6 F: Tutorial 3

The opening scene of this tutorial presents the module outcomes in text (F1). Remote sensing is discussed within this tutorial (F2). Hereafter, spectral and spatial resolution are described, using narration and pictures. A real-life example, namely the city of Potchefstroom, is used where the learner interactively creates polygons to measure the development of this city over a past number of years. This tutorial consists of 52 snippets that can be reviewed by the learner. The closing scene of this tutorial is a revisit of the module outcomes with the invitation to revise this tutorial or to continue to Exercise 3 as indicated on the menu (F3).

5.2.1.7 G: Exercise 3

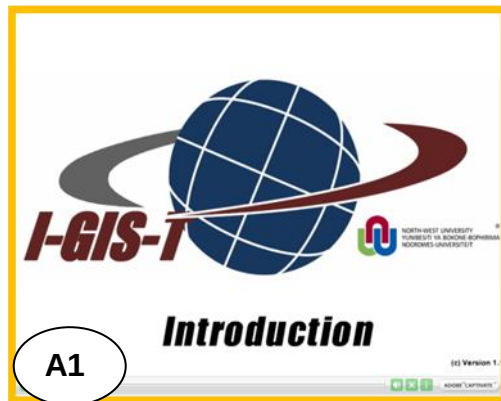
This exercise consists of an introduction (G1) to a small, interactive exercise (G2), where the learner employs skills acquired during Tutorial 3. A multiple-choice quiz follows (G3), which includes multiple opportunities and direct feedback to the learner. The learner can either review this exercise (G4) or the previous tutorials, or continue to Exercise 4. Exercise 3 consists of 19 snippets that can be reviewed by the learner.

5.2.1.8 H: Exercise 4

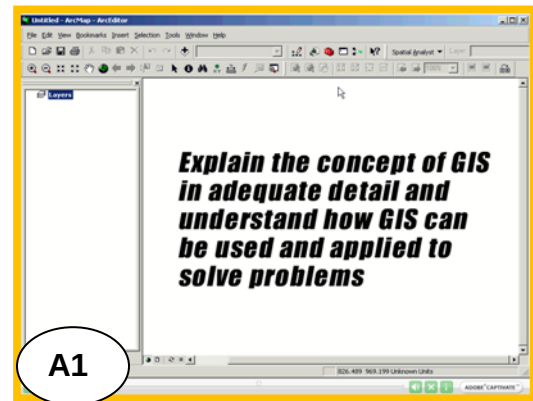
Exercise 4 starts with a welcome screen explaining the exercise to follow (H1). Within this exercise, all the skills attained during the I-GIS-T activities are employed (H2). This exercise consists of 15 snippets that can be reviewed. After this exercise the learner has the option to review any of the other exercises or tutorials (H3).

5.2.2. I-GIS-T screenshots and description

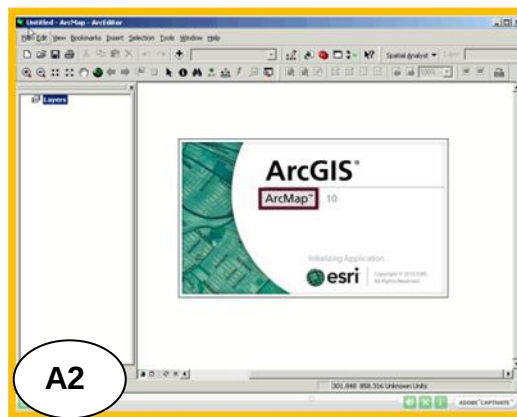
Screenshots and explanation of the introduction, Tutorial 1 and Exercise 1 are elucidated in this section. Figure 5.3 provides sequential screenshots (a-f) taken from the Introduction of the I-GIS-T. The screenshots are coded (for example A1 - A3), corresponding to the labels within Figure 5.2. Figure 5.4 provides sequential screenshots from Tutorial 1, together with descriptions. Sequential screenshots, with descriptions taken from Exercise 1, are presented in Table 5.1.



a) This is the welcome screen in the introduction. The I-GIS-T is a development from NWU.



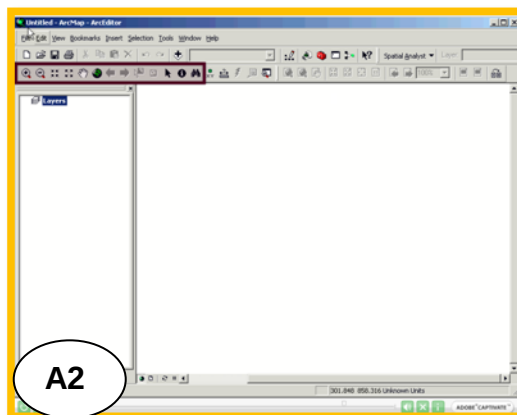
b) Screenshot of the introduction outcomes also narrated voice.



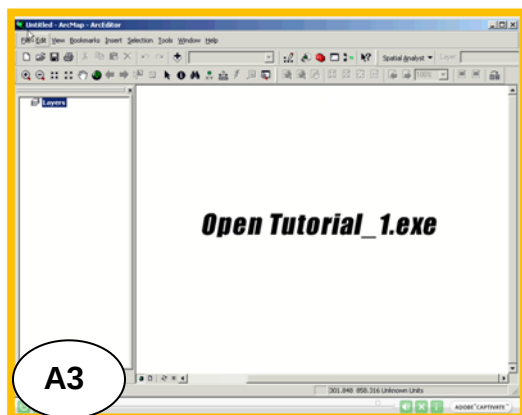
c) Narrated voice explanation regarding the use of ArcMap 10, developed by ESRI used during these activities.



d) Narrated voice explanation regarding the use of ArcMap.

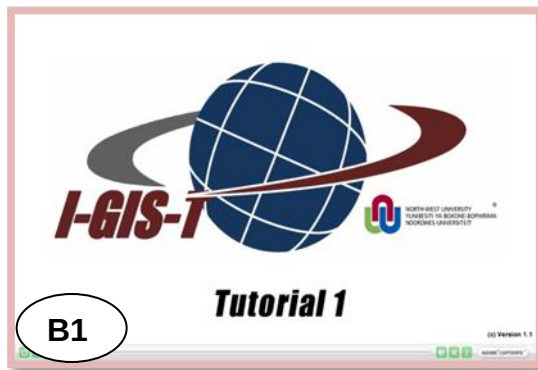


e) Narrated voice and animated explanation regarding the features within ArcMap.

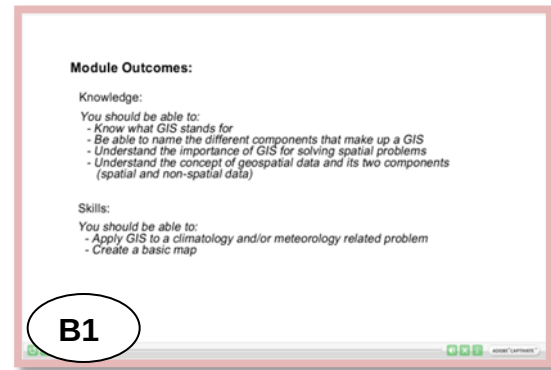


f) Narrated voice invitation to open Tutorial 1

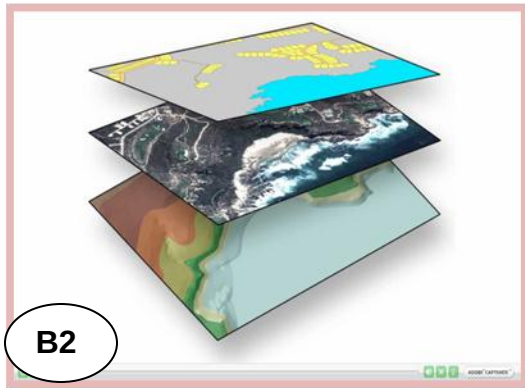
Figure 5.3 Sequential screenshots from the introduction of the I-GIS-T



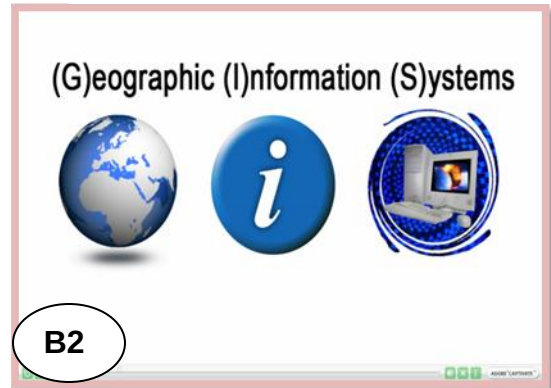
a) Opening screen of Tutorial Narration 1



b) Screen with module outcomes of knowledge and skills



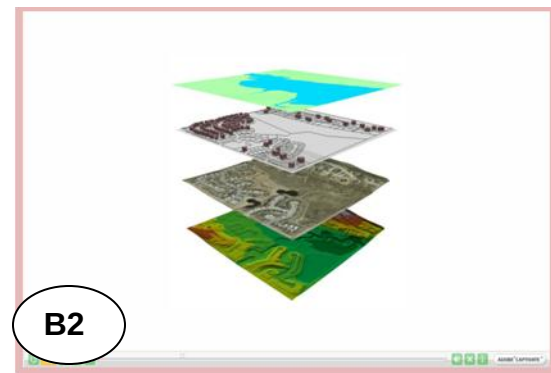
c) Narrative explanation of GIS



d) Narrative description of GIS acronym



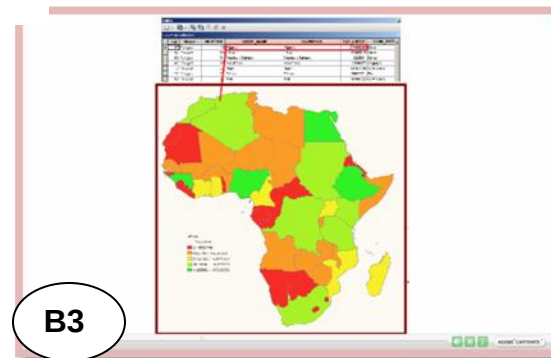
e) Narrative explanation of GIS process



f) Narrative explanation of map layers



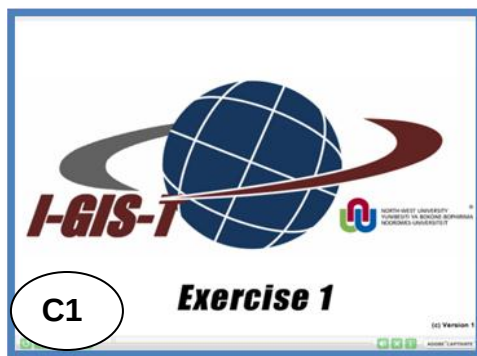
g) Narrative explanation of GIS components



h) Narrative explanation of map data

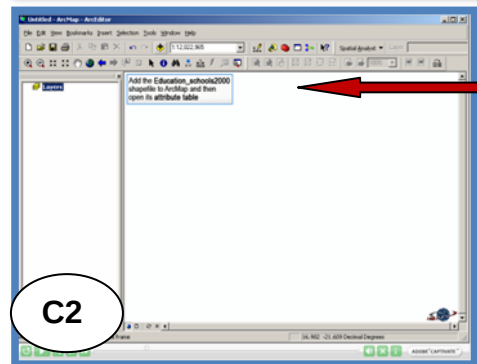
Figure 5.4 Sequential screenshots from the introduction part of the I-GIS-T

Table 5. 1 Sequential screenshots with descriptions from Exercise 1



a) Opening scene

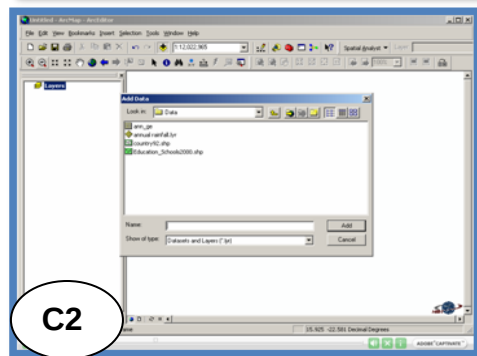
Music jingle



b) Interactive activity

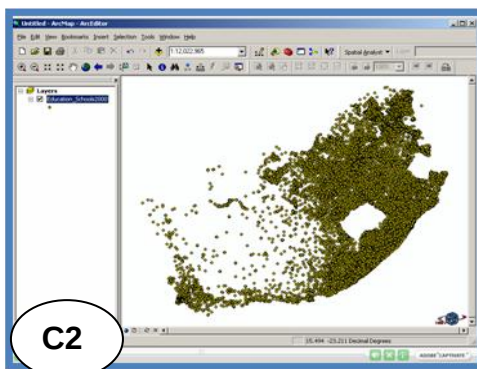
Narration (voice): "Welcome to exercise 1, use the skills obtained from tutorial 1 to do this exercise."

The arrow indicates the instruction. Learner interactivity, learner needs to choose the right button to comply with the instruction.



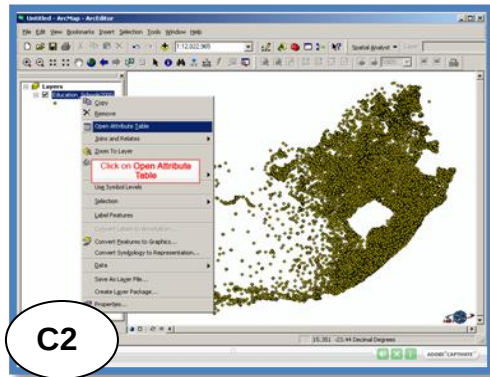
c) Interactive activity

If a wrong button is chosen, text gives the message that the wrong button was chosen or the right button is indicated. If the right button was chosen, then this window opens. The learner needs to select the schools file. This instruction was given in the text box as indicated with the red arrow.



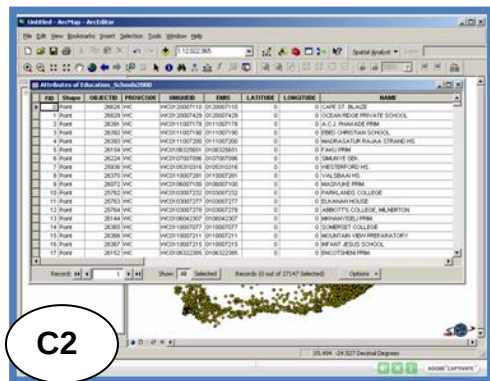
d) Interactive activity

The learner needs to follow the instruction given in the text box as indicated with the red arrow.



e) Interactive activity

If the learner fails to follow the right sequence with the buttons, this textbox in red appears, giving clear instructions.



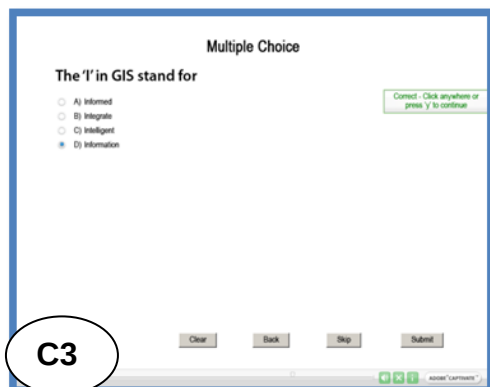
f) Interactive activity

If the right sequence was followed by the learner, this table appears.



g) End screen

At the end of this exercise, this screen is seen together with an invitation to a multiple choice quiz.



h) Multiple choice quiz

This is one of a few multiple-choice questions combined with instant feedback to the learner

Quiz results follow with a score as well as the number of attempts. The learner can continue to the next activity or review the Quiz

This section concludes the description of the I-GIS-T activities. Tutorial 1 of the I-GIS-T is included on the attached USB stick.

5.3 AN HOUR IN THE LIVES OF I-GIS-T GRADE 11 USERS

This section encloses a description of the I-GIS-T activities within this case study.

It is 12:45 in the computer lab of this rural school. The learners will arrive within 20 minutes. I take a few photos in order to support the detailed record of the computer lab's physical setting (Merriam, 2009:146).



Figure 5. 5 Adjoining computer labs of school

Meanwhile, CAT teaching is in full swing in the adjoining computer lab. Directive sounds from a male voice drifts through the window and walls from the adjoining lab. As each computer in this lab has connecting earphones, the male voice will not disturb the learners. Good thing, I think, maybe a plus point for I-GIS-T. Mr. Smith⁵, the IT school assistant appears in the door with a broad smile. He quickly helps me to switch on the computers. I had fears that they might not finish, because of the many questionnaires, if we also need to start up the computers. The previous evening I timed all the activities and found them to on average be about 40 - 60 minutes, depending on the learners' pace. Additional time will be needed to complete the questionnaires. The twelve USB sticks, containing the I-GIS-T, are inserted in the USB ports and the I-GIS-T is checked. All the screens show the introduction.

⁵ Mr Smith – pseudonym



Figure 5. 6 Opening scene of the I-GIS-T

A bell rings. The learners shuffle towards the computers silently, wide-eyed as they observe the two video-cameras and my Canon, ready for the still photos. Teacher 1 appears in a hurry from the previous lesson. She fetched the learners from the Geography class. The students are seated, each with individual access to an I-GIS-T loaded computer. Peter⁶, the cameraman, focuses the camera mainly on two learners during the whole procedure. I hand the additional video-camera to Teacher 1, still wondering if I should not handle that camera while she facilitates the lesson. At the last minute I decide against it, as I would like to have inside information on difficulties that the learners experience. I give a brief explanation to the learners, again emphasising that this activity is voluntary. They agree to continue.

I hand out the pre-attitudinal questionnaire (see Addendum 4.20) and the activity evaluation forms (see Addendum 4.19). I briefly explain it to them. They first complete the pre-attitudinal questionnaire and then start with the I-GIS-T activities at their own pace. I take in the forms as they are completed.

As the learners start clicking, one learner seems to be restless. She is experiencing problems. On closer observation, she explains that she cannot get logged onto the computer. Mr Smith comes to my aid and starts to work on the problem.

Three hands are lifted on the left; I go over to them. They do not know how to close the programme and how to start with the next one. I show them and from then on everything seems to run smoothly. I take a few pictures of the learners. All of the learners are soon each on their

⁶Peter – pseudonym

own mission, and remain fixed in their chairs, concentrating on the tutorials. They seem to be totally lost in their own I-GIS-T activity. I quickly take a few more photos.

A gentle “click”, “click” follows as the low audio-level of the tutorial drifts faintly through the air. Again the male voice from the adjoining lab, but the learners seem to be lost in their work. Good, I think.

A Korean girl seems to concentrate intently while pressing the earphones to her ears. Maybe the pre-set sound level is too low? The students can use a volume turner fixed to the earphones to raise the volume level, so that should not be a problem.



Figure 5. 7 Dual coding learning of I-GIS-T (described in section 2.6.11)

After each activity, the learners fill in a questionnaire regarding that session.

During the session, two learners experience problems with the registration of the clicks on the computer. I take note of that and ask them to go to the next exercise. I am wondering why this has happened, as I used the same master source to copy the I-GIS-T on all the memory sticks. There are no other problems. One learner, though, struggles with the exercises, as she does not yet understand the guidance of the tutor. I quickly explain and the problem is solved. Here and there I have to remind them to complete the evaluation of each section after completion.

It is 13:55 and as the learners finish, I take in the evaluation and give them the post-attitudinal form as well as the I-GIS-T evaluation. As they complete these forms, I take them in as well.

Teacher 1 instructs everyone to stay until the last learner finishes. Learners who have finished, quietly start to search on Google for their various hobbies, or practise their typing skills with a game, while others start chatting. The last learner finishes with the questionnaires. They file out

of the lab room. The teacher next door also comes out of the other lab with a big grin. “Always something new?” The voice now seems familiar. I nod my head in agreement.

The I-GIS-T hour experience is over in the life of the grade 11 Geography learners. Video-recordings and field notes provide further richness to the data. All the learners completed the I-GIS-T evaluation questionnaire as well as an attitudinal pre- and post-questionnaire.

5.4 INTERVIEW TIME

It is 16:15 the next day. Teacher 1, the grade 11 Geography teacher, has arranged the location. The office is sealed off with glass. “I have the three learners ready, just wait, I will quickly call them.” Teacher 1 has selected three learners from three different academic achievement groups: Lily, a below-average achiever; Alice, an average achiever; and Helen, a high achiever. Since it is after hours, not all the learners are available, so she has made use of those who are available. I check my recorder while I wait. Yes, it is working.

5.4.1 Interview with Lily

Lily enters the room, quite nervous but excited. She is a Zulu girl with a shy, friendly smile. The teacher previously mentioned to me that she is an under-achiever in grade 11 and from a rural background. I read through the request for informed consent. She relaxes a bit, and gives her consent. I ask: “Are you ready to start?” She motions that she is. I start with the first question.

“Complete the following phrase: I think the I-GIS-T is....”

Wonderful miss, it just takes you to do the practical, actual thing, makes you, out there, thinking, how to and everything.

I ask her if she has used GIS software before and she says she has not. She tells me that besides the software they have only used the textbook. I ask her to complete the sentence “When working with the I-GIS-T, I liked ...” Lily replies a bit unsure:

...you had to find out something. I can't remember, you have to find out how to put something you had to first measure the hockey field, we first need to measure the hockey field and then you need to put something cannot remember correctly...

She tells me that her biggest challenge when using the I-GIS-T activities was “...to make my own map”. When asked if she felt in charge of her own learning during the experience she

beams and exclaims, “Yes, Miss, I felt SO in charge [satisfied laughter], I could actually teach myself at that”. She seems proud and very excited.

“Do you feel you have learned more about GIS through the I-GIS-T activity?” I ask. “Yes, very much, I have learned a lot. I have learned how to make my own map, what is GIS and how I can use GIS in real life...” She laughs and exclaims that she could have worked with the I-GIS-T activity for three or four hours and “...it made my heart happy and very interesting in doing Geography... just to do something to do with GIS and everything”.

She says she would like to make her own maps and “overlap the things” at home as well as at school “...I would LOVE to”. She ends the interview with, “Miss, can we PLEASE use I-GIS-T next year?” We both laugh and with that the interview ended.

5.4.2 Interview with Alice

The next learner, **Alice**, is an Afrikaans girl who seems to be unsure of herself, but very willing to share her insights. I soon realise that this learner craves additional stimulation. The teacher had informed me that she had been a 60% scorer, but lately her marks were starting to pick up. After the introductions, I ask her to complete the phrase, “I think the I-GIS-T is...” Alice immediately lists the learning aspects of the I-GIS-T:

It allows the child to like learn while doing it itself. Because usually in class while you just read it, it does not go in when the teacher teaches it also more for kinetic and help those that are visual, audio and kinetic learner. This actually agrees for all three.

Alice also mentions that the I-GIS-T has a designing and problem solving aspect to it. I am quite astonished at her educational insight. She chuckles a bit. I ask her how the I-GIS-T compares with learning GIS from the textbook. She says,

I could understand [the I-GIS-T] much better, I mean I knew how they did it and everything, but did not know how it could actually do it practically you know... I just thought this is confusing, ok this is paper number one, on top of that, ok now you have to make sure this is all in correct and everything and so in comparison with this, it is much easier.

When asked if she felt in charge of her learning during the I-GIS-T activity, she states, “Not really, because it is a tutorial it is like press this button then press that button and press that button and so just press it and it is highlighted”. She also adds, “It was a bit like, click this...click that...o oops, I think I forgot that one, but on the other hand it was like... wow these people must be geniuses.”

I ask her if she would like to explore more and she nods, and answers confidently,

because of the many maps and everything, we usually have these large maps...and have to find this place...especially in the exams when you are all stressed and everything, you know... you have to find this dot... it gave me a dislike in certain amount of dislike in map work. So when I did THIS, [I-GIS-T], I started actually to like map work again... you know, because I see it is useful.

I ask her for recommendations for future development of the I-GIS-T. Alice thinks a bit and then mentions that she would like more activities, but that it is actually good just as it is because she has learned a lot in one hour. Then she concludes with,

I actually like it a lot, I think it would make me motivated to do Geography now.

I thank her for the interview, we greet and Alice leaves the room with a smile.

5.4.3 Interview with Helen

The next learner is **Helen**. Helen is Korean, and speaks English fairly well. The teacher had informed me that Helen stands second in the Geography class with an average score of 90%. After the introductions, I ask her what she thinks of the I-GIS-T. She remarks that she thought it was fun. Helen mentions that she used Google Earth before but that she gathered more information about GIS through the I-GIS-T application. She states that she also liked it when the narrator navigated her through the activity and she could follow that. She exclaims, "That was cool." I asked her what was difficult for her, and she acknowledges that she had some difficulty finding out how to open and close the files. However, as she got used to the I-GIS-T she felt more at home with it. I ask her if she has learned something from the I-GIS-T and she explains, "When doing the exercise, I thought, oh I did not know about this. Now I can learn more specifically". I ask her, on a scale from 1 to 10, how much she had learnt. She thinks a bit and then states, "Maybe 10".

Helen affirms her learning. "It was worthwhile for me because I learned new things, because you also use computer technology. I think it gave me vision to more geography and technology". In addition, Helen states, "I felt very much excited, I enjoyed doing this, tutorials and exercise." She explains,

I think it would be very nice to learn GIS like this. Like tutorials and then exercises. Because like... for example, if the teacher just speaks, then sometimes we do not know... we don't know what is going on, but this tells you and you can also do as you listen to it.... so like you say it is interacting... so I think this way can teach the students much better.

This concludes the individual learner interviews within this section.

(find sound files of all three interviews in Addendum 4.13, 4.14 and 4.15 and see Table 6.15 for transcribed interviews table).

5.4.4 Interview with Teacher 1

A semi-structured interview with Teacher 1 is described next. The interview was conducted after she had worked through the I-GIS-T application during the day, and had filled in the evaluation questionnaire on the I-GIS-T. Teacher 1 is in her twenties. It is 18:00. We greet. I read through the request for informed consent. She gives her consent. I ask: “Are you ready to start?” She nods.

Teacher 1 expresses that that she had definitely found the I-GIS-T workable because it instructs the user right from the start. She also states that the teacher does not have to take a course to know how it works and “if the teacher just goes once through it, it is sufficient”.

Regarding any foreseen I-GIS-T barriers, the teacher remarks that she does not think there will be any, except if a learner is not computer-literate. She refers to the I-GIS-T activity as “I think it is very clear and interesting, all the learners seems to enjoy it, and it is much better than just the textbook version, which is very theoretical and can be confusing to the learners”. Teacher 1 concludes that she thinks she will promote the I-GIS-T application to other Geography teachers as

most Geography teachers or many don't really do this practically usually because they are scared of using new software, or think they won't have the time. But with this, you don't need a lot of time. I think the main thing is that you don't want to spend hours before the time trying to figure out what to do, but with this programme you don't have, even if you have not done it before you can do it with your class. You just do it with them and it is self-explanatory. So it is...ja really a good idea.

Both her answers in this interview, as well as those in the questionnaire suggest that she is positive about the I-GIS-T application.

(find Addendum 4.16 for sound file)

After these interviews, I wondered if the participants were not so positive about the I-GIS-T just because of “multimedia overcloudiness”. Therefore, after a period of approximately four weeks I conducted two focus group interviews. These focus groups provide more in-depth insight into the long-term outcome of the I-GIS-T on the learner. It must be noted that two other teachers were also interviewed at a different time as explained in section 4.5.2.

5.4.5 Interview with Focus group 1

Two focus group interviews were conducted. These involved seven (focus group 1) and five (focus group 2) grade 11 learners, respectively. I had arranged with the teacher that the learners would not expect the interviews. Focus group 1 consists only of girls. Three are Korean and four Zulu learners. The Zulu learners come from rural homes. All these girls live together in the school's dormitories. Group pressure seems to have a strong influence on them.

It is 11:00. The learners look surprised to see me again. I briefly explain that I need them to evaluate the I-GIS-T activities that they did a few weeks before. They agree. I ask them what they think about the I-GIS-T. They answer, "I think it was very interesting"; "We could learn more from it"; "I think it was wonderful"; "It was special"; "It was quite interesting". Then the top achiever of the class says, "I think the I-GIS-T was a little bit boring". After this remark, two others agree. I look at the top achiever. She blushes a bit. "Good," I reassure them, "We need to have interaction. Why would you say it is boring?" One learner suggests, "There were many chapters." "It was boring... because ...it was boring," another learner adds. "I did not understand the system, I don't know how the system works with the thing, so I don't get it"; "...was difficult, because...I don't use computers." I ask them how the I-GIS-T compares with the textbook. Now group dynamics are set at work, and the answers came tumbling out: "Much easier"; "No, not at all, not for me"; "Much better"; "Much better"; "Better, because we could try it out"; "Better than the textbook"; "The textbook you just read"; "I found it a bit challenging"; "Was difficult because I didn't understand, don't use computers".

I ask them if the I-GIS-T was user-friendly. "No, because of language," one learner snaps. "Why?" I ask. "Some people don't understand English, and so... it is a bit confusing..." "Auw" [meaning no in Zulu] "I am serious". I ask the learner if she is speaking for herself or for those who are less confident in English. She confirms that she had not been speaking about her own experience, but was rather imagining what it might be like for rural learners from other schools. I ask them how they would feel if there was an option for other languages within the I-GIS-T. The learners seem to agree: "Perfect"; "Then I will understand much better". I ask them if they would like to do the I-GIS-T activities in the future. Some say they would, others say they would only if it was not for marks. I ask them to rate how worthwhile the application is, on a scale of 1 to 10. They call out: "9", "8", "7", "5", "7", "8", "6", and "7". I realise that the learner who said 6 had had difficulty logging into the computer in the lab.

(find sound file of Focus group 1 within Addendum 4.17)

5.4.6 Interview with Focus group 2

Focus group 2 is a group of day-scholars and consists of two Afrikaans and three Zulu learners. Group pressure does not seem to be as strong as with the first group. This group consists of two boys and three girls. All are familiar with basic computer skills.

I ask them to complete the phrase: "I think the I-GIS-T is..." They call out: "Interesting"; "Useful for the future... in careers such as architecture and stuff..."; "I think you get a better idea of how the world is, and how meetings can be found in certain areas"; "It is useful but simple..."; "Informative and interesting, because I did not know most of the things we did there even exist and I found it nice. It was something nice to do for a change."

I ask them whether the I-GIS-T had sparked their interest in GIS. They answer:

Definitely.

Yes,...I think it helped like to get some practice too on it, because the first time you do it, it is like not extremely easy, and you have to think back and I like the idea, I first thought , oh where am I going to get the answers at the end, but when I saw the answers after it was, oh I was wrong here and right here is nice to see where you have been wrong and you could also find the answers, and it is nice because you can redo it again until you get it right. Because the first time it is like, where did I press again and stuff like that but as you continue you get to improve and get much better and understand much better.

Regarding their attitude towards GIS:

At first I had no interest, and thought it is a bit boring, and as I did that, and afterwards I really got to see the full picture of what about it is, so there was a little bit of an interest after. I thought it was something boring, and had no enthusiasm about it.

I also actually did not thought much about GIS, because I did not understand it, but now that I understand it, I think it is a very good thing.

...also agree, because it brings everything to life, not just pictures... but reality.

I ask them about the workability and user-friendliness. They all agree that the I-GIS-T was workable and that it is also user-friendly. With regard to future developments, they say they would like to see the software developed further so that it could provide enrichment and possibly earn them bonus points for future qualification:

Because you have some young children that are really talented, or not necessarily even talented, but get a bright idea that has been overlooked or something and then... even though they don't want to do it they can at least get a plan of how it would work and how it would look like and..."

(find sound files for Focus group 2 within Addendum 4.18).

5.5 CONCLUSION

This chapter gave an in-depth description of the I-GIS-T application, the I-GIS-T activities, filling-in of questionnaires and some of the interviews. This description painted the backdrop of this case study evaluation and might prove useful for teachers in the field in order to analyse and generalise the results within their own setting.

The learners and the grade 11 teacher (Teacher 1) interviewed expressed a generally positive attitude towards the I-GIS-T. They found that the software infused the learning with fresh excitement and interest. The majority of the learners said they preferred the use of I-GIS-T to textbook GIS learning. Quite a number of learners expressed the desire to engage in future I-GIS-T activities in order to equip them for job opportunities after school. However, a few learners used the word 'boring' to describe some parts of the learning experience. In one case this was because the software provided limited opportunity for exploration. In other cases, it appears that the learners used this label because of GIS-anxiety within the computer lab due to having limited computer skills.

In addition, Teacher 1 experienced the I-GIS-T activities as an answer to overcome the main GIS practice barriers. She therefore affirmed that she would use this application in future. In fact, she would definitely promote this application to Geography colleagues within the FET phase.

In the next chapter, the description given in this chapter is extended as the study's results are interpreted in the light of the research questions.

CHAPTER 6

RESULTS AND INTERPRETATIONS

6.1 INTRODUCTION

The review of the related literature in the previous chapters revealed the scarcity of research on GIS implementation in SA. Chapter 4 justified the case study evaluation with qualitative data with supportive quantitative data. Chapter 6 consists of an analysis of the data as collected from (i) four teacher interviews, (ii) three one-on-one learner interviews, (iii) two focus group interviews, (iv) twelve learner evaluation questionnaires with open-ended questions, (v) twelve pre- and twelve post-attitudinal tests, (vi) a video-recording, (vii) photos and (viii) field notes in order to best answer the research question as described in chapter 4. The aim of this chapter therefore is to describe and interpret the results of this case study evaluation by addressing the primary and the second to fifth secondary research questions posed in Chapter 1.

The primary research question deals with the viability of the I-GIS-T application as a GIS teaching learning tool within the FET phase Geography class. The aim of this chapter is to attempt to answer the second to fifth research question against the backdrop of GIS practice barriers. In order to answer the primary research question, the following empirical secondary questions need to be addressed:

- What barriers do FET phase Geography teachers face regarding GIS practice?
- To what extent does the I-GIS-T application influence learner attitude towards GIS within the FET phase?
- To what extent is the I-GIS-T workable within GIS practice in the FET phase?
- How can the I-GIS-T further be developed to enhance GIS practice within the FET phase?

In order to answer the above research questions, the data gained through this case study evaluation comprises both narrative and tabular form. Moreover, this case study evaluation

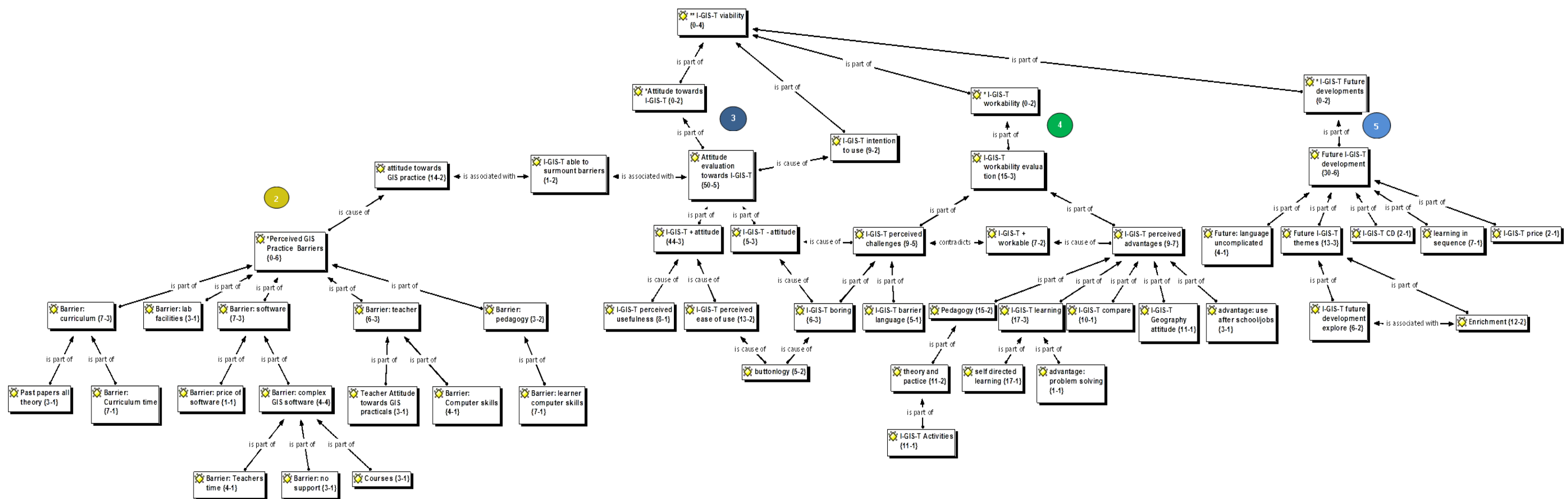
covers both the processes (workability) and the outcomes, such as attitude development towards GIS, of the I-GIS-T activities (Yin, 2012:173).

With the purpose of depicting a visual overview regarding complex relationships concerning GIS practice, an inclusive pattern network (Figure 6.1), as generated by means of the Atlas.ti™ software, is included in this chapter. This inclusive pattern network represents the primary research question (with secondary research questions) and presents the integrated data gained from various data-collection tools, as listed in section 4.5.3.2, within qualitative research.

So as to ensure logical discussions and answers to each of the second to the fifth secondary research questions, as grouped within the inclusive pattern network (Figure 6.1) in five categories, data will be discussed under the following headings (categories) with corresponding colour indexing as allocated in Figure 6.1:

-  GIS teaching barriers experienced by the teachers.
-  Attitude towards I-GIS-T and GIS.
-  Perceived workability of the I-GIS-T.
-  Future I-GIS-T developments.

Within the section of each heading (category) a network summary of data patterns is drawn. The labels within the networks reflect the number of quotations as well as the number of links. For example, the label *Barrier curriculum {7-3}* in Figure 6.1 and Figure 6.2 contains seven quotations and three links to other labels. Following each network, within a category, quotation evidence is submitted with allocated codes within tables. Thereafter each code is discussed. In other words, flowing from the pattern network, categories of the pattern network are discussed (See more on pattern networks in Figure 4.2 and related discussion). Finally, knowledge claims are drawn from the discussions, answering that specific secondary research question.



Category number	Corresponding Secondary Research Question
2	What barriers do FET phase Geography teachers face regarding GIS practice?
3	To what extent does the I-GIS-T application influence learner attitude towards GIS within the FET phase?
4	To what extent is the I-GIS-T workable within GIS practice in the FET phase?
5	How can the I-GIS-T further be developed to enhance GIS practice within the FET phase?

Figure 6.1 Comprehensive overview on the viability of the I-GIS-T

6.2 GIS TEACHING BARRIERS EXPERIENCED BY TEACHERS

With the purpose of answering the second secondary question: *What barriers do FET phase Geography teachers face regarding GIS practise*, three FET phase teachers were interviewed.

The three FET phase teachers (identified only by pseudonyms: Teacher 1, Teacher 2 and Teacher 3) gave, by means of interviews (see section 4.5.3.2.2), an in-depth insight into their struggle and reasons for shying away from implementing GIS practice. All three teachers suggested that limited time to learn new software programmes impede GIS practice. Although the three teachers have been on ArcView 3.3 courses and the school does possess ArcView 3.3 software, they find no time to implement it. These findings coincide with Audet and Paris (1997:294) who argue that the mere presence of GIS software in a school does not mean GIS practice has been incorporated within the curriculum. Not surprisingly, Teacher 2 and Teacher 3 felt intimidated by software and computers, especially when they have to teach learners who are already computer literate. In addition, Teacher 3, the grade 12 Geography teacher, stated that she herself might be the biggest barrier towards GIS learning. On probing for possible solutions, all three teachers clearly indicated that there is a need for user-friendly software and affirmed that they would utilise such an application if available in future.

This section provides an overview of category *Perceived GIS Practice Barriers {0-6}* (Figure 6.2) that emerged from the integrated dataset consisting of three semi-structured one-on-one interviews with teachers. Collectively these interviews contributed to addressing the research question: to determine the main GIS practice barriers.

The network of the category in Figure 6.2 presents a summary of the GIS practice barriers that the three teachers experienced within this case study as generated by Atlas.tiTM. Figure 6.2 is a segment (as indicated with the 2 in yellow, top left corner) of the summative network in Figure 6.1.

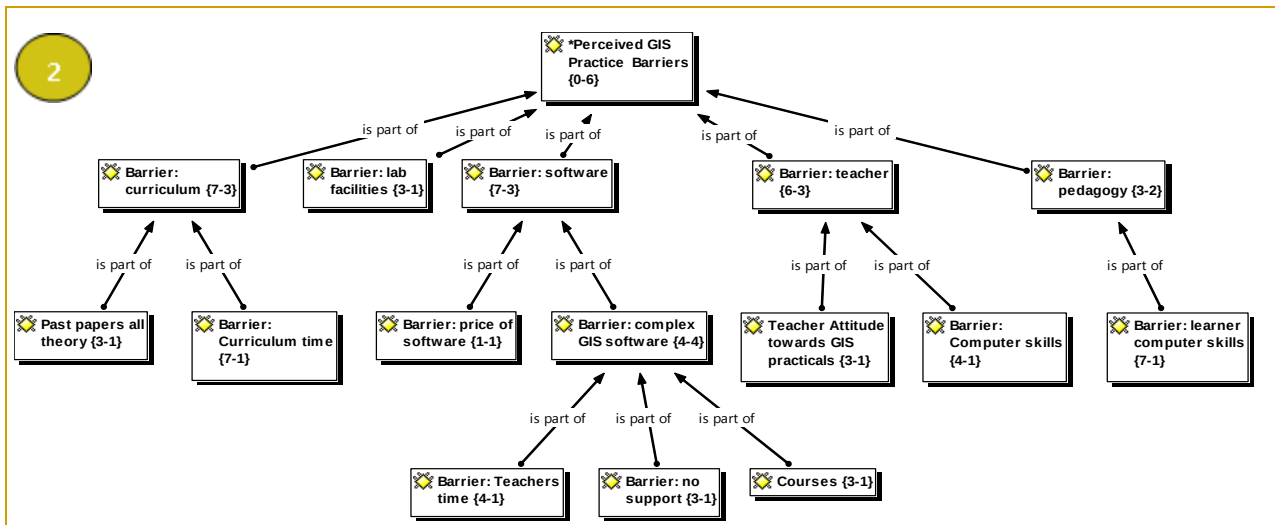


Figure 6.2 Overview of data and patterns regarding perceived GIS practice barriers

This overview of data regarding perceived GIS practice barriers category (Figure 6.2) will now be broken up and analysed in smaller segments. Figure 6.3 therefore represents the primary barriers that emerged during this case study. Figures 6.2 and 6.3 represent data gained from interviews conducted with the three FET phase teachers.

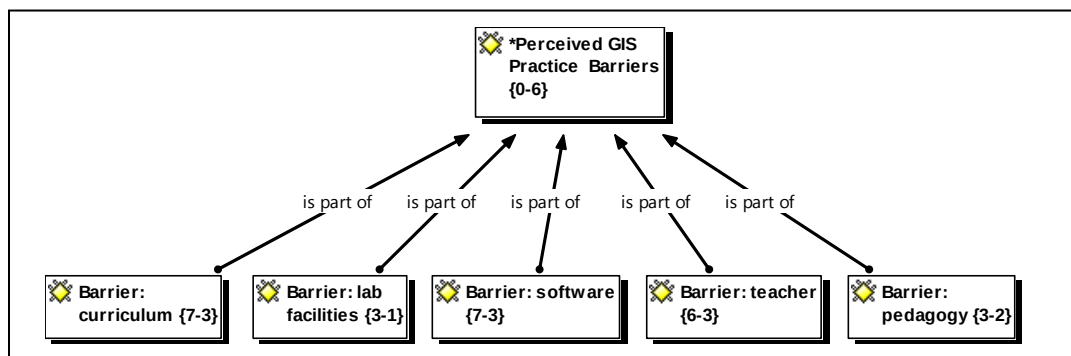


Figure 6.3 Main barriers towards GIS practice

Figure 6.3 indicates five aspects that emerged from the integrated dataset. They are: (i) barrier curriculum, (ii) barrier: lab facilities, (iii) barrier: software, (iv) barrier: teacher and (v) barrier pedagogy.

The perceived barriers during this study typically agree with those found in literature, as described under section 3.2. However, it should be noted that within the South African context, the teacher is likely to also see him/herself also as a barrier towards GIS practice as veteran Geography teachers are themselves sometimes computer illiterate. Table 6.1 presents an overview of typical evidence from the integrated dataset supporting the network (Figure 6.3) pertaining to the category of GIS practice barriers as experienced by teachers. Each of the

codes is explained in greater detail hereafter.

Table 6.1 Typical codes and quotations for the category of GIS practice barriers as reported by teachers

Codes	Quotations (<i>verbatim</i>) gained from Teacher 1, Teacher 2 and Teacher 3
Barrier: Curriculum	• Teacher 3: <i>So there is NO NEED to go into depth. That is in the exam... In fact, there is seldom more than if ten marks out of both papers which add up to 400 marks on GIS... so why spend ages on it? So that is how it is at the moment. (P11,42:42)</i> • Teacher 3: <i>I think FET phase is too late for it to start there. It must start earlier on... (P11, 127:127)</i>
Barrier: Lab facilities	• Teacher 1: <i>We do have the facilities at the school, so... (P9, 37:37)</i> • Teacher 3: <i>It will be a problem if your period clashes with a CAT lessons. (P11,72:72)</i>
Barrier: Software	• Teacher 1: <i>I think it was good, but, you have to practise... if I would use the same programme now, I don't know where to start. So it is something that you have to practice. (P9,234:234)</i> • Teacher 1: <i>if you just open ArcGIS, there are so many features but I do not know where to start, how to use it... (P9,161:161)</i>
Barrier: Teacher	• Teacher 3: <i>I think maybe I... you have spoken about barriers... I for example may be the biggest barrier... because I did not grow up with computers, I can do the basic skills and I always feel left behind... with whatever is going on there and it is not right really, because I am maybe the barrier to what the children could be doing at school. (P11:66:66)</i> • Teacher 2: <i>In my specific case I would prefer that the learner will not be held back by the teacher, that they can just go ahead on their own. Because I feel, that I am keeping them back from that. It is actually not right towards the child. (P10,134:134)</i>
Barrier: Pedagogy	• Teacher 1: <i>They get bored very quickly if they just use the talk and chalk method. So I think they will enjoy it more and put in more effort if it is something actual and interesting. (P9,191:191)</i> • Teacher 3: <i>But I think it would be an EXCELLENT thing because I think practical is always better than theory. Theory at the moment... the children are bored. I always feel, I hate having to teach that section, because it is always so up in the air. And I am teaching them that way, I teach them there is a raster, there is a vector.... And this and that and... I try to read up on real life examples on how it is been used, to solve some crime or something like that to make it more, you know... interesting. (P11,90:90)</i>

Pseudonyms: Teacher 1, Teacher 2 and Teacher 3

The main perceived barriers to GIS practice, as given set in Table 6.1, coincide with global barriers as discussed in section 3.2. However, computer literacy of the teacher within the South African digital divide context additionally hinders the implementation of GIS practice. For example, within this case study two of the three teachers feel ill-equipped to handle a GIS practical (see Table 6.1), although they view the I-GIS-T application as a way to circumvent their computer illiteracy barrier. Sections 6.2.1.1 to 6.2.1.5, along with Figures 6.4 to 6.9, provide evidence of each of the aspects illustrated in Figure 6.3. There are, in fact, breakdowns of the summative Figure 6.2 into five smaller parts. Each of these so-called sub-figures (Figures 6.4 to

6.9) will host its own table (Tables 6.2 to 6.7) with typical codes and quotations for each of these five categories.

6.2.1 Facing the curriculum as barrier

The network given in Figure 6.4 represents data found from the integrated dataset (section of Figure 6.2) regarding the curriculum as a barrier to implementation.

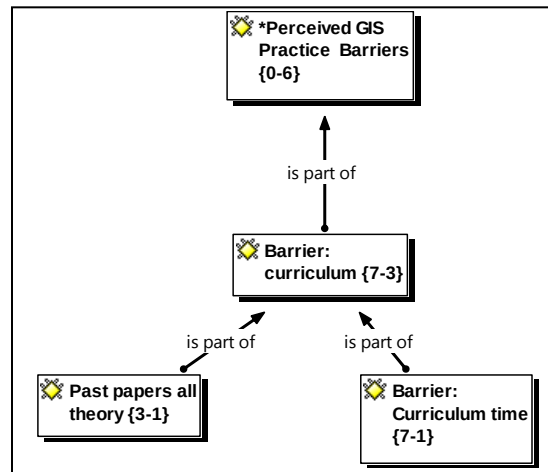


Figure 6.4 Curriculum as barrier

As seen in Figure 6.4, there are two main reasons why teachers experience the curriculum as a barrier to implementation of I-GIS-T. Firstly, grade 12 exams only assess GIS theory and secondly, the time allocated for GIS in the curriculum is very short. Table 6.2 presents an overview of typical quotation evidence from the integrated dataset of each of the aspects presented in Figure 6.4.

Table 6.2 Typical codes and quotations for the aspect of curriculum as barrier

Codes	Quotations (<i>verbatim</i>) gained from Teacher 1 and Teacher 3
Barrier: Curriculum time	• Teacher 1: <i>But I think there is time to do it in grade 11. Matric⁷ is a bit full and grade 10, but grade 11 is fine. (P9,83:83)</i> • Teacher 3: <i>Just because of time, we can't spend more than... 2 hours, 3 hours maximum in matric. Unless we incorporate it in a very clever way into the others, that it is just not an extra thing that we are doing at the end but they do but it is a learning tool as part of the syllabus. (P11,121:121)</i>
Barrier: Past papers all theory	• Teacher 1: <i>But what I see from past papers, it is all theory and just the notes in the book and that is all, I don't think they really do it practically. (P9,31:31)</i> • Teacher 3: <i>So there is NO NEED to go into depth. That is in the exam... In fact, there is seldom more than if ten marks out of both papers which add up to 400 marks on GIS... so why spend ages on it? So that is how it is at the moment. (P11,42:42)</i>

Pseudonyms: Teacher 1 and Teacher 3

From evidence as captured in Figure 6.4 and the related quotations presented in Table 6.2, the following conclusions were drawn:

Firstly, although GIS has been included in the curriculum, there are no specific requirements regarding GIS practice. Secondly, because there is no GIS practice exam in grade 12, teachers are not motivated to put in some extra effort with GIS practice. As mentioned by the teachers, out of the four hundred marks, of the matric Geography examination, only approximately 10 marks are allocated for GIS *theory*. These remarks clearly indicate that, within the full curriculum of grade 10 and matric, teachers feel pressurised to “teach to the test”, which in turn leaves little room for GIS practice. Thirdly, the full Geography curriculum of grade 10 and 12 leaves the teacher with much to do, and little time to struggle through GIS practice, let alone working out GIS practice lessons and studying complex GIS software. Finally, Teacher 3 refers to the lack of pre-FET phase GIS practice, stating that GIS practice starts too late. The grade 10 teacher also faces a full curriculum. However, whilst analysing the curriculum as a barrier to I-GIS-T implementation, Teacher 1 remarked that the grade 11 curriculum is very flexible with a positive prospect for further GIS practice experience.

⁷ Matric – Grade 12 in SA

6.2.2 Facing computer lab facilities as barrier

The availability of lab facilities during this case study has also been noted as a barrier regarding GIS practice, as portrayed in Figure 6.5.

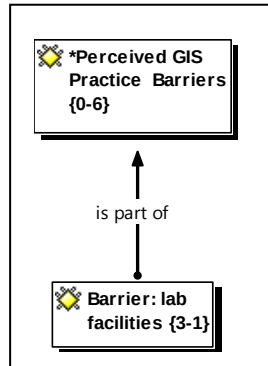


Figure 6.5 Computer lab availability

Table 6.3 encloses some quotation evidence from the integrated dataset regarding computer lab availability as a barrier, reflected in Figure 6.5.

Table 6.3 Typical codes and quotations for the aspect of lab facilities as barrier

Codes	Quotation (<i>verbatim</i>) gained from Teacher 3
Barrier: Lab facilities	• Teacher 3: <i>Our computers are not always accessible, they are used mainly for CAT lessons and a few other lessons and so then it is booked, and you don't always know if you can get there, because we book on a weekly basis and then it changes and things like that...</i> (P11,72:72)

Pseudonyms: Teacher 3

Within this case study, Teacher 3 stated that although they have a computer lab available, it needs to be booked for GIS practice. Booking, however, seems to be a problem as some periods are taken by CAT lessons and bookings are done on a weekly basis. This situation may also be found in other schools. However, the school within this case study possesses two adjoining computer labs that might prove to be able to accommodate the GIS practice demand, even though CAT lessons are being booked. It is worth mentioning that during the I-GIS-T activities in this case study, the adjoining computer lab was being used for a CAT lesson. It should also be noted that the computers within both computer rooms were all in a good working condition. This might not be the case in other schools in South Africa. However, as the I-GIS-T does not require a computer network, this application might therefore alleviate network problems as discussed in section 3.2.

6.2.3 Facing GIS software as a barrier to GIS implementation

Apart from hardware and computer lab facilities as possible barriers, the teacher interviews highlighted the GIS software as a barrier to GIS implementation. The network in Figure 6.6 derived from the integrated dataset obtained through interviews with the three teachers. This network is a section of the barrier network in Figure 6.2.

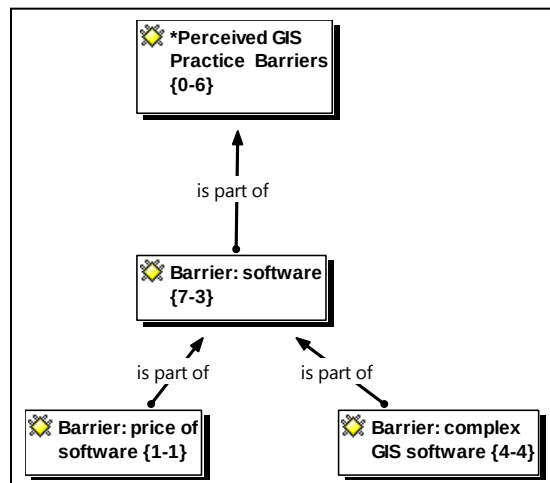


Figure 6.6 GIS software as barrier

The main software barriers as presented in Figure 6.6, pinpointed the price and complexity of GIS software as obstacles, thus hindering GIS practice. Although the price of GIS software was mentioned, the complexity of GIS software also seems to deter the teacher from using the software in many ways. Firstly, the teacher's time is absorbed. The teachers expressed the need for GIS practice support and then GIS training courses were mentioned. Table 6.4 depicts some evidence, as taken from the integrated dataset for the category of the software as barrier, to clarify each of the barriers in Figure 6.6.

Table 6.4 Typical codes and quotations for the aspect of GIS software as barrier

Code	Quotations (<i>verbatim</i>) gained from Teacher 1, Teacher 2 and Teacher 3
Barrier: Price of software	• Teacher 1: <i>I don't think it would be worthwhile to buy something like this if you would only use it for one week during the whole year. (P5,74:74)</i>
Barrier: Complex GIS software	• Teacher 1: <i>If you just open ArcGIS, there are so many features but you do not know where to start, how to use it... and you don't like reading through a thick manual. (P9,161:161)</i> • Teacher 3: <i>I really don't grasp it, you know and they often come with really advanced software and show what can be done but it is all up there and down here. (P11,54:54)</i> • Teacher 3: <i>Lack of software, suitable software, maybe software that takes us back right back to the basics. (P11,60:60)</i>

Pseudonyms: Teacher 1 and Teacher 3

According to the evidence in Table 6.4, the price of available GIS software hinders GIS practice. Expensive software that will only be used during one week in the year does not seem viable. This barrier correlates with global GIS practice barriers (for example Malaysia), as mentioned within section 3.2. Furthermore, Teacher 1 and Teacher 3 stressed that they found educational GIS software complex, while Teacher 2 clearly pointed to the fact that "...everything that has to do with computers is above me". (P10, 76:76). Teacher 1 argued that she would not like to plough through a thick manual in order to know the GIS software and that she in fact does not know where to start. Teacher 3 also highlights that educational GIS software is advanced and that she would prefer GIS software to start at the basics. Data that emerged from this studied revealed some more aspects pertaining to complex software. The following section (6.1.3.1) will further analyse these findings.

6.2.3.1 Facing complex GIS software as a barrier to GIS implementation

Figure 6.7 describes network patterns gained from the integrated dataset regarding complex GIS software as a practice barrier. This further breakdown of the subsection facing GIS software as a barrier to GIS implementation, is depicted at the middle-bottom of Figure 6.2

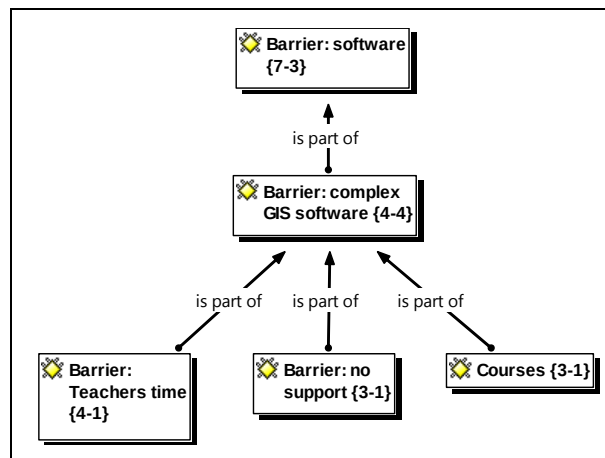


Figure 6.7 Complex GIS software as barrier

The following three basic codes emerged during the analysis of complex GIS software as a barrier to: teachers' time, no support and course inadequacy. Evidence for the support of these codes is included in Table 6.5, by means of quotations gained from the interviews.

Table 6.5 Typical codes and quotations for the aspect of complex GIS software as barrier

Code	Quotations (<i>verbatim</i>) gained from Teacher 1, Teacher 2 and Teacher 3
Barrier: Teachers time	Teacher 2: <i>So, there is really not time, with teaching at the moment one is very busy with the administrative part of it all and the evidence one needs to show and moderation and there is really not much time to learn new things. Ja, that is what I find, is the biggest hindrance for me. (P10,76:76)</i> Teacher 1: <i>So you must just know how to use it and not spend hours in trying to figure out how to use it because, teachers don't have time to do extra studying and if they can see that it works and don't take too much time. (P9,113:113)</i>
Barrier: no support	Teacher 1: <i>But if maybe someone shows me how maybe I could use it. (P9,37:37)</i> Teacher 3: <i>I think if we could get someone who really is into this, I think this could become a very interesting topic. (P11,102:102)</i>

Barrier: Courses	• Teacher 3: <i>I always feel ill-equipped, because it is something that we haven't, I have been on a few course, one here at the College and I went on a day course in Johannesburg once... and the people who presented it were extremely well versed in GIS... and I always feel as if I am left behind. And so I really don't grasp it, you know and they often come with really advanced software and show what can be done but it is all up there and down here. I enjoyed the course here at the College, because it was a hands-on approach [ArcView 3.3] but it seems like an on-going thing, we go to courses and that but we don't introduce it in our school in that way. (P11,54:54)</i> • Teacher 3: <i>So I think something we did here at the College would be good, maybe a little more basic, although it was pretty much basic, I mean if I could do it. (P11,72:72)</i>
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Pseudonyms: Teacher 1, Teacher 2, and Teacher 3

Limited curriculum teaching time allocated for GIS, as well as the teachers' own time constraints, seems to be a major barrier to GIS practice. Because of limited curriculum time allocated to GIS, the teachers regress to the use of the textbook. Teacher 1 also refers to the time factor in becoming familiar with the GIS software. All three Geography teachers went on GIS courses (ArcView 3.3) and even though the school has purchased the software, they are still fearful and struggle to implement it. Lastly, shortage of GIS support for the teachers seems to be real. The teachers were not even sure that they have the software ArcView 3.3 available at school. Teacher 1, who is computer literate, also expressed a need for someone to show her how to use GIS software. It seems as if pedagogy of GIS practice also plays a major role in determining whether the software is used or not.

6.2.4 The teacher as a barrier

Figure 6.8 represents evidence found from the integrated data set regarding the perception of the teacher that she views herself as a main barrier towards GIS practice. In fact, the reason for this also emerged from the dataset. Figure 6.8 is the second last section taken from Figure 6.2.

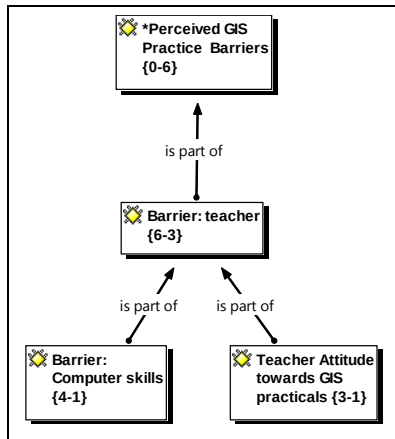


Figure 6.8 Teacher as barrier

From this extraction of the integrated data set it is evident that computer skills and attitude towards GIS practice play roles with regards to the teacher's experience being seen as a barrier. Table 6.6 supplies evidence gathered from the integrated dataset regarding these aspects.

Table 6.6 Typical codes and quotations for the category of teacher as barrier

Code	Quotations (<i>verbatim</i>) gained from Teacher 2 and Teacher 3
Barrier: Teacher	Teacher 3: <i>I think maybe for example I may be the biggest barrier, because I did not grow up with computers, I can do the basic skills and I always feel left behind... with whatever is going on there and it is not right really, because I am maybe the barrier to what the children could be doing at school. (P11,66:66)</i> Teacher 2: <i>In my specific case I would prefer that the learner will not be held back by the teacher, that they can just go ahead on their own. Because I feel, that I am keeping them back from that. It is actually not right towards the child. (P10,134:134)</i>
Barrier: Teacher attitude towards GIS practice	Teacher 2: <i>It is the practical side of it; everything that has to do with the computer is above me. [laugh] I have tried, but it is not that I have not tried, but I forget... as I learn I forget, so it is a mountain every time I need to do something. (P10,76:76)</i> Teacher 3: <i>There are probably so many people like me that really feel all incapacitated... and you know what, we often feel threatened by the children themselves, because they know more than we do... so it is a THREATENING thing... you feel intimidated... now you have to present something on computer and meanwhile they are far more knowledgeable than we are, I think... young people actually intimidate people like us. Ja. (P11,84:84)</i>

Barrier: Computer skills	• Teacher 2: <i>Because I am not really computer literate and for me it is a MOUNTAIN... to teach that to the children, but I can see, that it would be a good thing if they can manage that. (P10,45:45)</i>
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Pseudonyms: Teacher 2, and Teacher 3

All three teachers teaching Geography in the FET phase experienced themselves as being a barrier to GIS practice. Even though they all went on GIS training courses, they still feel incompetent in implementing GIS practice. Even the teacher (Teacher 1) who is computer literate feels intimidated by the thought of bringing GIS into practice, as seen in the following quotation:

If I would just do my own thing I wouldn't make use of it because I am not very familiar with it myself, but if maybe someone shows me how maybe I could use it, because we do have the facilities at the school, so...
(P9:37:37)

6.2.4.1 Teacher attitude towards GIS practice

Attitudes of teachers toward the instructional GIS practice, GIS practice implementation and educational technology affect motivation in employing GIS practice (Yazici & Demirkaya, 2011:2061). Attitudes are affected by efficacy and perceived environmental constraints. (Environmental constraints have been discussed under barriers of GIS practice in section 3.2). As Teacher 2 and 3 are not computer literate, their attitudes toward GIS practice are negative, even though they view GIS as useful. For example, Teacher 3 responded as follows:

I think it [GIS] can be of value a lot because GIS is not just Geography, it is anything, whatever career you do GIS can apply to it, and, whether you have done Geography or not, I think in some way or another you will use it in life... whether you deal with water or with settlement or whatever career you do. I think it is valuable.
(P11:66,66)

In order to clarify as to why some teachers view themselves as a GIS practice barrier, lack in computer skills came to the fore:

6.2.4.2 Barrier: Computer skills

For a teacher to be able to implement GIS practice, computer skills are needed. In fact, teachers lacking computer skills may feel threatened since learners are more computer literate than themselves. This is illustrated in the following quotation from Teacher 3, as seen in Table 6.6:

There are probably so many people like me that really feel all incapacitated... and you know what, we often feel threatened by the children themselves, because they know more than we do... so it is a THREATENING thing... you feel intimidated... now you have to present something on computer and meanwhile they are far more knowledgeable than we are. (P11,84:84)

Lack of teacher computer skills therefore hinders GIS practice.

6.2.5 Facing GIS pedagogy as barrier towards GIS practice implementation

GIS practice requires some changes regarding pedagogy. Figure 6.9 represents the evidence gained from the integrated dataset pertaining to pedagogy as a barrier as taken from Figure 6.2.

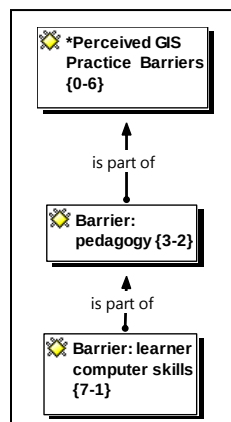


Figure 6.9 GIS pedagogy as barrier

The evidence for each of the codes in Figure 6.9 is given in Table 6.7, by means of quotations gained from the interviews. In other words, Table 6.7 depicts evidence gained within the integrated dataset on pedagogy as a barrier towards GIS practice.

Table 6.7 Codes and quotations for the aspect of GIS pedagogy as barrier

Code	Quotations (<i>verbatim</i>) gained from Teacher 1 and Teacher 3
Barrier: Pedagogy	• Teacher 1: <i>I am scared to even try something...</i> (P9,71:71) • Teacher 3: <i>Theory at the moment... the children are bored. I always feel, I hate having to teach that section, because it is always so up in the air. And I am teaching them that way, I teach them there is a raster, there is a vector...</i> (P11,90:90)
Barrier: Learner Computer skills	• Teacher 1: <i>I don't think there are problems; the only barrier that might happen is when the learners are not familiar with a computer.</i> (P5,44:44) • Teacher 1: <i>But I think by grade 11 you should be able to use it. Although in a rural school it won't work. They first need to learn how to use the computer.</i> (P5,44:44)

Pseudonyms: Teacher 1 and Teacher 3

Learners' computer skills seem to have a crucial influence on, especially in rural areas. Similarly, within this case study, one learner mentioned, after the I-GIS-T activity, that she had struggled within the software, and therefore found this application "boring" because she was computer illiterate and did not know the "computer system". Referring to Figure 6.15, the I-GIS-T has the potential to surmount the main barriers faced by teachers when implementing GIS practice. This notion was tested through the analysis of the post I-GIS-T Teacher 1 interview. On asking the question regarding the workability of the I-GIS-T (on a scale from 1-5) in her class in the future, Teacher 1 answered as follows:

I think five if you have the necessary technology like computers and so on it is definitely workable, because it takes you right from the beginning, not that the teacher first has to take a course before the teacher actually understand it. I think if the teacher just goes once through it, it is sufficient. (P5,16:20)

It should be noted that Teacher 1 is computer literate, and that the I-GIS-T alleviates the barriers posed by complex GIS software, the lack of GIS pedagogical knowledge and teacher time. Teacher 1 is therefore the most likely of the three teachers to use the I-GIS-T in her future classes.

Within the South African context, however, I-GIS-T still requires workable hardware and electricity. Many schools in SA do not have these resources. Nevertheless, many schools do have sufficient hardware, but may struggle to implement GIS practice, and therefore the I-GIS-T

might prove a viable GIS practice option. This notion was tested by asking Teacher 1 if she would promote the I-GIS-T to other Geography teachers. Teacher 1 replied:

I think so, because most Geography teachers or many don't really do this practically usually because they are scared of using new software, or think they won't have the time. But with this, you don't need a lot of time. I think the main thing is that you don't want to spend hours before the time trying to figure out what to do, but with this programme you don't have, even if you have not done it before you can do it with your class. You just do it with them and it is self-explanatory. So it is... ja really a good idea.
(P5,64-68)

The above quotations and discussions are concluded by knowledge claim 2.

Knowledge claim 2:

The I-GIS-T has the potential, to a large extent, to surmount the main barriers Geography teachers face regarding the practical application of GIS within the FET phase.

6.3 ATTITUDE TOWARDS I-GIS-Tand GIS

As Kerski (2009:172) mentions, positive values and attitudes are essential elements for optimal and self-directed learning (chapter 2). This section aims to answer the third secondary research question: *To what extent does the I-GIS-T application influence learner attitude towards GIS within the FET phase?*

6.3.1 Attitude analysis and evaluation

Figure 6.10 depicts complex qualitative patterns regarding the category attitude towards the I-GIS-T application found within this case study. Figure 6.10 is a sub-section (as indicated with nr 3 in blue, top left corner) of the summative network depicted in Figure 6.1.

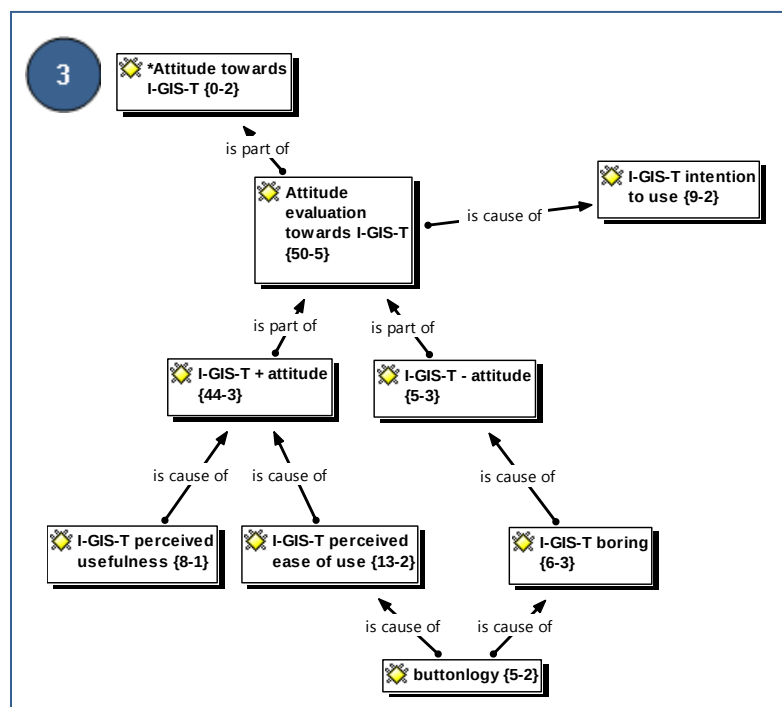


Figure 6.10 Network patterns of attitude towards I-GIS-T

From the findings generated by Atlas.ti™ it was concluded, as seen in Figure 6.10, that the attitude evaluation towards I-GIS-T included both (i) positive and (ii) negative attitudes. Table 6.8 represents some of the evidence in the form of quotations, as gathered from the integrated dataset to further clarify and explain evidence for these aspects which influence students' attitudes. The evidence for each of the codes in Figure 6.10 is set in Table 6.8, by means of quotations gained from the interviews.

Table 6.8 Typical codes and quotations for the category of I-GIS-T attitude

Code	Quotation (<i>verbatim</i>) gained from Teacher 1, Lily, Focus group 1, Focus group 2 and Alice
I-GIS-T attitude evaluation (Attitude towards the I-GIS-T application)	Teacher 1: - Most Geography teachers or many don't really do this practically usually because they are scared of using new software, or think they won't have the time. But with this, you don't need a lot of time. I think the main thing is that you don't want to spend hours before the time trying to figure out what to do, but with this programme you don't have, even if you have not done it before you can do it with your class. You just do it with them and it is self-explanatory. So it is... ja really a good idea. (P5,68:68) Learners: - Lily: When we have the tutorials, I liked it when the speaker like say presses this and I did it, and I could follow that. That was really cool... I can say. (P14,55:55) - Focus group 1: - I think it was very interesting. We could learn more from it. (P13,9:13) - I think it was wonderful. (P13,9:13) - It was special. (P13,9:13) - It was quite interesting. (P13,9:13) - I think the I-GIS-T was a little bit boring. (P13,13:13)
I-GIS-T positive GIS attitude	Did it spark your interest in GIS? (Question from semi-structured interview questionnaire) Focus group 2: - Definitely. (P14,18:20) - Yes, I think it helped like to get some practice on it. (P14,18:20) - It is nice because you can redo it again until you get it right. Because the first time it is like, where did I press again and stuff like that but as you continue you get to improve and get much better and understand much better. (P14,18:20) - Alice: Well because of the many maps and everything, we usually have to have these large maps and you put it and have to find this place and everything and especially in the exams when you are all stressed and everything, you know, you have to find this dot. It gave me a dislike in certain amount of dislike in map work. So when I did THIS, I-GIS-T, I started actually liking map work again... you know because I see there is a use in it actually. Ja... it is useful. (P15,118:119)
I-GIS-T negative attitude	Focus group 1: I think the I-GIS-T was a little bit boring. (P13,13:13)

towards GIS practice	• <i>Was difficult because I didn't understand, don't use computers.</i> (P13,59:59)
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Pseudonyms: Teacher 1, Alice and Lily

According to the interviews and evaluation questionnaires, the majority of learners enjoyed the I-GIS-T. Three of the two learners who did not enjoy the I-GIS-T activity and stated that it was boring for them, experienced difficulties with the logging on of the computer, and/or lacked basic computer skills. Although the majority of learners enjoyed the I-GIS-T activities, some felt that there was no option to explore on their own. In fact, one learner stated that she did not feel in charge of her own learning because she just needed to do what was asked (buttonology). These negative remarks will be further discussed under I-GIS-T perceived challenges (section 6.4.2) and future development (section 6.5).

In order to verify *qualitative* findings (with group dynamics within focus group 1 taken into consideration), *quantitative* pre- and post- GIS attitudinal questionnaires were employed to support the qualitative data, in the attempt to best answer the third research question. The following Table 6.9 reflects the 12 learners' attitudinal change towards GIS. Attitudinal changes were captured during the pre- and post-tests using 5-point Likert scales, where 1 corresponds with strongly disagree, 3 neither agree nor disagree and 5 to strongly agree with statement (Addendum 4.20). The results were analysed by NWU Statistical and Consultation Services by means of SPSS version 20 software.

Table 6.9 Attitude development towards GIS

Statement on attitude to GIS		Pre-test		Post-test		Dependent P-test value	Effect size
		Mean	Standard Deviation	Mean	Standard Deviation		
1	I feel GIS is an important part of the school curriculum	3.42	1.084	3.83	1.193	0.186	0.38
2	GIS thrills me and I like it	3.17	0.718	3.50	1.168	0.737	0.46
3	GIS work is fun	2.83	0.937	3.67	1.371	0.044	0.89
4	I can apply the GIS we learn at school	3.25	0.754	3.67	1.155	0.515	0.55
5	The wide application of GIS gives me a feeling of accomplishment	3.17	0.835	3.75	1.138	0.079	0.70
6	I like GIS because it helps me understand the world around me	2.92	0.900	4.17	0.718	0.335	1.39
7	Looking at GIS data in different ways helps me to learn	3.33	0.888	4.08	0.669	0.423	0.84
8	Using a GIS map to study data helps me to learn	3.92	0.669	4.08	0.793	0.254	0.25
9	GIS is an interesting topic	2.92	1.564	3.75	1.215	0.176	0.53
10	Explaining patterns in GIS data helps me to learn	3.33	1.155	3.83	0.835	0.073	0.43
11	In GIS, explaining why phenomena occur helps me to learn	3.50	0.905	3.83	0.835	0.113	0.37
12	I like working on all types of GIS problems	2.58	1.084	3.75	1.055	0.135	1.08
13	I can analyse GIS data in many different ways	2.25	0.965	3.17	0.718	0.008	0.95
14	I am capable of using GIS to display geographic data	2.83	0.937	3.17	0.937	0.112	0.36
15	I am capable of asking questions to help focus my GIS investigation skills	3.17	1.193	3.37	1.073	0.556	0.42
16	I can draw conclusions from GIS data	2.92	1.443	3.58	0.996	0.260	0.46
17	I am capable of using a map to analyse GIS data	3.08	1.165	3.50	0.905	0.688	0.36
18	I am capable of asking new geographic questions from data that I have drawn from GIS	2.83	1.193	3.50	1.243	0.704	0.56
19	I can study data with the help of GIS maps	3.25	0.965	3.50	0.905	0.872	0.26
20	I like GIS because it presents me with a challenge	3.25	1.215	4.00	1.044	0.503	0.62
21	I have a growing appreciation of GIS through understanding its values, applications and processes.	3.25	1.215	4.00	1.206	0.159	0.62

(Adapted from Huynh, 2009)

As the sample size was only twelve ($n=12$), and not large enough for statistical power, effect sizes were calculated. The effect sizes were employed to determine if there was a practically significant increase in attitude of learners with regard to GIS. Effect sizes are calculated as the standardised difference between means (Cohen's d-values) and is independent of the sample size (Ellis & Steyn, 2003:51). Practical significance indicates a large enough difference to have an effect in practice if d-values of larger than 0.8 and a medium effect if values of 0.5 are obtained (Ellis & Steyn, 2003:51).

Table 6.9 shows 15 out of the 21 statements indicating a medium (larger than 0.4) or large effect sizes (Ellis & Steyn, 2003:53). Interestingly, the I-GIS-T activity influenced a positive attitude development on *all* the questions. According to Table 6.9, the I-GIS-T activity had the greatest impact on question 6: *I like GIS because it helps me understand the world around me*. This specific question also reflects the perceived usefulness of GIS, as reflected within the TAM and discussed in section 2.4.2.

In addition, question 12 showed a large effect size of 1.08 for the statement: *I like working on all types of GIS problems* and question 13 showed a large effect size of 0.95, regarding the statement: *I can analyse GIS data in many different ways*. This indicates that the I-GIS-T exerted a large positive influence with regards to these two statements. Equally important, both these effect sizes indicate that the I-GIS-T activities enhance higher-order thinking skills, as described in section 2.5.5.

An overall positive attitudinal development regarding GIS was observed. Again, because attitude is an essential element found within the TAM, this observed attitudinal shift might project a positive future use of a technology, which in turn reflects the viability of the I-GIS-T. The TAM has been discussed in section 2.4.2. As this model may be employed to project the future acceptance of the I-GIS-T quantitatively for further research, this case study probed, by means of deductive coding, for correspondence in the quotations to the various labels, as included within the TAM, during the analysis of the integrated data set. Figure 6.11 represents a comparison of network patterns regarding attitude towards the I-GIS-T and the TAM.

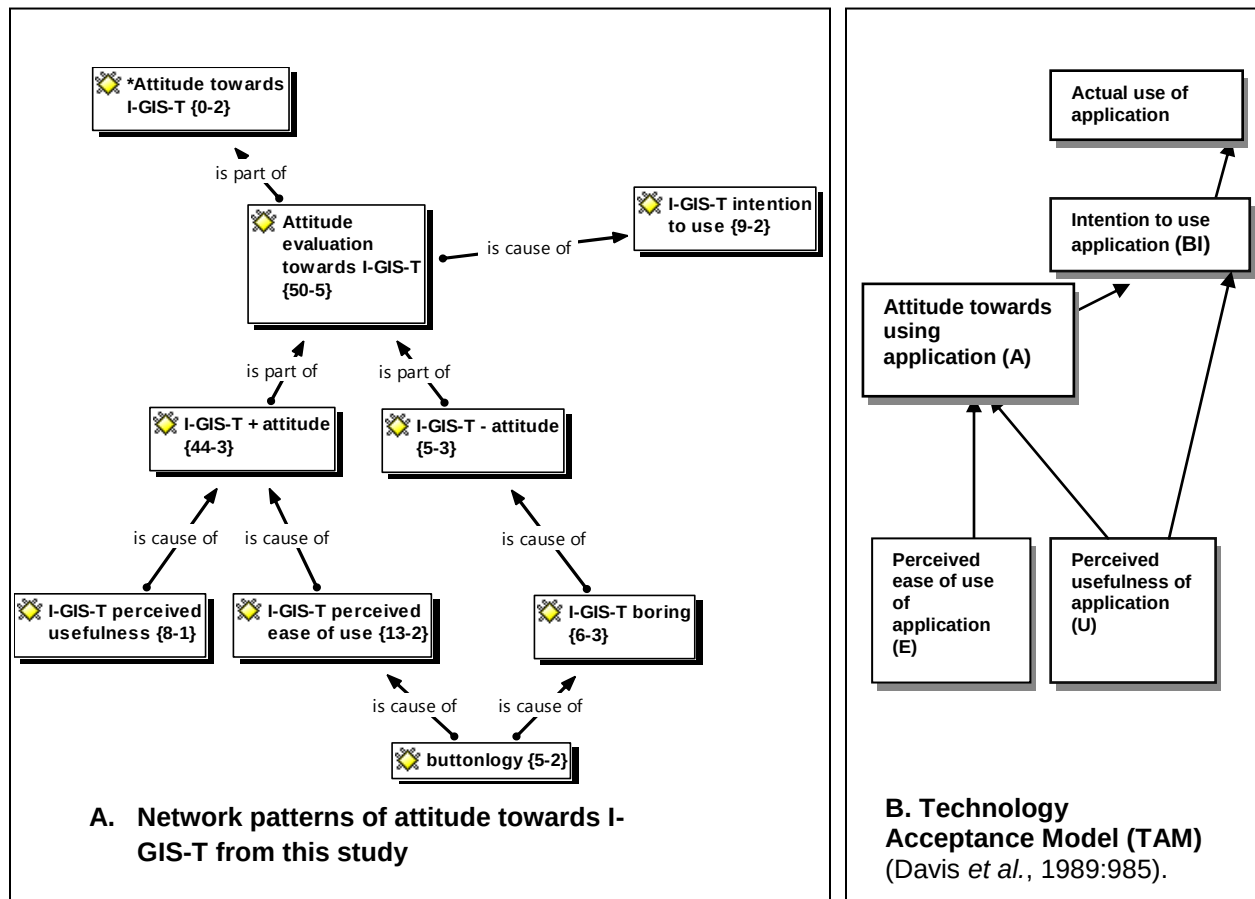


Figure 6.11 Attitude towards I-GIS-T network pattern and TAM comparison

As noted within Figure 6.11B, attitude towards technology plays an integral part in the acceptance of that technology, as proposed within the TAM discussed in chapter 2 under section 2.4.2. According to this model, the attitude towards technology directly influences the intention to use that technology. As the TAM has been verified through numerous *quantitative* studies, this model was used for deductive coding in this *qualitative* study. That is the reason why some labels in 6.11A reflect the labels of the TAM in Figure 6.11B.

Figure 6.11 suggests a correlation between the network pattern of attitude towards I-GIS-T and the TAM. According to the researcher's observation, the perceived I-GIS-T ease of use reflects the findings that the majority of learners found the I-GIS-T activities easy and user-friendly (Table 6.10). From the *qualitative* data it can therefore be concluded that, according to the TAM, the I-GIS-T might project positively towards intentional future use. However, additional supportive quantitative data on attitude progression towards GIS indicates, within the TAM, a possible positive projection towards the future use of I-GIS-T in order to implement GIS practice. Table 6.10 represents some corresponding evidence gained from the integrated data set.

Table 6.10 Deductive codes and quotes corresponding to the technology acceptance model (TAM)

Codes	Quotations (<i>verbatim</i>) gained from Teacher 1, Focus group 1, Focus group 2, Alice and Helen
I-GIS-T perceived ease of use	- Teacher 1: <i>I think the main thing is that you do not want to spend hours before the time trying to figure out what to do, but with this programme, you do not have to, even if you have not done it before you can do it with your class. You just do it with them and it is self-explanatory. So it is... ja really a good idea.</i> (P5,68:68) - Learners: If you think of the user-friendliness on a scale of 1-10 Focus group 1, n=7: 6...6...6...6...8...9...7 Focus group 2, n=5: 10...10...10...10...10 <i>it depends how familiar you are with computers, but as far as I know 10.</i> For you all, are you all right with that? Yes [five learners gave 10].
I-GIS-T perceived usefulness	- Alice: <i>With this activity, it actually brought an interest in me, you know it is actually nice, you know you don't have to buy a GPS and stuff, you can actually go into that and... you know research it yourself and everything .</i> - Focus group 2: <i>It is useful but simple....</i>
I-GIS-T attitude evaluation	What is your feeling regarding this on a scale of 1 to 10? Focus group 1: 10...7...8...7...7...6...7
I-GIS-T intention to use	So you would definitely make use of this maybe next year or so when you have a new class? - Teacher 1: <i>I think so, ja.</i> On a scale of one to ten, how much would you like to use it? - Helen: <i>nine.</i>

Pseudonyms: Alice, Helen and Teacher 1

According to Table 6.10, quotations emerged for each of the labels, as taken up within the TAM. Evidence of each of the codes in Table 6.10 will be discussed further in sections 6.3.2.1 to 6.3.2.4.

6.3.2.1 I-GIS-T perceived ease of use

Focus groups 1 and 2 differed in opinion regarding the ease of use of the I-GIS-T. It was noted in section 4.5.3.2.3 that focus group 1 consisted of some learners who were not familiar with computers, while focus group 2 consisted of computer-literate learners. Basic computer skills of the learners influence the perceived ease of use and therefore also the attitude towards the I-GIS-T. In fact, the two learners who were not familiar with the use of computers chose the textbook as a learning tool instead. Computer literate learners, on the other hand, perceived the I-GIS-T as user-friendly and more stimulating than the textbook and therefore intend to use the I-GIS-T in future, should it become available.

The teacher should therefore facilitate computer illiterate learners, guiding them through the first I-GIS-T activities, until they become familiar with the use of computers during the I-GIS-T. It should be noted here that the I-GIS-T requires only basic computer skills that can be acquired with ease during the first activity, with some guidance from the teacher.

6.3.2.2 I-GIS-T perceived usefulness

The perceived usefulness of the I-GIS-T was noted in the discussion regarding the *advantages* found in section 6.4.1. This includes the following: Support pedagogy, learning (problem solving and self-directed learning), compared overall better than textbook learning, enhancing Geography interest, and future career opportunities.

6.3.2.3 I-GIS-T attitude evaluation

The perceived attitude of the learners and teacher towards the I-GIS-T was discussed in section 6.3. Although there has been an overall positive shift in the effect sizes, as indicated in Table 6.9, two learners stated that they struggled because of computer illiteracy.

6.3.2.4 I-GIS-T intention to use

The qualitative evidence as captured in Table 6.10 positively projects towards future use of the I-GIS-T. Moreover, the grade 11 teacher (Teacher 1) stressed that she does not need to spend hours to figure out how the I-GIS-T software works. She perceived the I-GIS-T as user-friendly and would like to employ the application next year. This teacher also said that she would advocate this application to other Geography teachers.

In view of this discussed evidence, there is an overall positive attitude development after the

use of I-GIS-T. Therefore the following can be stated:

Knowledge claim 3:

The teacher and the majority of the learners reflected a positive attitude towards the I-GIS-T. However, learners who lack basic computer skills reflected a negative attitude towards the I-GIS-T. These learners may need additional assistance during the first activity in order to familiarise themselves with the system.

The I-GIS-T application furthermore enhanced a positive attitude towards GIS and GIS practice within the FET phase.

6.4 PERCEIVED WORKABILITY OF THE I-GIS-T

Workable, as defined in *Webster's encyclopaedic unabridged dictionary* of the English language (1996:2189), within the context of this study, implies the following: Practicable or feasible and capable of or suitable for being worked. In order to answer the fourth research question: *To what extent is the I-GIS-T workable within GIS practice in the FET phase?*, perceived advantages and challenges are weighed against each other. The summative network found in Figure 6.12 presents patterns that emerged regarding the evaluation of the workability of the I-GIS-T category as was generated by the Atlas.ti™ software. This is also a segment (as indicated with green in the top left corner) of the total data network in Figure 6.1.

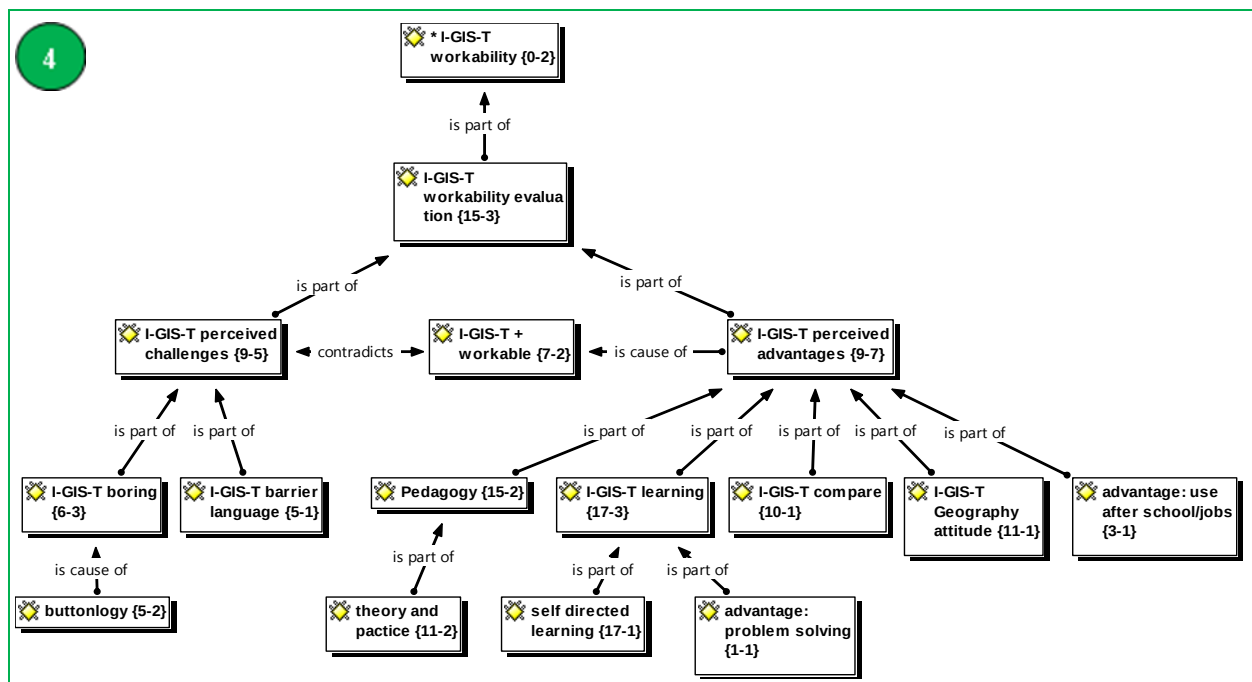


Figure 6.12 I-GIS-T workability

Figure 6.12 portrays (i) perceived challenges and (ii) perceived advantages as main indicators regarding the workability of the I-GIS-T is. The following discussion evaluates the workability of the I-GIS-T. Teacher 1, the grade 11 teacher of this research class, was asked whether the I-GIS-T would be workable (on a scale of 1-5) for her class in the future. Teacher 1 replied as follows:

I think five if you have the necessary technology like computers and so on it is definitely workable, because it takes you right from the beginning, not that the teacher first has to take a course before the teacher actually understand it. (P5,16:20)

Teacher 1 concluded that the I-GIS-T was easy to follow and therefore workable. She also mentioned that as the I-GIS-T is self-explanatory, no course will be needed to train her to use the software. Obviously advantages and disadvantages of the I-GIS-T are weighed against one another and analysed in order to evaluate the workability of the I-GIS-T within the class situation.

In the attempt to answer the fourth research question and ensure a logical order of discussion, this research question will be discussed under the following headings: Perceived advantages/usefulness (section 6.4.1), perceived challenges (section 6.4.2), workability of the I-GIS-T through the eyes of the teacher (section 6.4.3) and the workability through the eyes of the learners (section 6.4.4). Perceived advantages (on the right hand side of the diagram in Figure 6.12) will therefore be discussed first.

6.4.1 Perceived advantages/usefulness of the I-GIS-T

The I-GIS-T activities disclosed a number of advantages within this case study. Figure 6.13 is a section of the summative network pattern in Figure 6.1 gained from the integrated data set.

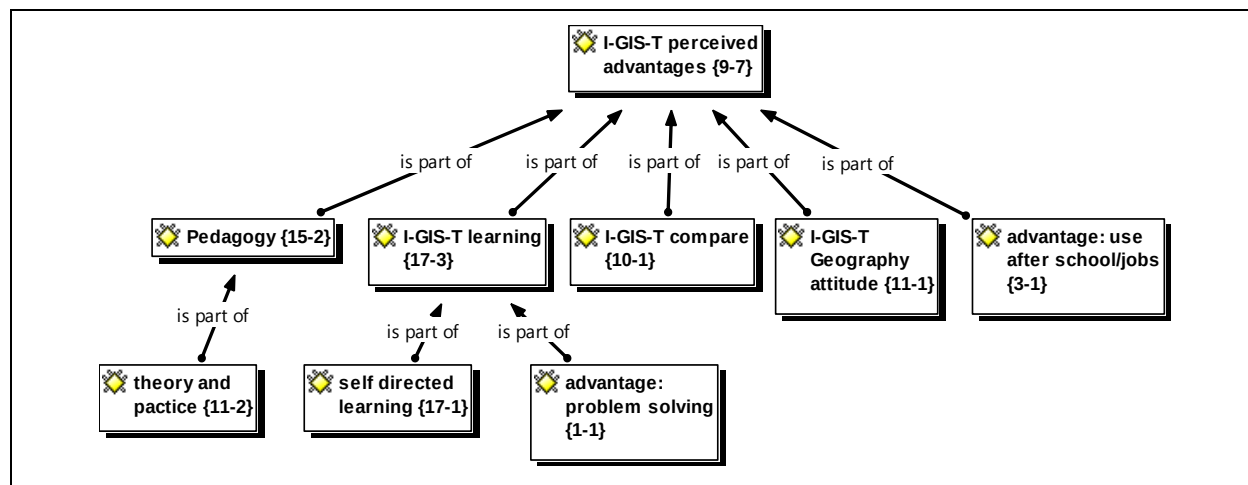


Figure 6.13 Perceived advantages of I-GIS-T

As seen in Figure 6.13, the perceived advantages of the I-GIS-T is ease of pedagogy, self-directed and problem solving learning, positive comparison to other methods of GIS learning, enhancing of attitude towards Geography, and the use of GIS in job opportunities. Table 6.11 provides an overview of the typical evidence from the integrated data set that contributed towards the above network. Each of the perceived advantages is described in added detail hereafter by means of the relevant quotations. Some of the codes in Table 6.11 are further divided (with additional code descriptions) into sub-codes in correspondence to Figure 6.13.

Table 6.11 Typical codes and quotations for the aspect of perceived advantages of the I-GIS-T

Code	Quotations (verbatim) gained from Lily, Alice, Focus group 1 and Focus group 2
Pedagogy Theory and practice - I-GIS-T activities	Lily: <i>I think it would be very nice to learn GIS like this. Like tutorials and then exercises. Because like... for example, if the teacher just speaks, then sometimes we do not know... we don't know what is going on, but this tells you and you can also do as you listen to it... so like you say it is interacting... so I think this way can teach the students much better.</i> (P14,97:97)
I-GIS-T learning	So do you feel you have learned more about GIS through the I-GIS-T activity? Alice: <i>Yes definitely.</i> (P15,97:101)
Problem solving	- Alice: <i>It kind of got a designing and problem solving aspect to it... ja it is both interests...</i> (P15,78:78) - Focus group 2: <i>It is a fast way of being able to solve a lot of geographical problems and it is easy to use with some practice.</i>
Self-directed learning	Alice: <i>... it allows the child to learn while doing it themselves. Because usually in class while you just read it, it does not go in when the teacher teaches it... also more for kinetic and help those that are visual, audio and kinetic learner. This actually agrees for all three.</i> (P15, 24:24)
I-GIS-T compare	When you compare this application with your textbook, the usual way of teaching, how would it compare with that? Focus group 1: <i>Much easier.</i> <i>No, not at all, not for me.</i> <i>Much better.</i> <i>Better, because we could try it out.</i> <i>Better than the textbook.</i> <i>The textbook you just read.</i> <i>I found it much better in the textbook.</i> (P13,51:60 & 60:73)
Advantage: use for Geography	Alice: <i>You know, honestly when you learn GIS, from a book, you memorise it, you make sure you just know enough so that you can pass... for the test, and after the test you forget and one day someone brings this subject up again and you think, ok, o ja GIS and that is that thing with the layers, and you kind of forget everything, but ja With this activity, it actually it had... brought an interest in me, you know it is actually nice, you know you don't have to buy a GPS and stuff, you can actually go into that and... research it yourself and everything.</i> (P15,106:107)
Advantage: use after school/jobs	Alice: <i>No I am not actually one for a certain one career type... you know, I want to do like maybe different projects running... as an entrepreneur making money for the projects, something like that. So, I would not say a career, but I might consider it as part of a project... something like that.</i> (P15,131:131)

Pseudonyms: Alice and Lily

The following sections (6.4.1.1 to 6.4.1.5) each contain a discussion and evidence of the aspects listed in Figure 6.13, with the supported evidence in Table 6.11.

6.4.1.1 Pedagogy theory and practice of I-GIS-T activities

According to literature, teachers experience the pedagogy of GIS practice as a barrier to GIS practice (Rød *et al.*, 2010:34). The I-GIS-T, according to Teacher 1, does seem to ease pedagogy of GIS practice, as illustrated in the following quotation:

...but with this programme [I-GIS-T] you don't have, even if you have not done it before, you can do it with your class. You just do it with them and it is self-explanatory. So it is... ja really a good idea.
(P5,68:68)

6.4.1.2 GIS learning with the I-GIS-T

This section describes whether learning took place in the course of the I-GIS-T activities. During the learner interview, the learners were asked whether they had learned more about GIS through the I-GIS-T activity. Helen, Alice and Lily responded with:

Yes definitely.
(P15,97:101)

Yes definitely [Laughs]. Maybe 10 on a scale of 1-10.

Yes, very much, I have learned a lot.
(P16,158:161)

When asked to rate her learning, during this experience, on a scale of one to ten, Lily's response was:

Ten
(P14,70:73)

It is important to note that although Lily is an under-achiever, the I-GIS-T application did support her learning. Alice, a high achiever, also rated 10 on learning GIS from the I-GIS-T. According to these quotations, it seems that the I-GIS-T caters for both under- and high achievers.

6.4.1.3 I-GIS-T comparison with other teaching learning support material

This class had not used other GIS software before, so the only comparison they could make was with learning GIS from the textbook. Focus group 1 debated this point. Some agreed that the I-GIS-T was much better than the textbook, while two learners chose the textbook instead, as seen in the following quotes.

Much easier.

No, not at all, not for me.

Much better... much better.

Better, because we could try it out.

Better than the textbook.

The textbook you just read.

I found it a bit challenging.

I found it much better in the textbook.

(P13,51:60 & 60:73)

The main cause for this debate seemed to arise from the fact that the two learners were not very familiar with computers themselves as they later pointed out:

*It was difficult because I didn't understand, don't use computers.
Maybe because I don't know how the system works with the thing, so I don't get it.*
(P13,70:73)

Interestingly, although computer literacy is not crucial for the teacher to facilitate the I-GIS-T activities, learners' basic computer skills remain a requirement for handling the I-GIS-T.

6.4.1.4 I-GIS-T advantage: use for Geography

The I-GIS-T makes Geography worthwhile by giving a new vision to Geography, as seen in the following statement from the individual interview with Alice:

It was really worthwhile for me because I learned new things, because you also use computer technology. So I think it gave me vision to more geography and technology. (P14:81:85)

Alice stated that the I-GIS-T renewed an interest in Geography:

With this activity, it actually it had... brought an interest in me, you know it is actually nice.
(P15,107:107)

Lily confirmed, within the individual interview, that the I-GIS-T also renewed her interest in Geography:

It made my heart happy and very interesting in doing Geography... yes... just to do something to do with GIS...
(P16,209:209)

According to the statements above, the I-GIS-T has the capacity to spark interest in Geography within all achievement levels.

6.4.1.5 I-GIS-T advantage: use after school/jobs

During the individual interview Alice confirmed that after having used the I-GIS-T, although she would not go into GIS for a career, she would consider the use of GIS as part of a project.

No I am not actually one for a certain one career type... you know, I want to do like maybe different projects running... as an entrepreneur making money for the projects, something like that. So, I would not say a career, but I might consider it as part of a project... something like that.
(P15,131:131)

Focus group 2 also mentioned the prospect of furthering GIS studies as enrichment activities for gifted learners, leading to projects within their communities.

And with the nice thing if you could put that to GIS and maybe you have an excellent idea that they could do in a city like Durban that you can go in there and maybe add a reservoir somewhere and something, and then you can even maybe give that to a municipality, so that they can observe that because it would be of those specific surroundings around them, that they can observe that and the benefits and have an idea of what it will be like. (P14,144:144)

The I-GIS-T has, according to the quotations, made the learners realise the usefulness of GIS.

6.4.2 Perceived challenges of the I-GIS-T

This section elucidates the perceived challenges of the I-GIS-T as part of I-GIS-T workability evaluation (Figure 6.13) in the attempt to partly answer the fourth research question. The network of patterns regarding the perceived challenges in Figure 6.14 emerged from the integrated data set analysis.

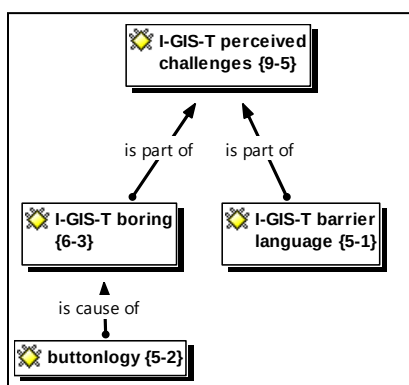


Figure 6.14 Perceived I-GIS-T challenges

As seen in Figure 6.14, two major I-GIS-T challenges are that some learners stated that they found it “boring”, and some experienced language difficulties. Quotation evidence supporting the codes within Figure 6.14 is portrayed in Table 6.12.

Table 6.12 Typical codes and quotations for the aspect of perceived I-GIS-T challenges

Code	Quotations (<i>verbatim</i>) gained from Focus group 1 and Alice
I-GIS-T perceived challenges	Focus group 1: • <i>Maybe because I don't know how the system works with the thing, so I don't get it.</i> (P13,60:60)
I-GIS-T boring	Focus group 1: • <i>I think the I-GIS-T was a little bit boring.</i> (P13,13:13) It is good; we need to have interaction...Why would you say it was boring? • <i>There were many chapters.</i> (P13,16:16) Focus group 1 Who also felt it was a little bit boring? You too? • <i>It was boring because, I don't like GIS. I found it boring.</i> (P13,19:20) • <i>We couldn't understand one of the questions, like the one with the raster and the vector... we did not understand we never learnt it before.</i> (P13,19:20) Would you listen to it again to understand it better? • <i>Yeah.</i> • <i>Maybe.</i> • <i>I found it a bit challenging.</i> • <i>Was difficult because I didn't understand, don't use computers.</i> (P13,27:31) In what way can one improve this to make it not boring? • <i>Give more explanation and more time.</i> • <i>More activities.</i> • <i>More nice pictures.</i> • <i>It must be simple and understandable.</i> • <i>The speaker was speaking too fast.</i> (P13,27:31)
I-GIS-T buttonology	How did you feel while working with the I-GIS-T? Alice: • <i>...a bit like, click this...click that...o oops, I think I forgot that one, but on the other hand it was... wow these people must be geniuses who actually make this or... the input that is put in... to make those to have this programme.</i> (P15,121:125)
I-GIS-T language	Do you think the I-GIS-T is user friendly? Focus group 1: • <i>No, because of language</i> (P13,134:135) Why? • <i>Some people don't understand English, and... so it's a bit confusing... because everything is in English [some did not agree with her]. I am serious.</i> Ok, she said she is serious. Are you speaking about yourself or for other people that might not understand? • <i>No, I am speaking in general.</i> So yourself, you could understand? • <i>Yes.</i> (P13,134:146)

The following sections (6.4.2.1 to 6.4.2.3) provide a discussion for each of the codes listed in Figure 6.14 and the supporting quotes in Table 6.12

6.4.2.1 I-GIS-T boring

Three learners stated that the I-GIS-T activities were a bit “boring”, although the majority of learners enjoyed it. Upon further investigation regarding the reason for this, two main reasons surfaced. Firstly, two of the learners had struggled to manage the computer. One of these learners had had problems logging on, while the other was not computer literate. Within the group dynamics of the focus group the learner who had struggled the most with the computer stated it was boring, because she did not “know the system”. It is important to note that learners must at least have some basic computer skills when attempting the I-GIS-T. This coincides with Teacher 1’s view as shown by her statement in the pre-interview, that learners will need computer skills for GIS practice, and that in some rural schools (where there are still many without electricity) computer literacy is absent. She remarked:

The only barrier that might happen is when the learners are not familiar with a computer. Because it does not go fast, but if you have not really used computers before it will be completely Greek. But I think by grade 11 you should be able to use it. Although in a rural school it won’t work. They first need to learn how to use the computer... (P5:44:44)

Another reason why some learners found it boring is because the I-GIS-T does not support exploring possibilities. This came through when the top Geography achiever shyly admitted in the Focus group 1 interview that

...the I-GIS-T is a little bit boring. (P13,13:13)

Although it is crucial to first learn the basics (learning *about* GIS), gifted learners desire opportunities to follow their own route of discovery. In fact, this yearning came out strongly within the following discussion with the largely computer literate Focus group 2:

Definitely, I would also use it, if it has the exploring side to it. (P14,123:124)

You must be able to explore, but like he said you must be able to work on simple computers... some people at their homes, they don’t really have advanced laptops and computers so that it must be very broad but simple... and not too advanced that old computers can’t use it. Because at the school, you maybe have a nice computer but at home, you have old ones. (P14,123:124)

Because you might get learners that really excel. And then they can get rewarded properly or nicely and you can encourage them to excel even more and to get closer and get to know better the big main GIS. (P14,129:129)

Something else, maybe if this thing could be developed in such a way that it is used for people that is interesting, like boys for engineering and stuff like that... and courses like 3 months courses and certificates and stuff like that. That people can use for further study.

(P14,130:130)

Yeah good idea, you could also get... credit, that the university knows you have done GIS, and maybe even a rating, that they can see how well you have excelled in GIS, and that you have done it.

(P14,132:132)

From the above extracts, it became clear that gifted learners also felt bound by an inflexible curriculum system. Moreover, according to my observation, they yearn for GIS opportunities to contribute towards their communities, as suggested by the following statements from Focus group 2:

Because you have some young children that are really talented, or not necessarily even talented, but get a bright idea that has been overlooked or something and then... even though they don't want to do it they can at least get a plan of how it would work and how it would look like...

(P14,146:146)

Maybe you have an excellent idea that they could do in a city like Durban that you can go in there and maybe add a reservoir somewhere and something, and then you can even maybe give that to a municipality, so that they can observe that because it would be of those specific surroundings around them, that they can observe that and the benefits and have an idea of what it will be like.

(P14,144:146)

Through these quotations, it became evident that learners would like to explore GIS further and not just remain with the basic knowledge of GIS. Critical spatial thinking implies data manipulation processes, analysis, data mining and modelling, that provoke and require critical thinking (Goodchild & Janelle, 2010:8), in contrast to buttonology (section 3.2). Consequently, buttonology is a cause of boredom.

6.4.2.2 I-GIS-T buttonology

Although learning *about* GIS is the common approach found in Geography classrooms today (Chun, 2008:32), this type of learning pilots the learner away from the actual learning of geographic concepts to a type of buttonology while focusing on the technological skills of GIS (Barcus & Muehlenhaus, 2010:364; Marsh *et al.*, 2007:697). In fact, some learners experienced a measure of boredom during the I-GIS-T activities, as noted in the following quotations:

But it was kind like a spoon-feeding... first they click, and then you must click...
(P13,91:91)

Yes, not the step by step thing that you just do it and then you just go and make whatever.
(P15,95:95)

Others, though, enjoyed this procedure, as can be seen from the following remark:

Also when the person was explaining, I like it to try it out, one by one... you click again, it was nice.
(P13,90:90)

Although scholars argue that learning about GIS basics requires buttonology, a shift to learning *through* GIS is important, not only to learn Geography concepts but also to lessen boredom experienced by button-pushing. The following quotation from Focus group 2 highlights the interest of learners to move beyond buttonology.

...it is another pity, that it is so short, it is an hour, or hour and a half, two hours and then it is over, and that is basically all you get and like I said you get a small piece of it, so if you could take it home and you could explore a lot more and have a lot more time with it and learning the GIS getting to know it.
(P14,116:116)

It should be noted, however, that the I-GIS-T mainly aims to teach the basic GIS practice concepts and to spark an interest in GIS. Inclusion of exploring activities and learning through GIS are discussed under future I-GIS-T developments, in section 6.5.

6.4.2.3 I-GIS-T language

During Focus group 1 interviews, one learner stated that language could arise as a challenge. Although this particular learner stated that she understood English, she made the statement that many do not. This statement led to the recommendation to integrate other languages within this multimedia in future.

Within the digital-divide context of South African schools (section 3.6), IT resources are scarce in rural areas. Furthermore, this case study includes a wide spectrum of learners, incorporating

both rural and privileged backgrounds. Having to cater for all these types of learners, makes GIS practice even more challenging. It should, however, be noted that the I-GIS-T application enables self-paced learning, while the teacher can facilitate those who struggle to understand the computer system. It is important to note that only basic computer skills are needed to operate the I-GIS-T. However, for a computer sub-literate teacher, this might not pose any threat at all.

6.4.3 The workability of the I-GIS-T through the eyes of the teacher

During the post-teacher interview the grade 11 teacher (Teacher 1) stated that she would definitely use the I-GIS-T application in the future. Although she is computer literate, she mentioned that she does not have the time to go through the school's GIS package (Arcview3.3) again to familiar herself with it. Her rating for the workability of the I-GIS-T application was 5 out of 5, which was the highest possible. Teacher 1 motivated this rating as follows:

It is definitely workable, because it takes you right from the beginning, not that the teacher first has to take a course before the teacher actually understands it. I think if the teacher just goes once through it, it is sufficient. I think five.
(P5,16:20)

In addition, Teacher 1 observed that all the learners in her class enjoyed the I-GIS-T application. She confirmed that she would like to use the application and would like to refer it to other Geography teachers:

...ja, but other than that, I think it is very clear and interesting all the learners seems to enjoy it, and it is much better than just the textbook version, which is very theoretical and can be confusing to the learners.
(P5,44:44)

When Teacher 1 was asked if she would promote the I-GIS-T to other Geography teachers she answered in the affirmative:

I think so, because most Geography teachers or many do not really do this practically usually because they are scared of using new software, or think they will not have the time. But with this, you do not need a lot of time. I think the main thing is that you do not want to spend hours before the time trying to figure out what to do, but with this programme, you do not have to, even if you have not done it before you can do it with your class. You just do it.

This evidence as captured in the quotations, points towards a positive workability, through the eyes of the teacher. This concludes the first part of knowledge claim 4 regarding the workability of the I-GIS-T through the eyes of the teacher (see section 6.4.5.)

Knowledge claim 4a:

According to the grade 11 teacher, the I-GIS-T is to a large extent workable, within the FET phase Geography class.

with them and it is self-explanatory. So it is... ja really a good idea.

(P5,68:68)

6.4.4 The workability of the I-GIS-T through the eyes of the learner

An I-GIS-T evaluation questionnaire was completed by the learners after each I-GIS-T activity. This questionnaire contained a five point Likert scale as well as open-ended questions. Point 1 on the Likert scale indicates a strong disagreement with the statement, whereas point 5 indicates a strong agreement, as seen in Table 6.13

The majority of the evaluations scored either a four or a five on the Likert scale, which implies an agreement or a strong agreement with the statement. This quantitative data provided support and triangulation possibilities with regards to qualitative data gained from interviews and the open-ended part of this questionnaire. For instance, the scores that reflected a *disagree* or *definitely disagree*, came from the learner who was not computer literate and the learner who experienced problems to log on the computer, as discussed previously under section 6.4.2.1.

Table 6. 13 I-GIS-T evaluation questionnaire

A - Introduction: (1:30)	1	2	3	4	5
The introduction was clear.	0	1	1	8	2
The graphics supported my gaining of understanding of GIS.	0	0	5	5	2
Any comment/thought?	<i>"Very clear and understandable." "Understandable!" "It was not as clear as it could have been." "Excellent." "The introduction was clear." "Lips to close to mike"</i>				
B - Tutorial 1: (12 min)	1	2	3	4	5
This tutorial explained GIS in a clear way.	0	0	2	8	2
The graphics supported my gaining of understanding of GIS.	0	0	2	5	5
Any comment/thought?	<i>"Speechless." "Graphics used, caught my eyes and made me to understand more easily." "I like the thing that could participate while listening," "Some picture which had letters were cracked." "Good, too long though." "GIS is used in many different ways." "It was a good start." "Interesting!"</i>				
C- Exercise 1: (03:00)	1	2	3	4	5
I gained GIS skills from this exercise.	0	2	1	5	4
The graphics supported my gaining of understanding of GIS.	0	1	3	5	3
Any comment/thought?	<i>"I enjoyed it very much." "It is difficult." "It was fine." "It did not work. (I wanted to do it!)" [technological problem]. "Helps one learn quickly." "it is nice to have exercise." "It was very exciting!!"</i>				
D- Tutorial 2: (5:30)	1	2	3	4	5
This tutorial explained GIS in a clear way.	0	1	0	8	3
The graphics supported my gaining of understanding of GIS.	0	0	0	8	4
I gained new insight in GIS	0	1	1	4	6
Any comment/thought?	<i>"Brilliant." "This was the most wonderful and interesting to do." "Excellent." "Nice explanation". "Interesting."</i>				
E – Exercise 2: (2:30)	1	2	3	4	5
I gained GIS skills from this exercise.	0	0	1	6	5
The graphics supported my gaining of understanding of GIS.	0	1	3	5	3
I gained new insight in GIS.	0	0	1	9	2
Any comment/thought?	<i>"good accuracy, starting to understand" "It was ok" "questions too easy" "It was quite difficult for me"</i>				
F- Tutorial 3: (6:00)	1	2	3	4	5
This tutorial explained GIS in a clear way.	1	1	0	7	4
The graphics supported my gaining of understanding of GIS.	0	0	0	7	5
I have gained new GIS insight during this tutorial.	0	0	1	9	2
Any comment/thought?	<i>"I am serious" [this learner marked all 5]</i>				
G- Exercise 3: (2:15)	1	2	3	4	5
I gained GIS skills from this exercise.	0	2	1	6	3
The graphics supported my gaining of understanding of GIS.	0	2	1	5	4
Any comment/thought?	<i>"this was wonderful" "I had a problem doing this exercise" [software did not want to register the click]</i>				
H- Exercise 4 (2:00)	1	2	3	4	5
I gained GIS skills from this exercise.	0	1	1	5	5
The graphics supported my gaining of understanding of GIS.	0	1	0	6	5
I have gained new GIS insight during this tutorial.	0	1	1	7	3
Any comment/thought?	<i>"It was enjoyable and easy to follow." Good ending." "This tutorial and exercise gave me more information about GIS." "Quite challenging but nice! "I am a bit shaky on this one as it seems pretty complex at first. It is good that I did the exercise myself to ground the info."</i>				

As seen in Table 6.13, the comments gained from the I-GIS-T activity evaluation were mostly positively towards the I-GIS-T. However, some negative remarks were also received. Table 6.14 summarises both positive and negative remarks.

Table 6.14 Typical codes and quotations for the category of workability of I-GIS-T

On the positive side	On the negative side
• <i>I think this is excellent. Genius. However, as young minds do forget easily I will add more exercise and a space where they can create their maps anywhere in the world (But of course that is for the way-in-the-future reference).</i> • <i>It is a wonderful part of Geography that I would definitely invest myself in.</i> • <i>A nice thing on computer. At the end, I got some interest after thinking it was boring. Got to understand what this GIS is about...</i> • <i>Enjoyed the exercises and some of the tutorial especially Tutorial 3.</i> • <i>It is interesting to learn about GIS.</i> • <i>NICE WORK TO LEARN ABOUT.</i> • <i>It is a fast way of being able to solve a lot of geographical problems and it is easy to use with some practice.</i> • <i>Very effective way of working.</i>	• <i>It was not as clear as it could have been.</i> • <i>Lips too close to mike.</i> • <i>It did not work. (I wanted to do it!) [Technological problem].</i> • <i>It was quite difficult for me.</i> • <i>I had a problem doing this exercise [software did not want to register the click].</i>

From table 6.14, the following conclusions were drawn. On the positive side, analysis of the video clips of the I-GIS-T activity suggests that all the learners were intrigued by the activities. Here and there some learner raised their hands for help. After facilitation, the learners could again, continue on their own. The main problem that arose was that some learners did not know how to close the current activity, in order to open the next. Obviously, facilitation was therefore mainly needed within the first activity. After the first activity, all the learners were able to manoeuvre through the activities themselves. This activity eased the pedagogical barrier for the teacher, and the teacher was more than happy to make use of the I-GIS-T. On the negative side, some learners experienced some technical problems. One learner struggled to log on and another was held up with a mouse click that did not want to register within the I-GIS-T. One

learner in particular was not computer literate (coming from a rural background) and therefore experienced difficulties. Analysis of these findings pointed to the question of how learners of different achievement levels will experience the workability of the I-GIS-T.

In order to differentiate between the different achiever levels, three learners were sampled from the high, average and low achiever groups. All three learners also represented a different culture group. Interviews with these learners supplied more in-depth insight on the workability and viability of the I-GIS-T as viewed from the learner's perspective.

Table 6.15 represents more qualitative evidence gained from the three one-one-one learner interviews, regarding the workability of the I-GIS-T. Moreover, Table 6.15 depicts evidence regarding the workability of the I-GIS-T as perceived from different achievement levels.

Table 6.15 Semi-structured one to one learner interview after the I-GIS-T activity

Interview questions	Lily (under-achiever)	Alice (average achiever)	Helen (high achiever)
Description of grade 11 learner	Lily is a Zulu girl with a friendly smile. The teacher mentioned to me before that she is an under-achiever . She seems excited.	Alice is an Afrikaans learner and seems to be unsure about herself, but very willing to share her insights. I soon realised that this learner craves additional stimulation. The teacher informed me that she has been a 60% scorer but lately her marks start to pick up.	Helen is Korean, and speaks English well. She was second in the Geography class and scored on average 90% .
Complete the following phrase: I think the I-GIS-T is....	<i>Wonderful Miss, it just takes you to do the practical, actual thing, makes you, out there, thinking, how to and everything.</i>	<i>It allows the child to like learn while doing it itself. Because usually in class while you just read it, it does not go in when the teacher teaches it also more for kinetic and help those that are visual, audio and kinetic learner. This actually agrees for all three.</i>	<i>I think the I-GIS-T is fun activity to do in school.</i>
Have you used GIS software before?	No	No	<i>I used Google Earth once before and I found that very interesting.</i>
What GIS technologies did you use?	Not applicable	Not applicable	<i>Google Earth, I did not know about GIS but just used it, but this application it taught me step by step and actually gave me more information about GIS</i>
How do the I-GIS-T compare with other GIS learning methods?	<i>Textbook, we did not do it practically, chooses the I-GIS-T</i>	<i>I could understand much better, I mean I knew how they did it and everything, but did not know how it could actually do it practically you know. Whether actually, you actually use papers, and I just thought this is confusing, ok this is paper number one, on top of that, ok now you have to make sure this is all in correct and everything and so in comparison with this, it is much easier.</i>	This question was not asked during the interview.
Complete the following: When working with the I-GIS-T, I liked ...	<i>...you had to find out something .I can't remember, you have to find out how to put something you had to first</i>	<i>I liked especially comparing the maps of different times, where you can just make a outlining the perimeter putting the modern day on top and see... or underneath and see how much it increase, you know it ja it kind of got a designing</i>	<i>...when we have the tutorials, I liked it when the speaker say press this and I did it, and I could follow that. That was cool. I can say.</i>

	<i>measure the hockey field, we first need to measure the hockey field and then you need to put something cannot remember correctly</i>	<i>and problem solving aspect to it. Ja it is both interest</i>	
Complete the following: My biggest challenge when doing the I-GIS-T activities was...	<i>...to make my own map.</i>	<i>...well there was one thing, the window of the [screen] ...was just a bit out, and so the file could not really been seen... but that was about it. I mean it is just a small thing. I mean I could still click on file, it is about it, I could not find anything else.</i>	<i>...because I am not really used how to start at first but as I continued I got used to how to open the files.</i>
Did you feel in charge of your own GIS learning experience while doing the I-GIS-T activity?	<i>yes miss, I felt SO in charged [satisfied laughter], I could actually teach myself at that.</i>	<i>Not really, because it is a tutorial it is like press this button then press that button and press that button and so just press it and it is highlighted.</i>	<i>I felt, because, we just did the tutorial for the first time, even though there might be some things we did not know, still but when doing the exercise, I thought, Oh I did not know about this. Now I can learn more specifically.</i>
Do you feel you have learned more about GIS through the I-GIS-T activity?	<i>Yes, very much, I have learned a lot. I have learned how to make my own map, what is and how I can use GIS in real life, and everything.</i>	<i>Definitely, yes definitely. [laughs]</i>	<i>Yes definitely [Laughs] Maybe 10 on a scale of 1-10</i>
To what degree do you think the I-GIS-T activity was worthwhile?	<i>[laughter]... it could have been three hours or four.</i>	<i>because of the many maps and everything, we usually have to had like....to have this large maps and you put it and have to find this place and everything and especially in the exams when you are all stressed and everything, you know, you have to find this dot. ..As I do not know, it gave me a dislike in certain amount of dislike in map work...and I liked other parts of Geography much more. So when I did THIS, I-GIS-T, I started actually liking map work again...you know</i>	<i>It was worthwhile for me because I learned new things, because you also use computer technology. I think it gave me vision to more geography and technology.</i>

		<i>because I see there is a use in it actually. Ja... it is useful.</i>	
How did you feel while working with the I-GIS-T?	<i>it made my heart happy and very interesting in doing Geography... just to do something to do with GIS and everything.</i>	<i>...a bit like, click this...click that... o oops, I think I forgot that one, but on the other hand it was ...wow these people must be geniuses who actually make this or... the input that is put in... to make those to have this programme.</i>	<i>I felt very much excited, that I enjoyed doing this, tutorials and exercise, yes. On a scale from 1-10 learner enjoyed it at 8</i>
What future recommendations do you have regarding GIS activities in class?	<i>the computer</i>	<i>Just more activities... yes, and if they could go deeper into the thing, you know...if a tutorial could tell you like... about other tools as well and everything, but as the tutorial was now, it was really very good. You know, you learned a lot in that one hour. Ja.</i> <i>I would actually like it a lot... I think, I think it would make me motivated to do Geography now.</i>	<i>I think it would be very nice to learn GIS like this. Like tutorials and then exercises. Because like example, if the teacher just speaks, then sometimes we do not know... we don't know what is going on, but this tells you and you can also do as you listen to it... so like you say it is interacting... so I think this way can teach the students much better.</i>
To what degree would you like to use the I-GIS-T at home as well?	<i>yes, to make my own maps, to overlap the things...I would LOVE to</i>	<i>If I have to listen to it, again... I think... I would not, because I think I understood it. But I LIKED the programme.</i>	<i>Maybe I can just do by myself... when I do not have anything to do... and want to keep myself busy. Maybe I can take the file and do it at home and look for more things. On a scale of 1-10 learner chose 9.</i>
Any other comments?	<i>Miss can we please use I-GIS-T next year?</i>	No other comment.	<i>One thing, that the score for how we like the exercise... when I did the exercise and got 70% something I did not like to see, "you have failed." [Laughter]</i>

(Pseudonyms: Lily, Alice and Helen)

As noted in Table 6.15, all three the learners from different achievement levels enjoyed the activities, although one learner stated that she would have liked it if she were able to explore more on her own. In order to see whether all the learners in this study perceived the I-GIS-T as workable, two focus group interviews were conducted. As the grade 11 Geography class consisted of 12 learners, two groups of five and seven learners were interviewed. (Sound files of these Focus group interviews are found in Addenda 4.17 and 4.18). This section concludes with the knowledge claim regarding workability of the I-GIS-T according to the learners.

6.4.5 I-GIS-T workability against GIS practice barriers and knowledge claims

It is of paramount importance for the viability of the I-GIS-T application to overcome the main GIS practice barriers. This section will therefore discuss the I-GIS-T application against faced GIS practice barriers. Finally, this section will present knowledge claim 4 regarding the workability of the I-GIS-T application within FET phase Geography. Knowledge claim 4 is divided in two parts, the workability of the I-GIS-T according to the teacher (4a) and learners (4b) of the I-GIS-T. This is done in order to evaluate the workability from both groups.

6.4.5.1 I-GIS-T surmounting GIS practice barriers

After analysing GIS practice barriers in this case study, the following *summary* (Figure 6.15) for understanding the barrier forces regarding the implementation of FET phase GIS practice in developing countries was constructed based on the theoretical framework of Draper's model for ICT use for developing countries (Draper, 2010:208) described in section 2.4.3.

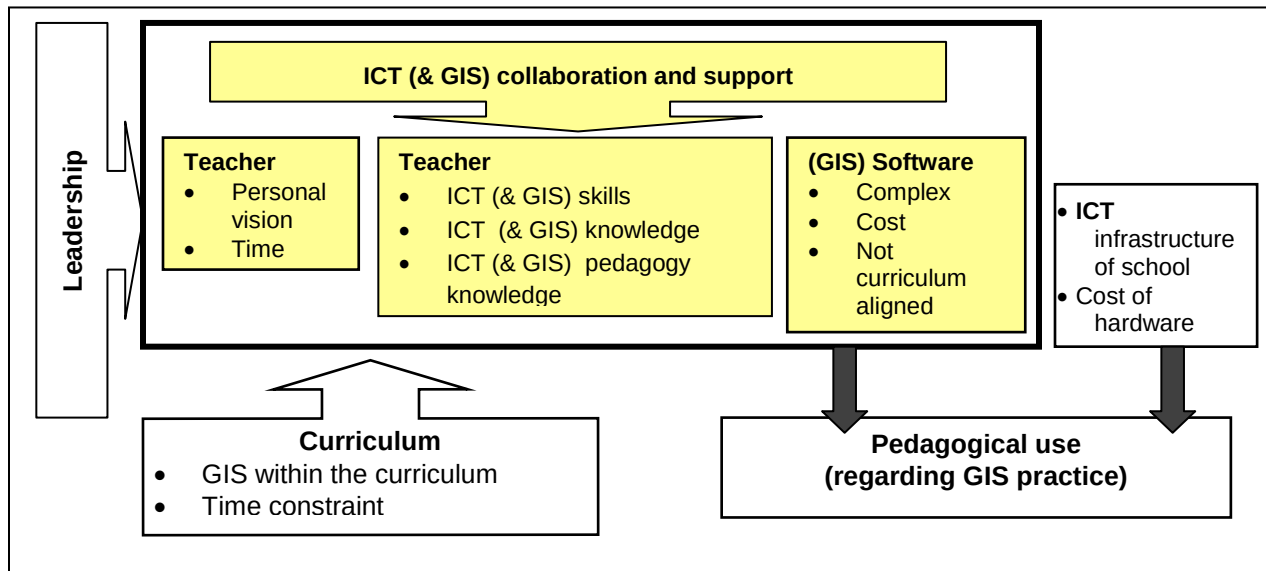


Figure 6.15 Summary of educational GIS practice implementation for developing countries adapted for GIS from Draper (2010:208)

The features of the I-GIS-T surmount some of these barriers faced, as seen within the rectangle, which incorporates the yellow blocks, as presented in Figure 6.15. The yellow blocks depict the four problem areas regarding to GIS practice. These barriers depicted in Figure 6.15 emerged during the analysis regarding GIS practice barriers given in section 6.2. Because the I-GIS-T has the potential to circumvent the highlighted barrier areas indicated in Figure 6.15, the I-GIS-T seems to be according to this summary, workable within GIS practice, to a large extent.

Moreover, the following two sub-knowledge claims drawn from section 6.4.3 and section 6.4.5, affirm the workability of the I-GIS-T during GIS practice.

Knowledge claim 4a:

*According to the grade 11 **teacher**, the I-GIS-T is to a large extent workable, within the FET phase Geography class.*

Knowledge claim 4b:

*According to the majority of **learners**, the I-GIS-T application is to a large extent workable, within FET phase Geography class.*

These knowledge claims conclude this section regarding the workability of the I-GIS-T application.

6.5 FUTURE I-GIS-T DEVELOPMENTS

As developments in educational GIS software and hardware continue to exert a positive influence on future GIS practice in schools (Kerski, 2009:346), future developments of the I-GIS-T were also explored. This section aims to answer the fifth secondary research question: *How can the I-GIS-T be developed further to enhance GIS practice within the FET phase?*

In order to best answer this research question, a network pattern will be provided (Figure 6.16), with corresponding tabled evidence (Table 6.15) followed by a brief discussion (section 6.5.1 to 6.5.5). Figure 6.16 is a segment (as indicated with nr 5 in light blue) of the summative network in Figure 6.1. Moreover, Figure 6.16 depicts the network regarding the category, future development of the I-GIS-T application, as generated from the findings through Atlas.ti™.

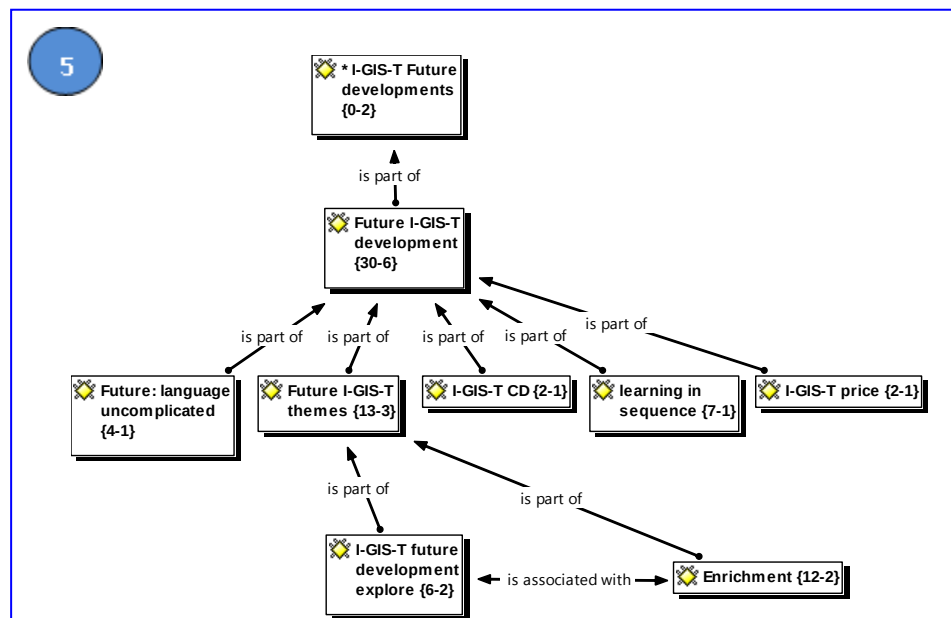


Figure 6.16 Future I-GIS-T developments

Within the network of Figure 6.16, various aspects contributed towards the future development of I-GIS-T. These aspects include: (i) future language uncomplicated, (ii) future I-GIS-T themes, (iii) I-GIS-T CD, (iv) learning in sequence and (v) I-GIS-T price. Table 6.15 represents some quotation evidence that emerged from the integrated data set regarding the category, future I-GIS-T developments especially from the teachers and the two focus groups.

Table 6.16 Typical codes and quotations for the category of future I-GIS-T development

Code	Quotations (<i>verbatim</i>) gained from Teacher 1, Focus group 1, Teacher 3 and Focus group 2
Future: language uncomplicated	• Teacher 1: <i>The language should also not be too complicated, if we had a software package. (P9,179:179)</i> • Focus group 1: <i>If only they can slow down the person who talks... it was too fast. (P13,31:31)</i> How would you feel if we think of the language if there is maybe a button we could press for Zulu...? • <i>Perfect.</i> • <i>Then I will understand much better. (P13:153:153)</i>
Future: I-GIS-T themes and enrichment	• Teacher 1: <i>GIS, but it could be linked to themes, maybe... that you do not think of GIS separately but link it to map work or link it to maybe resources and that you study those topics but using GIS. (P9,131:131)</i> • Teacher 3: <i>We can't spend more than... 2 hours, 3 hours maximum in matric. Unless we incorporate it in a very clever way into the others, that it is just not an extra thing that we are doing at the end but they do but it is a learning tool as part of the syllabus. (P11,121:121)</i> • Focus group 2: <i>Maybe if you could add more aspects to the GIS. So that you have a broader view of everything so that is involved with GIS, not just rainfall... (P14,106:106)</i> • Focus group 2: <i>it is another pity, that it is so short, it is an hour, or hour and a half, two hours and then it is over, and that is basically all you get and like I said you get a small piece of it, so if you could take it home and you could explore a lot more and have a lot more time with it and learning the GIS getting to know it. (P14,116:116)</i>
I-GIS-T CD	How would you feel if you you've got a textbook with a CD coming with it? • <i>Nice.</i> • <i>That would be nice.</i> • <i>You can go listen to it after school and compare the textbook.</i> • <i>Yes.</i> • <i>Yes... I think it would be very nice because people learn in different ways, some people learn like visual learners and audio learners and other people would just read things and it will be able to work for many different learners, especially for those that find reading a book very boring. They would also be able to go home and also work on what they can see and what they can hear. And what is also nice is that</i>

	<i>you can actually go further than what other children do in class and you are not just stuck to the borders of the classroom as many children find it like that that when you have in a subject, that maybe this is the border of what you really are good at and in other subjects you find it difficult. And with this you would just like to go further and work on more things.</i> Would you go to the computer after school in your own free time to use it? • <i>Yes.</i> How many of you would use that? • <i>All of us.</i> What would you like to have on that CD? • <i>GIS.</i> • <i>Work with GIS.</i> • <i>I think for me that explanations would work and then I could get the textbook with the activities.</i> • <i>How things are done, book is just reading, but in a computer there are movements... it is quite easier.</i> Something else? Let's give everybody a chance... • <i>Explanations and more practical things.</i> • <i>A game.</i> (P13,252:271) – Focus group 1
Learning in sequence	• Teacher 1: <i>I think it really should explain everything step by step. (P9,161:161)</i> • Teacher 3: <i>Very things that build up gradually over time, not starting with something difficult, but to start at the basics. And make sure that the basics are really established... before going on. (P11,147:147)</i> • Teacher 1: <i>It must not focus on teaching the learner what each feature on the program means, because.... then they will try to remember that and will still not know how to apply it. So that is like basic vocab, first you learn about it, and then you learn how to use it, or to apply something... So it must not just be to teach them how the program works... (P9,222:222)</i>
I-GIS-T price	• Teacher 1: <i>Well I think firstly, if schools have to buy it, it will be quite expensive. (P5,74:74)</i> • Teacher 3: <i>Another barrier is price... of the software. I don't only think for us, but also for other schools. Private schools would have no problem</i>

	<i>usually but public schools, and for us, we almost fall under that category as finances are concerned. (P11,102:102)</i>
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Pseudonyms: Teacher 1 and Teacher 3

The codes in Table 6.16 depict various aspects of future I-GIS-T developments that emerged during the interviews. The following sections (6.5.1 to 6.5.5) provide a discussion of each of the codes listed in Figure 6.16 with some corresponding quotation evidence enclosed in Table 6.15.

6.5.1 Future: Language uncomplicated

Although all the learners could understand English, some learners indicated that within the rural areas learners might have difficulty in understanding the I-GIS-T. They also mentioned that the language should not be complicated, as depicted in Table 6.16. It seems, therefore, that multiple language catering, with options such as Zulu, English, Sotho, Afrikaans, etc., within the I-GIS-T might enhance GIS learning. (However, it is important to note that catering of multiple languages should be in the narrated audio form and not only text, as text and animations may overload the visual and pictorial channel, causing diminished learning (Mayer, 2001:152), as discussed in section 2.6.1.2).

6.5.2 Future: I-GIS-T themes

Some participants remarked that they would like to have enrichment activities included within the I-GIS-T. In addition, a few learners pointed out that they would like to have follow-up activities after the I-GIS-T, and that there should be programmes filling the gap between the I-GIS-T and GIS software, so that they can explore these at home. The learners proposed additional exploratory activities. However, the grade 12 teacher mentioned that curriculum time for GIS is limited, as the grade 12 Geography curriculum is packed. Other respondents concluded that themes should be linked to the curriculum, and in that way reinforce the learning content.

6.5.3 I-GIS-T CD

Wheeler and others suggest the inclusion of GIS-DVD within textbooks running parallel to the learning area (subject) in order to enhance teaching and learning through GIS (Wheeler *et al.*, 2010:168). This notion was verified within this case study, and it was found that both learners and teachers were in favour of the idea of having a CD running parallel to curriculum themes where GIS practice is being integrated. In addition, during the focus group interviews most learners indicated that they would use the I-GIS-T at home as well. Focus group 2 mentioned that a CD coming with the textbook would also help them not to get stuck only within the classroom borders, but they would like to study at home as well. Furthermore this group mentioned that learners differ in the ways they learn, and a [multimedia] CD running parallel with the textbook will enhance their learning. This statement coincides with multimedia learning theories as discussed in section 2.6.

6.5.4 Learning in sequence

Participants remarked that learning of GIS should start with the very basic and then progress in sequence to more difficult activities. Learning in sequence seems to be quite a prominent requirement, where the basics are learned, followed by the learners exploring more and more on their own. During the focus group 2 interview, the learners stated that they would appreciate the I-GIS-T to take them from the start to the complex industrial GIS, where gifted learners can excel.

6.5.5 I-GIS-T price

The price of the I-GIS-T seems to be a prominent factor. In fact, Teacher 1 noted that many schools would not spend large sums of money on software that they would only use for a week. Another argument was that public schools do not have the finances to buy expensive GIS software. (It should be noted that the I-GIS-T is a GIS tutorial and not a full-house GIS software, and therefore the price would be less.) In fact, the low price for the I-GIS-T (no pre-installation or computer network needed) might turn out to be a major advantage of the I-GIS-T for schools lacking finances to implement GIS software packages.

Knowledge claim 5:

Future recommendations of I-GIS-T development are the use of uncomplicated language, a variety of languages should be incorporated, enrichment activities running parallel to the curriculum taken up in a CD, learning activities developing from basics to complex, and a low price,.

6.6 CONCLUSION

Chapter 6 consisted of an analysis of the data as collected from four teacher interviews, three learner interviews, two focus group interviews, an evaluation questionnaire, pre- and post-attitudinal tests, a video recording and field notes. This was done in order to answer the following secondary empirical research questions:

- What barriers do FET phase Geography teachers face regarding GIS practice?
- To what extent does the I-GIS-T application influence learner attitude towards GIS within the FET phase?
- To what extent is the I-GIS-T workable within GIS practice in the FET phase?
- How can the I-GIS-T further be developed to enhance GIS practice within the FET phase?

These secondary questions revealed the perceptions of the teachers and learners regarding the viability of the I-GIS-T for the FET phase.

The *second secondary question* was an empirical question that dealt with the barriers FET phase Geography teachers face in GIS practice. Barriers teachers face when implementing FET phase GIS practice within this case study are as follows: Low teacher computer literacy, lack of user-friendly and educational GIS software, limited curriculum time, an exam-driven approach, limited teacher-time and limited availability of the computer lab. Moreover, some teachers see themselves as the greatest barrier (lacking in time and computer literacy). GIS practice pedagogy therefore remains an uncertainty.

The *third secondary question* dealt with the extent to which the I-GIS-T application influences learner attitudes to GIS within the FET phase. According to the pre- and post-attitudinal tests,

as well as the follow-up one-on-one interviews with three learners and two further focus group interviews, the I-GIS-T activities affected attitudes towards GIS practice positively. An overall positive attitude towards the I-GIS-T was also observed.

The *fourth secondary question* dealt with the extent of workability of the I-GIS-T. In order to answer these questions the advantages and disadvantages of the I-GIS-T activities were analysed.

- Post-interview with Teacher 1 was analysed in order to gain understanding regarding the workability of the I-GIS-T from the *teachers'* perspective.
- Questionnaires were also employed in order that the learners may evaluate the activities. These questionnaires, as well as the learner one-on-one and focus group interviews, were used to answer the question from the *learners'* perspective.

Although some disadvantages surfaced (where these are also taken up in the future developments of the I-GIS-T), most of the data reflected a great workability of the I-GIS-T within the FET phase Geography class.

The *fifth section dealt with the fifth secondary question* of how the I-GIS-T can be developed further in the future. Data from the integrated data set suggested that uncomplicated language, the incorporation of a variety of languages, enrichment activities running parallel to the curriculum, taken up in a CD, low price, and developing learning activities from basic to complex, are key elements to further development of the I-GIS-T.

The results presented here reflect data drawn from the Grade 11 Geography class and three FET phase Geography teachers at the same school. Although these research results regarding the I-GIS-T endeavour are context-specific and preliminary, data does suggest that the I-GIS-T may have a positive impact on GIS learning and that it does provide a viable alternative to current GIS teaching methods within the FET phase.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This dissertation set out to investigate the viability of the I-GIS-T within FET phase Geography against the background of current GIS practice barriers within a South African context. During this case study, a pragmatic stance was employed whilst investigating the viability of the I-GIS-T application in order to best answer the research questions.

This last chapter therefore concludes this case study, firstly, with a digest of knowledge claims presented in section 7.2, followed by a viability evaluation summary of I-GIS-T (section 7.3), thereafter a discussion of conclusions that have been reached (section 7.4), then a discussion of the limitations and their implications from this study (section 7.5), and, lastly, recommendations and further research possibilities (section 7.6). Knowledge claims are drawn from results that emerged during this study as represented and discussed in chapters 2, 3 and 6 while limitations of this study are outlined which identify research gaps, reflecting opportunities for further research.

7.2 SUMMARY OF KNOWLEDGE CLAIMS

This section comprises of a summary of all the knowledge claims that emerged during this study. In order to ensure clarity of the discussion within this chapter, each secondary research, with its corresponding colour code, is listed in Table 7.1. Furthermore, some colour codes are labelled 'ab'. This implicates that, those specific research questions are divided into two parts, namely 'a' and 'b'. The first, third and fourth research questions are divided into two parts. For example, the first research question is divided into advantages (1a) and barriers (1b). In the same way the fourth research question regarding workability has been divided according to I-GIS-T workability according to the teacher (4a) and the learners (4b). The second, third and fifth secondary research questions are not divided.

Table 7.1 Colour codes with corresponding secondary research questions

Corresponding secondary research question	Colour codes
What are the main advantages and barriers of GIS practice in schools globally?	1ab
What barriers do FET phase Geography teachers face regarding GIS practice?	2
To what extent does the I-GIS-T application influence learner and teacher attitude towards GIS practice within the FET phase?	3
To what extent is the I-GIS-T workable within GIS practice in the FET phase?	4ab
How can the I-GIS-T further be developed to enhance GIS practice within the FET phase?	5

In answer to the secondary research questions as taken up in Table 7.1, the following corresponding knowledge claims emerged from this study:

1a

Knowledge claim 1a:

The main advantages of GIS practice in schools globally as delineated by the body of scholars were: providing a catalyst for comprehending world and geographical phenomena while unlocking teaching and learning strategies, developing geospatial skills, enhancing positive attitude, value and motivation towards GIS and Geography learning and, lastly, enhancing higher-order thinking skills.

These main advantages of GIS practice in schools globally were discussed and delineated in the literature study within chapter 2 broadly as follows:

- GIS practice is a catalyst for comprehending the world and geographic phenomena in their complexity (Kerski, 2009:318) as well as boosting Geography's position within the school curriculum (Rød et al., 2010:27; West, 2003:269) while unlocking an array of teaching and learning strategies (depicted in Table 2.2).
- GIS practice develops geospatial skills, which improves Earth Science conceptual understanding (Black, 2005:402) in order to solve real-world problems and support decision-making (National Research Council, 2006:33).

- GIS practice enhances attitudes, values and motivation as required for optimal learning (Kerski, 2009:172).
- GIS practice enhances higher-order thinking skills, such as critical thinking (Baker, 2005:48; Fitzpatrick & Maguire, 2001:70; Goldstein, 2010:30) and problem solving (Audet & Abegg, 1996:28; Drennon, 2005:385; Hall-Wallace & McAuliffe, 2002:5; Hespanha et al., 2009:S20; Kerski, 2003:135; West, 2003:269).

1b

Knowledge claim 1b:

GIS practice barriers are broadly differentiated by the body of scholars in four sets of barriers, namely technological aspects, complex GIS software, lack of curriculum-orientated materials, wide-ranging systemic issues and lack of understanding of spatial thinking concepts.

The main barriers of GIS practice in schools globally, as broadly differentiated by the body of scholars, were gained from the literature study and discussed in chapter 3.

- **Technological aspects** of integrating GIS can be overwhelming. Teachers struggle within the set-time constraints, to assimilate the latest GIS technology innovations (Baker, 2005:44; West, 2006:256), while low access to appropriate hardware remains a critical barrier (Breetzke et al., 2011:2; Meyer et al., 1999:572; Sanders et al., 2002:126). The complex nature of desktop GIS (Baker, 2005:44; Kerski, 2009:161; Liu & Zhu, 2008:12) demands extensive professional teacher development, technical preparation (Baker, 2005:47) and extra instructional time (Meyer et al., 1999:572), not to mention hardware and network barriers.
- The **lack of curriculum-orientated materials** (Chun, 2008:2) and teacher professional development exists. As most GIS software was not primarily developed for educational purposes (Green, 2001:43; Kerski, 2003:130; Kerski, 2009:344; Liu & Zhu, 2008:13; National Research Council, 2006:167), both teachers and learners find GIS software complex.
- The **wide-ranging systemic issues** may encourage or discourage innovation. Wheeler refers to barriers faced in Australia, such as bottom-up resistance from Geography

teachers and top-down failure of support within the curriculum (Wheeler *et al.*, 2010:158).

- **Spatial thinking concepts** within GIS still need clarification. In fact, although the National Research Council of the USA highlights the importance of spatial thinking, they stress the deficiency of clearly identified and described operations of spatial thinking (National Research Council, 2006:15; Schultz *et al.*, 2008:28) making geospatial thinking (GST) much a *terra incognita* (Golledge *et al.*, 2008:86). Therefore Geospatial skills are under-recognised, undervalued and under-appreciated due to deficient understanding (Schultz *et al.*, 2008:28), and remain consequently the worst taught element within some curricula (Comber *et al.*, 2008:2; National Research Council, 2006:15).

The following knowledge claims emerged from empirical evidence from this case study and were answered within Chapter 6:

2

Knowledge claim 2:

GIS practice barriers found in this study were low teacher computer literacy, lack of user-friendly and educational GIS software, little curriculum time, no GIS practice exam, little teacher's time and unavailability of the computer lab.

These barriers emerged from the integrated data set, where network of patterns surfaced (Chapter 6). Although many of these barriers coincide with those proposed by the body of scholars (Chapter 3), *the teacher as greatest barrier* (because of lacking computer literacy), seems to be prominent within the South African context of this case study. GIS practice pedagogy therefore remains an uncertainty. The model for understanding the value of ICT and its use in developing countries (section 2.4.3) have been used as a basis to draw a summary of suggested GIS practice barriers found in developing countries (section 6.4.5.1, Figure 6.15). According to the findings in section 6.2.1 as depicted in Figure 6.15, the I-GIS-T has the potential to circumvent the main GIS practice barriers.

3

Knowledge claim 3:

The I-GIS-T application influences learner and teacher attitude positively towards GIS within the FET phase.

Both interviews and the pre- and post-attitudinal tests provided evidence regarding a positive attitudinal shift. In addition, all the questions in the pre- and post-attitudinal tests indicated a positive attitude development towards GIS as noticed in the effect sizes. A positive attitude towards GIS will not only enhance GIS learning, but also influence the acceptance and therefore the viability of the I-GIS-T. For instance, within the Technology Acceptance Model (TAM), as discussed in section 2.4.2, attitude plays a significant role in the acceptance of a technology (Davis *et al.*, 1989:985).

4ab

Knowledge claim 4ab:

According to the teacher and learners, the I-GIS-T application is largely workable within this FET phase Geography class.

When weighing the advantages and barriers experienced by the teacher and learners, the advantages of I-GIS-T were found to be more profoundly as discussed in section 6.4 and depicted in Figure 6.13. Moreover in Figure 6.13, it has been noted that the I-GIS-T to a large extent circumvent the main GIS practice barriers as stated in knowledge claim one and two. However, according to the teacher and learners, learners lacking basic computer skills may need guidance to a certain extent during the first activity.

Moreover, according to Rogers (1995:15) characteristics of innovations (in this case the I-GIS-T) as perceived by individuals, influence their adoption rate (discussed in section 2.4.1). Table 7.2 represents a comparison of the innovation characteristics (needed to enhance the adoption according to Rogers), with the characteristics of the I-GIS-T application.

Table 7.2 **Characteristics of the I-GIS-T in comparison to the Innovation Adoption curve of Rogers**

Characteristic of innovation	Description of characteristic	Characteristics of the I-GIS-T found in this study
Relative advantage	Extent to which the innovation is perceived superior to other innovations.	The teacher and the majority of learners perceived the I-GIS-T superior to other GIS learning methods.
Compatibility	Extent to which innovation is perceived as consistent with needs of potential adopters.	Against the backdrop of current GIS practice barriers, the I-GIS-T may fulfil the needs of both teacher and learners alike.
Complexity	Extent to which an innovation is perceived as difficult in understanding and usage.	According to the teacher and majority of the learners, the I-GIS-T is simple to use.
Trial ability	Extent to which an innovation may be experimented on a limited basis.	Both the teacher and learners have experimented on the I-GIS-T within this study
Observability	Extent to which the results of an innovation are visible to others	Observable results of the I-GIS-T within this study were mainly the measurement of learner attitude towards GIS. Preliminary findings of this I-GIS-T study were presented and well accepted by colleagues at an International GIS conference.

As seen in Table 7.2, the characteristics of the I-GIS-T correspond to a large extent with those set out by Rogers. This implies that the I-GIS-T application is likely to be adopted. Although Kerski (2009:182) stated that the critical mass (as discussed in section 2.4.1) has not yet occurred within GIS education, the I-GIS-T might therefore bridge the barrier of complex software and ease the adoption of I-GIS-T software within GIS teaching.

5

Knowledge claim 5:

Recommendations regarding future I-GIS-T development are the use of uncomplicated language, the incorporation of a variety of languages, enrichment activities running parallel to the curriculum and taken up in a CD, low price and learning activities developing from basics to complex.

Although multimedia design principles of enhanced learning have been implemented (Table 2.2) within the development of the I-GIS-T, these further recommendations are being made. According to TAM (section 2.4.2), incorporation of a variety of languages might further enhance the perceived ease of use and usefulness of the application. Inclusion of enrichment activities, running parallel to themes taken up in the curriculum, might further enhance the perceived usefulness of the application.

In addition, these further recommendations also correspond to the Innovation Adaption Curve Model (section 2.4.1). If the I-GIS-T application includes a home language option, this application might have an advantage over other GIS educational software programmes. The use of home language (in the narration of both voice and text) will also reduce the cognitive load of the working memory and therefore might further enhance learning as in the cognitive affective model (Moreno & Mayer, 2007:314). Furthermore, inclusion of curriculum themes might also further compatibility of the I-GIS-T within the Geography class.

These knowledge claims are also represented as a summary within Figure 7.1 (discussed in section 7.3), in answer to the primary research question regarding the viability of the I-GIS-T application.

7.3 VIABILITY EVALUATION SUMMARY OF I-GIS-T

This section presents a summary regarding the viability evaluation of the I-GIS-T application. The I-GIS-T application was evaluated against the background of perceived GIS practice barriers, as gleaned from literature as well as observed within the South African context in this case study. In order to ensure clarity in this chapter, colour-coded numbers of Table 7.1 were extended to the corresponding secondary research questions as depicted in both Figure 6.1 and Figure 7.1. Furthermore, Figure 7.1 represents an evaluation summary of both qualitative and quantitative data findings as well as the influence and or affect that these findings have on other secondary research questions and their findings.

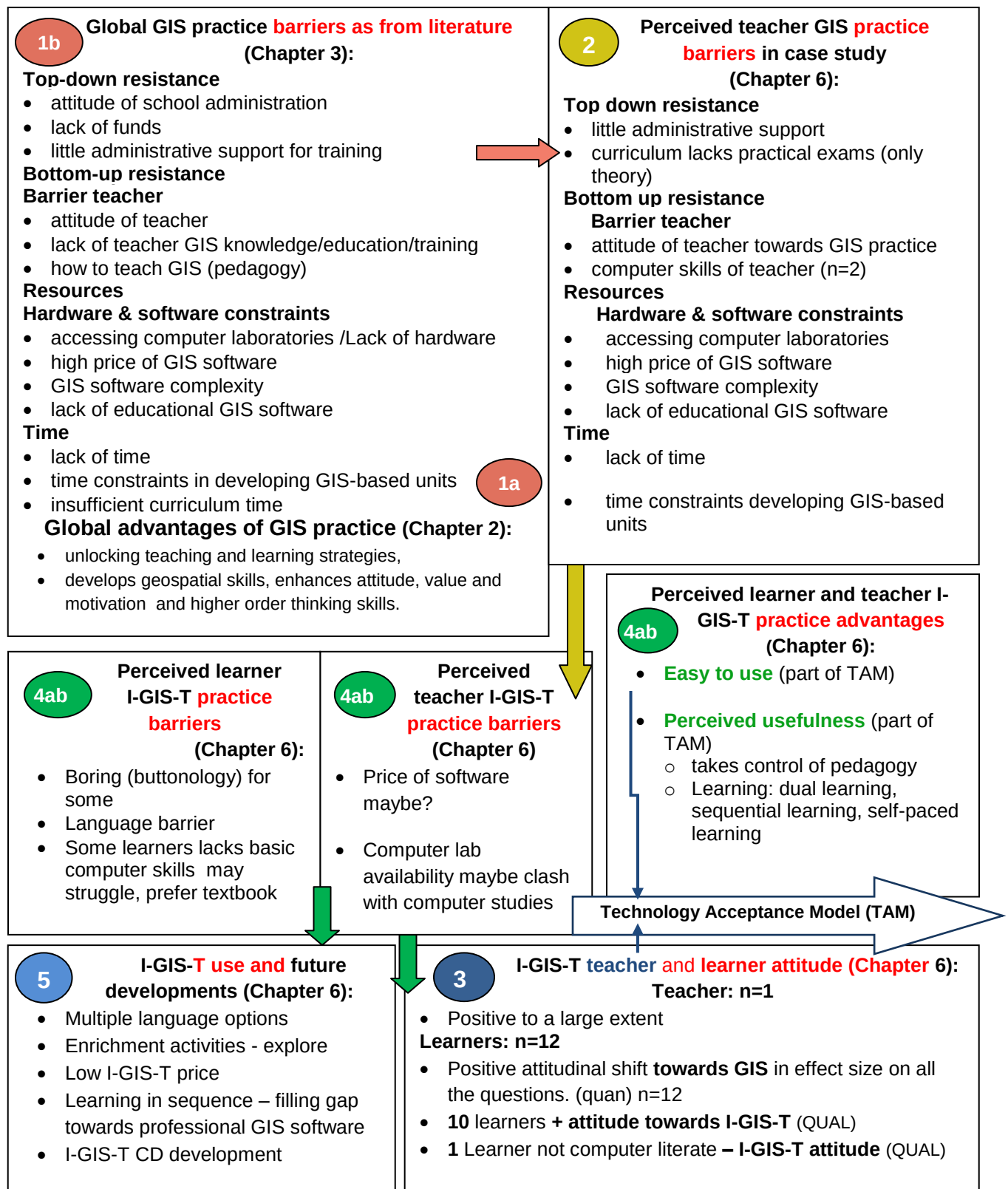


Figure 7.1 Summary of viability evaluation of the I-GIS-T

It is noticeable, as seen in Figure 7.1, that the five answers to the research questions, affect one another. Firstly, it was found that the main GIS practice barriers in South Africa (research question 2) largely correspond to the global barriers towards GIS practice (research question 1b). When viewing the South African GIS practice barriers as a backdrop during the evaluation of the attitude (research question 3) and workability evaluation (research question 4) of the I-GIS-T, it was noticed that the I-GIS-T did bridge many of the current GIS practice barriers, as numerous I-GIS-T advantages (second part of research question 4, namely 4a) emerged. Furthermore, the overall positive attitude towards GIS and I-GIS-T (3) together with its easiness to use and perceived usefulness (4ab) support TAM as indicated in Figure 7.1. In order to enhance adoption of the I-GIS-T (TAM), future developments of I-GIS-T (as in research question 5) might prove to overcome more barriers as set out in the second part of the fourth research questions (4b).

7.4 CONCLUSIONS

Although the numerous advantages of GIS practice have been extensively discussed in literature, teachers struggle globally to implement GIS practice. Similarly, also within this case study in the South African context, teachers grapple to implement GIS practice within the FET phase. In addition to the main GIS practice barriers, as experienced globally, the digital divide and South African's multilingual cultures add to additional barriers. In testing the I-GIS-T application against global and these additional barriers, as stated by the teachers, findings suggest that the I-GIS-T is indeed capable in circumventing the main GIS practice barriers. Furthermore, this study recommends that future development of the I-GIS-T should include multi-lingual options and exploratory capabilities aligned with curriculum themes.

Within South Africa's unique digital divide context, it should be noted that basic computer literacy of the learners plays an essential role regarding GIS practice. Computer literate learners find I-GIS-T an easy and viable application to learn GIS. However, learners who lack very basic computer skills may struggle and will need assistance in guiding them through the first activity. The same learners who lack basic computer skills might also battle with language barriers. In order to alleviate language barrier problems, future multilingual options within the I-GIS-T were recommended. The multilingual options may therefore also assist learners who lack the very

basic computer skills better, in order to understand the computer system.

7.5 LIMITATIONS AND THEIR IMPLICATIONS

In spite of cautious planning and executing of research methods, all studies inherently have limitations. The main limitation of this case study methodology is the dependence of one class, 12 learners and three FET phase teachers only (Maree, 2010:76). In other words, there is a lack of generalisation of results (De Vos *et al.*, 2011:322; Leedy & Ormrod, 2010:137; Maree, 2010:76; Mouton, 2011:150) to all grade 11 Geography classes of South Africa. This case study is therefore generalisable to theoretical propositions (analytical generalisation) and not to the whole FET phase population within SA (statistical generalisation) (Yin, 1994:10). However, insight gained in a particular case can serve as a prototype to similar cases (Yin, 1994:10). Obviously, it is the reader and not the researcher who determines what can apply to his/her context (Merriam, 2009:51), labelled naturalistic generalisation (Hesse-Biber & Leavy, 2011:263), while scholars provide abundant evidence of the acceptance of a single case as the object of study (Maree, 2010:76). Therefore, the intention of this case study is not to provide a generalising conclusion, but to gain greater insight and conception of the dynamics regarding the workability of the I-GIS-T application. Furthermore, this case study serves as a pilot study to a larger sample size of teachers and learners.

Secondly, data collection and analysis were time-consuming (Babby, 2011:402; Merriam, 2009:51; Mouton, 2011:150) and may prove to be too lengthy for busy policy makers or teachers to read and use.

Thirdly, qualitative case studies are also limited by sensitivity and integrity of the investigator, being the primary instrument of data collection and analysis (Merriam, 2009:52). Moreover, qualitative analysis drawn from a case study proves a tremendous challenge, as data gathering from multiple methods may be incompatible and even apparently contradictory (Merriam, 2009:203).

Fourthly, novel users of the I-GIS-T may focus on the quality of the multimedia rather than the content in assessing the application (Cartwright & Hunter, 2001:302). To minimise the influence of “multimedia overwhelming”, focus group interviews were conducted approximately four weeks after the I-GIS-T activity.

Fifthly, another limitation was that the researcher facilitated the I-GIS-T activities and not the teacher. Although the researcher gained insight that is more direct in the I-GIS-T workability, the teacher changed the role to the observer, while getting a more global picture of the I-GIS-T activity.

Finally, it was observed that qualitative data (and supportive quantitative data) correlates with labels within the Technology Acceptance Model (TAM) (see Figure 6.12), that in turn might reflect a positive intentional future use of the I-GIS-T application. However, the structural paths between the constructs of I-GIS-T (Figure 6.12) have not been tested empirically in this case study, although it will be taken up in the next phase of the I-GIS-T project.

The implications of the limitations are therefore as follows:

Firstly, because of the small non-probability sample, findings in this case study can only be generalised analytically and not statistically (Yin, 2012:177). However, through in-depth descriptions and analysis of qualitative data with supportive quantitative data, overall findings indicated that the I-GIS-T application indeed could be a viable option within the FET phase Geography class and that further research would therefore be worthwhile.

Secondly, busy policy makers and teachers might not have time to absorb the qualitative data of this case study, in order to change policies or class practices.

Thirdly, because the researcher was also the measurement tool during the analysis, the researcher's observation could shift from being objective to subjective.

7.6 IMPLICATIONS AND FURTHER RESEARCH POSSIBILITIES

This section discusses implications of this study, and further research.

The findings of this study imply that the I-GIS-T is likely to be a viable application for future use within FET phase Geography. This study is valuable in that it adds to existing GIS practice knowledge by extending this to the South African context. This includes providing information about barriers, advantages, workability, effects on attitude, and future developments, of GIS software. This study's findings also correspond to aspects of Davis' Technology Acceptance Model (TAM) and suggest applicability of Draper's model of ICT pedagogical usage in developing countries within South African GIS software integration.

Suggestions for future study include quantitative verification regarding these relationships. The use of the Technology Acceptance Model (TAM) and corresponding data within this study only referred to quotations and supportive attitudinal tests. The absence therefore of empirically tested structural paths within a proposed I-GIS-T Acceptance Model, necessitates future quantitative research on a I-GIS-T Acceptance Model by means of SEM (Structural Equation Modelling) in order to accept a proposed I-GIS-T Acceptance Model based on TAM. Further quantitative research with statistical measures can fill this research gap.

Because this case study consisted of only three teacher interviews regarding GIS-practice barriers, a teacher's survey with a larger sample of teachers (a whole district of the whole province's teachers for example) may further enlighten the current GIS practice implementation and teaching barriers in KZN within a survey. More empirical data on GIS-practice barriers are needed in order to verify the proposed GIS practice implementation model within developing countries. Although the attitudinal shift towards GIS has been tested with pre- and post-tests, the sample size used was small, and so this should be further investigated on a larger scale in more schools (of a whole district for example). Additionally, a larger sample of learners might prove to give more insight in the development of GIS attitude, an important element within the TAM. Further I-GIS-T evaluation therefore necessitates *quantitative* research by means of a pre- and post-test regarding the GIS attitude, spatial skills and knowledge of GIS. Furthermore, only one grade 11 class was used in this study. The selection of more grade 11 classes within a quantitative cross-section design will lead to better generalisations regarding the viability of the I-GIS-T in comparison to other GIS teaching learning support material. Finally, suggested research includes control groups within a cross-over-experimental design comparing the I-GIS-T with traditional GIS instruction methods.

In conclusion, the findings of this mainly qualitative case study can serve as hypotheses for testing within the quantitative, second, phase of this I-GIS-T project.

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