UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

AN INQUIRY-BASED LEARNING FRAMEWORK FOR TEACHING GEOGRAPHIC INFORMATION SYSTEMS IN A RURAL ECOLOGY

by

THABILE ARETHA ZONDI (206513797)

Bachelor of Education, Bachelor of Education Honours, Master of Education
(University of KwaZulu-Natal)

A Thesis submitted in fulfilment of the academic requirements for the degree of
Doctor of Philosophy
in
Geography Education
at the

University of KwaZulu-Natal
College of Humanities
School of Education

Promoter: Professor D.J. Hlalele

2022

DECLARATION

I, Thabile Aretha Zondi, declare that:

(i) The research reported in this thesis, except where otherwise indicated, is my original work.

(ii) This thesis has not been submitted for any degree or examination at any other university.

(iii) This thesis does not contain text, graphics or tables copied and pasted from the internet unless specifically acknowledged as being sourced from other persons.

(iv) This thesis does not contain other persons' data, pictures, graphs or other information, unless specifically acknowledged as being sourced from another person.

(v) This thesis does not contain other persons' writing, unless specifically acknowledged as sourced from other researchers.

Researcher: Thabile Aretha Zondi

STATEMENT BY SUPERVISOR

This thesis is submitted with my approval.

Professor Dipane Hlalele

ACKNOWLEDGEMENTS

Firstly, I would like to express gratitude to my supervisor, Professor Dipane Hlalele. I am eternally grateful for half a decade of guidance and wisdom. Thank you for your professional expertise, feedback and morale-boosting support during this journey.

I would like to say thank you to the co-researchers that participated in this study. My words are not enough to describe the impact of our collaboration on this project. Learning with and from each other has been a fantastic experience.

I wish to express gratitude to Kudzayi Tarisayi. Thank you for sacrificing so much of your time and for supporting me in this study.

I would also like to say thank you to the Room 32 Doctoral cohort, mainly Vusi Msiza and Nosipho Mbatha. Your friendship, advice and support went beyond the doctoral journey. I discovered brothers and sisters in you.

I wish to show my appreciation to my friends and colleagues from the School of Education, University of KwaZulu-Natal, as well as those who have left. Thank you for your support and deep insight into the study. Your smiles, words of encouragement and listening ears have pushed me on the worst days.

To my friends from all walks of life and my extended family, thank you for your love, care and support.

A special thank you to my mentors. It has been an honour and privilege to learn from you.

Finally, I would like to recognise and honour my children and family's sacrifices while I have been on this journey. To Samkelo, Siphesihle, Mum, Nkululeko, Andile and Sandile. When I count my blessings, I mention you twice – know that I love you always!

Romans 8:28 and Philippians 4:13

FINANCIAL ACKNOWLEDGEMENT

This work was supported by funding from the Accelerated Academic Leadership and Development Programme (AALDP), the University of KwaZulu-Natal's College of Humanities as well as the University Capacity Development grant (UCDP).

DEDICATION

This work is dedicated to my children Samkelo and Siphesihle, my mum Thandiwe and my brothers Nkululeko, Andile and Sandile. I hope I make you proud. My heart goes out to my late dad Sipho, he prophesied that I would study as much as I desired. I was in grade 10 at that time and the PhD was beyond my imagination. To all the single mums and dads out there, the only limit is yourself.

ABSTRACT

This study explored the use of an Inquiry-based learning framework for teaching Geographic Information Systems (GIS) in a rural learning ecology. This qualitative study was premised on the transformative paradigm. Using Participatory Action Research, 17 stakeholders shared their experiences of teaching and learning of GIS. Critical Emancipatory Research (CER) was used to frame this study and it allowed for the formation of a reciprocal relationship amongst the co-researchers. Data was generated through conversations with a purpose, focus group discussions, reflective journals and classroom observations. Thematic analysis was used to analyse data for this study. The study identified four major impediments to the teaching of GIS in the particular context: lack of formal GIS training, traditional teaching approaches, inadequate resources, and a negative teacher attitude towards GIS. It was noted from these findings that there was a training gap and consequently, the co-researchers and I participated in training workshops focused on GIS content knowledge and pedagogy. An Inquiry-based framework was integrated into the training workshops and as a result of these workshops, the co-researchers started exhibiting a positive attitude towards GIS. Central to the findings in this study was the importance of communicative action and the collaboration of different stakeholders in addressing educational challenges. To conclude, based on the findings from this study an Inquiry-based learning framework is recommended for teaching GIS in a rural learning ecology.

LIST OF ACRONYMS

GIS – Geographic information systems

DBE – Department of Basic Education

CER – Critical Emancipatory Research

RLE – Rural Learning Ecology

PAR – Participatory Action Research

IBL – Inquiry-Based Learning

PBL – Problem-Based Learning

FET – Further Education and Training

PGCE – Postgraduate certificate

HOD – Head of Department

ESRI - Environmental Systems Research Institute

IT – Information Technology

GPS – Global Positioning System

SACE – South African Council of Educators

CAPS – Curriculum and Assessment Policy Statement

QGIS - Quantum Geographic Information Systems

TABLE OF CONTENTS

CHAPTER ONE
PROBLEM-SETTING AND ITS CONTEXT

1.1 INTRODUCTION

This study was conducted to explore the use of an Inquiry-Based Learning framework teaching Geographic Information Systems (GIS) in a rural learning ecology. Rural learning ecology refers to a space where learning occurs in a rural context. This chapter provides an over-view of the thesis and how it unfolds. It begins by presenting the background of the study and the rationale for the study, which highlights the motivation for conducting this study. Thereafter, the statement of the problem, the research aims and the research questions are presented. Also, it is in this chapter where I situate myself as a researcher and I have provided a description of the research site where this study was conducted. Prior to providing a summary of this chapter, I provided a description of every chapter herein.

1.2 BACKGROUND TO THE STUDY

Geographic Information Systems (GIS) was introduced into the South African Geography secondary school curriculum in the year 2006. The integration into the Geography curriculum was gradual whereby in 2006 it was offered in grade 10 level only. In 2007 it was offered in grade 11 and the first cohort that wrote an examination which incorporated GIS was the grade 12 learners who completed their matric in 2008 (Breetzke, Eksteen, & Pretorius, 2011; Cilliers, Klerk, & Sandham, 2013; Scheepers, 2009). On the other hand, Fleming (2015) claims that GIS was introduced into secondary schools in 2013. Nevertheless, after the introduction of GIS in schools, research has been conducted into its implementation in various South African provinces. For instance, Scheepers (2009) confirmed that GIS training workshops for Geography teachers were conducted in the Western Cape. While this is the case, research conducted in 2015 reveals that some teachers in the province still experience GIS challenges as they teach this section in secondary schools (Fleming, 2015). The author further states that many schools in the Western Cape and the rest of South Africa are faced with many challenges with regard

to teaching GIS as part of the Geography curriculum and she concludes by stating that the level of GIS is low in South Africa.

Over time, more research was carried out into the teaching of GIS in South African secondary schools by scholars such as Fleischmann, van der Westhuizen, and Cilliers (2015); Innes (2012); Wilmot and Dube (2016). They all concluded that the teaching of GIS was a challenge in most South African secondary schools. The South African Department of Basic Education shares the same sentiments with the results of research that has been conducted into its implementation in various secondary schools in South Africa, confirming that indeed the introduction of the GIS has posed a challenge to many secondary schools in the country as many learners continue to perform poorly in this section (Department of Basic Education, 2013, 2016, 2018). Five years after the introduction of GIS into the curriculum of South African secondary schools, Breetzke et al., (2011) conducted research into its introduction in schools and found that there are a number of challenges involved in teaching computerised GIS in what they termed a 'technologically disadvantaged country'. To mitigate this challenge, the authors developed and supplied a paper-based GIS educational package that offers a basic introduction to GIS. This paper-based GIS educational package was developed specifically for schools that do not have computers and GIS software. The paper GIS manual and resources were tested in two schools in the Gauteng province and they produced positive outcomes from learners who participated in the research (ibid.).

As years went by, more research was conducted into the implementation of GIS in South African schools. For instance, Fleming (2015) pointed out that there have been a number of successful interventions targeting secondary schools in the Western Cape with positive results. Despite this, there is still room for improvement as they are still many challenges with regard to the teaching of GIS in basic education. The author further highlights that there is a no-model size fits all approach to teaching GIS in basic education as the available resources for teaching the latter are not standardised across schools. This suggests that one of the challenges of implementing GIS in schools is the lack of resources. By resources I am referring to human resources (teachers that are skilled to teach GIS as well as computer resources (computer software and hardware). This

corroborates the findings of Breetzke et al., (2011) presented above. This highlights that lack of resources (both human and computer resources) are indeed a hindrance to the effective teaching of GIS in South African secondary schools.

From the studies presented above, Breetzke (2006); Fleming (2015) and Scheepers (2009), the claim can be justified that GIS teacher training is lacking as many teachers still struggle to teach this section in schools. One of the reasons why so many Geography teachers struggle to teach GIS in secondary schools is because, according to Fleming (2015), teachers were not offered adequate professional GIS training prior to its inclusion in the Geography curriculum. Adequate GIS training should have been provided for Geography teachers prior to its introduction because most teachers were not equipped to teach this section as they did not possess GIS training which should have been provided by the DBE as a form of support before they received this new section that they were requested to teach (Fleming, 2015). One should also bear in mind that many Geography teachers received their teaching qualification before 2006, the year in which GIS was introduced. Therefore, there should have been in-depth initial GIS training for teachers that had not studied GIS and on-going teacher development workshops for all to support Geography teachers to enable them to teach GIS effectively especially in provinces where it is seen that GIS implementation is still a challenge.

Still on the issue of teacher training, Fleischmann et al., (2015); Innes (2012); Wilmot and Dube (2016) all agree that Geography teachers were not trained to teach GIS in a way that should have enhanced learners' spatial knowledge. Also, teachers lack different forms of support such as curriculum and technical support to teach GIS effectively. Consequently, most learners perform poorly in the GIS section in the Geography matric examination paper. Fleischman and van der Westhuizen (2017, p. 68) confirm the latter by stating that "although GIS has been included in the curriculum over the past decade, the majority of teachers lack formal GIS training". Additionally, the curriculum is problematic. For instance, Eksteen, Pretorius and Breetzke (2012) reveal that the DBE does not provide clear GIS implementation guidelines despite its inclusion in the secondary school Geography curriculum. Zuma (2016) coincides with the latter by stating that the CAPS curriculum does not equip the Geography teachers with clear direction as

to which approach to follow when teaching GIS. As a result, teachers make their own decisions regarding which methods they use to teach the prescribed GIS curriculum. Hence, this Participatory Action Research (PAR) involved different stakeholders who have an interest in the teaching of GIS in schools. Lecturers, teachers, subject advisors, student teachers and secondary school learners to explore the use of an Inquiry-Based Learning framework for teaching GIS in a rural learning ecology.

1.3 PROBLEM STATEMENT

The purpose of this study was to explore the use of an Inquiry-Based Learning framework for teaching Geographic Information Systems (GIS) in a rural learning ecology. GIS was first developed by the Canadian Land Inventory System during the 1960s and it became fully operational in 1971 (Balram & Dragicevic, 2006; Foresman, 1998). GIS is an extensively used technology in various sectors that make use of spatial data. These sectors include environmental departments, information technology, urban and regional planning, water resources, agriculture, surveying, land administration and education sectors (Chaudhuri & Ray, 2015; Coetzee, Eksteen, & Roos, 2014; Fradelos et al., 2014). GIS as educational technology has transformed the education system, more particularly the secondary school Geography curriculum (Kerski, 2003; Kidman & Palmer, 2006). Teachers' beliefs and attitudes pertaining to teaching and learning are essential factors in implementing educational technologies in a classroom (Englund, Olofsson, & Price, 2017). Thus, GIS teacher training is fundamental for GIS implementation to flourish in a Geography classroom.

In South Africa, GIS was introduced for the first time in the grade 10 Geography secondary school syllabus in 2006. Thereafter, it was offered to grade 11 in 2007 and then offered to Grade 12 in 2008 (Fleischmann & van der Westhuizen, 2017; Innes, 2012). The inclusion of GIS in the Geography Further Education and Training (FET) curriculum was an attempt aimed at laying a foundation to empower Geography school leavers with spatial technological skills (Innes, 2012; Scheepers, 2009). Equally important, its inclusion provides an avenue for Geography secondary learners to be exposed to computer literacy skills (Demirci, 2011; Johansson, 2003) and new careers in the field of

Geography. Moreover, Baker, Kerski, Huynh, Viehrig, and Bednarz (2012); Yap, Ivy Tan, Zhu, and Wettasinghe (2008) concur that GIS provides spatial literacy and develops spatial thinking in students. Considering the latter, it can be concluded that acquiring geospatial skills is necessary for the further development of South Africa. As a result, learners should be introduced to geospatial skills and computer literacy whilst still at school. This can be achieved through effective GIS teaching at basic education level.

According to Scheepers (2009, p. 40) "GIS is seen as a tool which can enhance the subject of Geography by supporting content delivery, developing spatial awareness and providing the context for critical thinking". The fostering of critical thinking by GIS places Geography learners in career pathways that are in demand in the 21st century (Baker et al., 2012). Providing learners with 21st century skills is imperative in the information-based economy that was triggered by globalisation. Thus, the inclusion of GIS in the Geography syllabus indicates that South Africa aligns itself with a trend that was set worldwide of offering learners an opportunity to engage with computerised spatial literacy through the usage of GIS to support the teaching and learning of Geography. This should enable learners to think critically and to contribute meaningfully to the 4th Industrial Revolution.

GIS also encourages the use of problem-based learning and it improves the learners' content knowledge and further motivates learners to study Geography (Singh, Kleeman, & Van Bergen, 2012). Teaching with GIS provides learners with an environment for learning about the real world by incorporating fieldwork that can be both multidisciplinary and interdisciplinary (Yap et al., 2008). GIS is interdisciplinary in nature because of its ability to address interdisciplinary questions by analysing spatial problems (Rickles and Ellul, 2015). Additionally, GIS integrates Geography, Maths, Literacy, Earth Science, Cartography, Remote Sensing and Computer science (Baker et al., 2012). The interdisciplinary nature of GIS broadens learners' knowledge and in different fields and makes them marketable to institutions of higher learning and future employers.

The problem is that the benefits mentioned in the previous section cannot be acquired by the majority of Geography learners because they were not taught with GIS as it what was envisioned by the DBE when it introduced GIS (Department of Basic Education, 2011).

Instead, they are taught about GIS (theory) without being exposed to its practical implementation, meaning that learner-centred approaches such as Inquiry-Based Learning are not used by many Geography teachers. For instance, Dube (2012) found that Geography teachers in the Western Cape Province had a shallow understanding of Inquiry-Based Learning. Similarly, a study conducted by Wilmot and Dube (2016) on the quality of school Geography education revealed that there was little evidence that suggested that the teachers sampled in the study understood Inquiry-Based Learning. This implies that some Geography teachers cannot apply the Inquiry-Based Learning approach in their teaching as they are not familiar with it. As a result, learners remain passive during Geography lessons. In response to this challenge, I worked collaboratively with different co-researchers to explore the use of an Inquiry-Based Learning framework for teaching GIS in a rural learning ecology.

Inquiry is one of the essential 21st century skills that is necessary for the professional world that learners are being prepared for. There is consensus that the effective teaching of GIS may help to develop this skill (Hong & Melville, 2018). In the same way, Johansson (2003, p. 1) emphasises that "GIS applications may help teachers to facilitate the implementation of constructivist and Inquiry-Based Learning environments at secondary schools." Despite this, many South African learners are missing out on the potential of GIS because quite a significant number of Geography teachers are not teaching GIS using an Inquiry-Based Learning approach. Research studies conducted by Baker and White (2003); Keiper (1999) and Wiegand (2001) recognise the importance of using Inquiry-Based Learning to teach Geography and yet, there is little evidence to suggest that the majority of Geography teachers are making use of this approach (Wilmot & Dube, 2016). Consequently, many Geography secondary school leavers do not have the foundational geospatial skills that the teaching of GIS should have provided them with (Department of Basic Education, 2018; Innes, 2012). This results in the shortage of GIS specialists in the country.

The shortage of personnel that possess geospatial skills has a negative impact on the South African economy because there is a shortage of people who are skilled in the latter. Given that the development of these skills is still lacking in many South African schools.

This also contributes to the slow development of the geospatial industry, Narain (2017, p. 1) conducted research into which countries have the most diverse geospatial skills. findings from the study reveal that “economies like Ghana, Oman, Ethiopia, Bangladesh, Zimbabwe, are countries which are still at the initial growth stage of developing their geospatial industry”. South Africa as a developing country is also affected by the shortage of personnel that possesses geospatial skills (Clarke, 2016). One of the ways of addressing this predicament is through effective GIS implementation in Geography classrooms, as it would lay a foundation for the geospatial skills in question. One of the ways of developing foundational geospatial skills is by adopting the Inquiry-Based Learning approach to teach GIS as it advocates for active learner engagement and discovery learning.

Learners that possess geospatial skills could be employed in the geospatial industry because GIS increases learner motivation as they engage in practical activities. Numerous scholars, Eksteen et al., (2012); Kerski and Demirci (2013); Wahyuningtyas, Laila, and Andini (2021) discussed the advantages of learning GIS for learners. Learners should be taught GIS effectively in order for them to learn geospatial skills that might be needed in their future roles. Liu and Zhu (2008) and Hong and Melville (2018) reveal that the Inquiry-Based Learning approach is a tool to enable GIS. Moreover, Jakab, Grezo, and Sevcík (2016) argue that teaching GIS using IBL cultivates more inquiry-based skills compared to traditional pedagogies which are used in Geography education, which is why in this study we propose this approach for teaching GIS.

To sum up, Kuhlthau, Maniotes, and Caspari (2015, p. 2) note that “Inquiry-Based Learning requires more than simply answering questions or getting the right answer. It espouses investigation, exploration, search, quest, research, pursuit, and study.” It can be concluded that Inquiry-Based Learning is a pedagogical approach that promotes learner centredness, Gribbins and Cook (2017) allude to the fact that teachers are responsible for creating curiosity among learners which can lead them to new knowledge and to enhanced learning. Thus, the use of an Inquiry-Based Learning approach to teaching GIS in a rural learning ecology, which this study envisaged, could lead to self-determined learners.

1.4 RATIONALE AND MOTIVATION FOR THE STUDY

This section discusses the three dimensions that motivate the research that was undertaken in this study; personal, professional factors and the available literature on Geographic Information System (GIS). At a personal level, when I was a secondary school Geography learner GIS did not form part of the Further Education and Training (FET) Geography curriculum. After secondary school, I enrolled for a Bachelor of Education (BEd) qualification that I completed over a period of four years from 2006-2009, specialising in Geography education. The year 2006 is the year in which GIS was introduced into the grade 10 Geography curriculum. Despite this, the training I received from the institution where I obtained the BEd did not offer programmes specific to the teaching of GIS to equip us as student teachers with knowledge and skills to teach GIS after it became part of the Geography secondary school curriculum. This implies that some initial teacher education institutions are slow to react to the demands of the professional world. The demands of the professional world have triggered my interest to explore this topic, as it requires teachers to be competent in teaching GIS. I believe that conducting research in the teaching of GIS will enhance my GIS teaching skills as well as those of my co-researchers since the research methodology that was employed by the study was participatory action research that enabled the co-researchers and I to work collaboratively in exploring the IBL framework for teaching GIS in a rural learning ecology.

When I began my teaching profession in 2010 at a rural secondary school, I discovered that GIS was part of the FET Geography curriculum. Consequently, I was expected to teach GIS as part of the Geography curriculum content. This was problematic because I had never been exposed to GIS content knowledge and skills before in my schooling nor in my initial teacher education training at the university. Due to my not being trained in GIS previously, I ended up lacking GIS content knowledge and pedagogy. Nevertheless, I was expected to teach the section to Geography learners. To cope with this challenge, I consulted my fellow Geography colleagues of that time, to see if I could get assistance with the teaching of this section. My former colleagues revealed that they also struggled with teaching GIS as it was introduced when they were already teaching in secondary schools. Additionally, when GIS was introduced, they were not provided with sufficient

GIS training. They indicated that they attended a two-day GIS training workshop which was organised by the Department of Basic Education (DBE).

Upon realising that my former colleagues could not assist me, I decided to approach the Head of Department (HOD) of Geography for assistance. This was because the roles of a HOD include “ensuring the good professional practice, standards, and quality of teaching and learning of subject(s) and mentoring other teachers in the subject/level of their specialty.” (Education, 2017). My HOD at that time stated that he did not have GIS training because he stopped teaching Geography before GIS was introduced into the Geography Curriculum. As a result, he could not assist me with the problem at hand. From the conversations that I had with my former colleagues and the HOD regarding the teaching of GIS, I could sense that there was a challenge with the implementation of GIS in the school where I was based. Well, at least this is what I thought before being involved in the Folweni school cluster. The school cluster acted as a support group for Geography teachers that were from various secondary schools in the neighbourhood. The school cluster included Geography teachers that formed part of a particular district in KwaZulu-Natal. During the time when I was a Geography school teacher, the school cluster would have meetings four times a year for planning and moderation purposes.

Being a member of the school cluster enabled me to interact with many Geography teachers from various secondary schools. During the scheduled meetings, we would have general discussions with Geography teachers from various schools pertaining to the Geography curriculum. It was through these discussions that I came to realise that the problem with the implementation of GIS was not only apparent in my previous workplace (secondary school). Then again, other Geography teachers in my school cluster were also struggling with the implementation of GIS. The Geography teachers from the school cluster also expressed the view that the Department of Basic Education provided inadequate training to enable them to teach GIS Furthermore, the assigned subject advisor had resigned and consequently, they were not getting the necessary support to teach GIS. From these conversations triggered by my lack of GIS content knowledge and pedagogy, I discovered that other teachers were also lacking in that regard. After observing the situation regarding the lack of capacity to teach GIS, I developed an interest

in conducting this study with different stakeholders that had an interest in the teaching of GIS in a rural learning ecology.

Recently, I was appointed as a Geography Education lecturer and I was expected to teach GIS to pre-service teachers. Thus, the issue of GIS implementation concerned me directly because I was now responsible for training pre-service teachers that would be competent to teach GIS. To be able to teach the pre-service GIS teachers properly, I first conducted diagnostic tests to assess the students' proficiency in high school GIS. Results of the tests revealed that many of the pre-service teachers in my class had a poor understanding of secondary school GIS. This troubled me as I expected the students to have secondary school GIS background since it is in the Geography curriculum. Additionally, I was concerned that if I did not do anything to change the situation, I would also be sending out Geography teachers who are not competent to teach GIS. In addition, pre-service teachers are expected to impart GIS content and skills to secondary school learners during teaching practice as well as when they become certified Geography teachers. Moreover, I was concerned about the fact that I lacked adequate GIS teaching skills and that this could hinder the development of the pre-service teachers' GIS content knowledge and pedagogy. Therefore, this study was necessary as it sought to explore the use of an Inquiry-Based Learning framework for teaching GIS in a rural learning ecology. In so doing, it developed the co-researchers' and my GIS content knowledge and pedagogy.

The third dimension for conducting this research study is conceptual. Research studies by de Róiste (2014); Innes (2012); Smit & Makanga (2010) and Weiner & Harris (2003) report that the shortage of geospatial skills is a global phenomenon, and the introduction of GIS into the Geography secondary school curriculum should be helping to close this gap. Nonetheless, the gap remains open due to GIS implementation challenges that are experienced by many secondary schools in South Africa. This is supported by the most recent annual diagnostic report of the national senior certificate examination, which revealed that learners performed the least in the GIS section compared to other Geography sections (Department of Basic Education, 2020). On the other hand, Innes (2012) and the Department of Basic Education (2020) found that there is a very low map

work literacy among Geography school leavers in South Africa. This is a concern because mapwork is the foundation for GIS. Meaning that GIS and mapwork are interconnected which implies that the Geography school leavers with a very low mapwork literacy would also have low or no GIS background knowledge as well because they are not competent in mapwork. This section has presented the three dimensions where the motivation for conducting the research study originated from. The following section presents the research objectives.

1.5 RESEARCH OBJECTIVES

Primary Objective

To explore the use of an Inquiry-Based Learning framework for teaching Geographic Information Systems in a rural learning ecology.

Secondary Objectives

1. To explore the current situation in teaching Geographic Information Systems in a rural learning ecology.
2. To assess the need for an Inquiry-Based Learning framework for teaching Geographic Information Systems in a rural learning ecology.
3. To understand the circumstances under which an Inquiry-Based Learning framework may be used to teach Geographic Information Systems in a rural learning ecology.
4. To describe the benefits and challenges of using an Inquiry-Based Learning framework in the teaching of Geographic Information Systems in a rural learning ecology.
5. To demonstrate the implications for the use of an Inquiry-Based Learning framework to teach Geographic Information Systems in a rural learning ecology.

1.6 RESEARCH QUESTIONS

Primary Question

How can an Inquiry-Based Learning framework inform the teaching of Geographic Information Systems in a rural learning ecology?

Secondary Questions

1. What is the current situation in teaching Geographic Information Systems in a rural learning ecology?
2. Why do we need an Inquiry-Based Learning framework for the teaching of Geographic Information Systems in a rural learning ecology?
3. How can an Inquiry-Based Learning framework be used to teach Geographic Information Systems in a rural learning ecology?
4. What are the possible benefits and challenges of using Inquiry-Based Learning framework in the teaching of Geographic Information Systems in a rural learning ecology?
5. What are the implications for the use of Inquiry-Based Learning to teach Geographic Information Systems in a rural learning ecology?

1.7 RESEARCH SETTING

The study was conducted in KwaZulu-Natal in the greater eThekwini Municipality previously known as the Durban Municipality. Its topography is hilly with many gorges and some flat areas; eThekwini is a coastal city with a warm subtropical climate (EThekwini Municipality, 2011) meaning that it receives rainfall mainly in summer. A huge portion of the city's economy is generated through tourism as it is the leading domestic destination in South Africa. The port of eThekwini is also known as the busiest port in Africa (Rajgopaul, 2018). EThekwini has uneven development and inequalities as many its inhabitants are still trapped in the cycle of poverty (EThekwini Municipality, 2011), residing in townships such as Kwa Mashu, Umlazi, Chesterville Lamontville and also in rural areas such as Embo, Kwa Nyuswa, Inchanga, Molweni and Umbumbulu. On the

other hand, it has produced most of South Africa's millionaires at a fast rate (Press, 2015), many of them reside in Ballito, Umhlanga, Amanzimtoti as well as in Kloof and Hillcrest.

The inequities in eThekwini's socio-economic spectrum are also manifested in its provision of basic education to the local inhabitants of this city. As a result, there are well-resourced elite private schools and former Model C schools located in urban learning ecologies and many poorly resourced schools located in townships and rural learning ecologies. This study was conducted in a rural learning ecology with an aim of centring voices of various stakeholders that are affected by the teaching of GIS in the rural learning ecology in which this study was conducted and it is under traditional leadership. It comprises beautiful landscapes with mountains and valleys. As well as strongly flowing rivers and clean air.

1.8 THEORETICAL FRAMING

This research study was informed by Critical Emancipatory Research (CER). This theory developed from the Critical Theory of the Frankfurt School in Germany (Dube & Hlalele, 2018; Mahlomaholo & Nkoane, 2002) and Emancipatory research. CER continues to grow in conjunction with activists' movements as it has the potential to enhance social justice in education. In this section, I presented this theoretical framework noting its contribution to anti-oppressive educational research. The stated aim of this study was to work collaboratively with the co-researchers to explore the teaching of GIS in a rural learning ecology. Just like any other theoretical framework, CER is fraught with inconsistencies. However, I maintain that it offers valuable insights as it is concerned with power dynamics that shape society and how societies can work together to bring about emancipation from an undesirable situation. Meaning that it calls for action for change to occur.

As stated previously, CER falls within the sphere of the Critical Theory thus an understanding of the latter is fundamental in this study. The Critical Theory allows for reflexivity and critique of education since it views education as an ideologically formed historical process (Carr & Kemmis, 1986) that is subject to critique. The focus of this study was on the teaching of Geography content in a rural learning ecology. Geography as a

discipline is interested in understanding the society and the impact of their activities on the environment (Baerwald, 2010). Therefore, it relates to the critical theory in the sense that the critical theory is also interested in understanding the society as well as in changing the society. Critical theory accepts that there are multiple realities (Mezirow, 1981) because people come from different backgrounds. Thus, it advocates for the collaboration of different stakeholders in research to bring about change to an undesirable situation. Hence this study involved a variety of co-researchers such as teachers, learners, lecturers, student teachers and a Department of Basic Education official (subject advisor). This study draws on the ideas of the second generation of the Frankfurt School, specifically on the work of Habermas, since communicative action and emancipation are the main principles of CER (Dube & Hlalele, 2018; Mahlomaholo & Nkoane, 2002; Tshelane & Mahlomaholo, 2015a).

1.9 RESEARCH DESIGN AND METHODOLOGY

Qualitative research was chosen as a research design for this study, on the basis that it enables researchers and co-researchers to study meaning that they use to frame their world (Forsey, 2010; Mohajan, 2018). This particular study focused on the teaching of GIS in a rural learning ecology. Thus, the qualitative research design enhanced our understanding of the teaching and learning of GIS in a secondary school. Glesne (2016) and Schratz (2019) reveal that there is a growing body of education studies that makes use of qualitative research design. I chose to locate this study under the transformative paradigm (Phelps, 2021), this was because it had a transformative agenda to bring about change in the teaching of GIS in a rural learning ecology. Hence, the aim of the study was not only to understand how co-researchers make meaning but to bring about change through providing empowerment opportunities for all throughout the research process (Avelino et al., 2017; Mertens, 2007).

Participatory action research (PAR) was the research methodology chosen for this study. PAR has been used with success in education research (Cammarota & Fine, 2010; Carr & Kemmis, 1986; Husni, 2020; Tshelane, 2014) because it enables co-researchers to define and address problems from their perspectives. This implies that the co-researchers

become active in making informed decisions throughout the research process to bring about meaningful change (MacDonald, 2012). I favour PAR more than the other research methodologies because it prioritises action, PAR enabled the co-researchers and myself to address some of the concerns about the teaching of GIS in a rural learning ecology, particularly to bring about change in the way that GIS was taught previously. Ayaya, Makoelle and van der Merwe (2020) and Whitehead (2000) argue that PAR enhances teaching practices and increases teachers' awareness of decision-making pertaining to their own practice, thus, improving their working conditions. Chapter four presents a more detailed account of the qualitative research design and the PAR methodology.

1.10 SELECTION OF CO-RESEARCHERS

The initial process of selecting co-researchers for this study began via an informal conversation with a Geography teacher regarding the teaching of GIS in his school. Thereafter, he suggested other people that he thought would benefit from the study. This method of selecting co-researchers is similar to what is termed snowball sampling, whereby co-researchers of a study recommend acquaintances that they think would benefit from participating in a research study. Cohen and Arieli (2011); Heckathorn (2011); Naderifar, Goli and Ghaljaie (2017) highlight that the snowball sampling technique of selecting co-researchers is a non-probability method of selecting [co-researchers] because it is where [co-researchers] recruit other co-researchers for a study. The selection of co-researchers for this study was on the basis that they had an interest in the teaching of GIS in a rural context.

The co-researchers included a subject advisor, two teachers, eight learners, two lecturers and four student teachers. All these stakeholders were regarded as important in this study because they were involved in the teaching and learning of GIS in the rural learning ecology, hence, they were able to contribute meaningfully to the study by reflecting on their challenges of teaching and learning GIS and by coming up with solutions to address these challenges. As the focus of the study was exploring the use of an Inquiry-Based Learning framework in teaching GIS in a rural learning ecology, every co-researcher's

voice was important, in order to change the situation. Chapter four presents a more detailed account of the selection of co-researchers.

1.11 DATA GENERATION PROCEDURES

Conversations with a purpose, focus group discussions, classroom observations and reflective journals were used to generate data for this research study. Various meetings were held for planning and for implementing action (Cumming & Norwood, 2012; Kemmis, McTaggart, & Nixon, 2014). Thereafter, we had meetings to reflect on the action and to plan a way forward. We worked collaboratively to achieve the objectives of the study by responding to the initial research questions. During meetings, the co-researchers and I reflected on our experiences and through their words, I was able to understand the meaning (Revell, 2013) of what they perceived teaching and learning to be. The voices of the co-researchers allowed me to get a sense of their emotions, feelings and understandings of GIS and this enabled us to work together in exploring the use of an Inquiry-based learning framework for teaching GIS in a rural learning ecology. Hence, the qualitative research design (Creswell & Creswell, 2018) that the study employed allowed me to focus on the co-researchers' articulations.

During our meetings, this is where the co-researchers and I developed trust and rapport through interacting and communicating. This is what Revell (2013) terms a 'conversational partnership'. We had discussions that I initiated through posing questions to the co-researchers, this was more apparent in the early phases of the research. Gradually, the co-researchers became more open to initiating discussions pertaining to the study and they even initiated appointments so that we would plan, teach and observe the GIS lessons. Thus, the meetings allowed me to gather a richer understanding of how the co-researchers navigated their social world and their voices were central during meetings.

Whist this research study was in progress, I found that the visits to the school was smoother when initiated by co-researchers because they were able to allocate sufficient time to the teaching of the lesson as well as to reflections afterward. We reflected on how the lessons were taught, thereafter, we planned a way forward. We followed the cycle of

participatory action research that involves planning, action, evaluation and acting (Kemmis, McTaggart, & Nixon, 2013). This was done because Cahill, Quijada Cerecer, and Bradley (2010) and Dewey (1916) state that reflective practices help a group to reflect on their actions. All the reflections were audio-taped and transcribed, moreover, there were also reflective journals that learners submitted after each lesson had been taught and their views were considered for subsequent lessons.

1.12 DATA ANALYSIS

I used thematic analysis as a data analysis method in this study. There are different ways of approaching thematic analysis. For this study, I used Braun and Clarke's (2006) six-step framework to analyse data as it offers clear guidelines to realise the goal of identifying themes. I analysed qualitative data generated through this study's participatory action research methodology. The data sources were conversations and reflective journals. Conversations with the co-researchers were audio-taped and later transcribed to text. Moreover, the co-researchers produced written text through reflective journals. I analysed the text from the audio files and the reflective journals thematically. Chapter four provides a more detailed account of thematic analysis and its application in this study.

1.13 TRUSTWORTHINESS

Trustworthiness in qualitative research is concerned with the extent to which the research findings of a research study are trustworthy, and that the lived experiences of the co-researchers are represented correctly in the writing up of the thesis. To address the latter in this participatory action research study we drew from the four major ideas for ensuring trustworthiness in qualitative research that are presented by Lincoln and Guba (1985) and Shenton (2004), namely: credibility, transferability, dependability and confirmability. These are discussed in more detail in chapter four.

1.14 ETHICAL CONSIDERATIONS

I obtained ethical clearance to conduct this study from the University of KwaZulu-Natal's Humanities and Social Sciences Research Ethics committee (Appendix A). Furthermore, I also obtained gatekeeper's permission to undertake the study from the KwaZulu-Natal

Department of Basic Education (Appendix B) as well as from the school principal (Appendix C) since the study was conducted in a secondary school. This was done before the data generation process began. Upon receiving ethical clearance, I visited all the co-researchers referred to above to request their permission to participate as co-researchers in the study and they gave me permission by signing an informed consent form. Informed consent was also sought from the parents of the learner co-researchers as they were minors and I obtained assent from the learner co-researchers. Informed consent and assent forms made it clear that the co-researchers' participation in this study was voluntary and that they had a right to withdraw from the study at any time without providing a reason for doing so.

1.15 OUTLINE OF THE THESIS

Chapter one is the introductory chapter where I provided a detailed account of the research problem and the context of the study. In this chapter, I included the background of the study, rationale and motivation for conducting participatory action research, the research objectives, research questions, a brief description of the theoretical framings, where the study was situated, the research design, methodology, selection of co-researchers, methods of data generation, data analysis, issues of trustworthiness, ethical considerations, the contribution of the study and a brief outline of the study.

Chapter two provides an understanding of what a theoretical framework is, more specifically, it provides a detailed description of critical emancipatory research (CER), focusing on its origin, philosophical assumptions as well as on how to go about implementing CER. The chapter also discusses the role of the researcher, the relationship between the researcher and the co-researchers, reflections on using CER as well as definitions and a discussion of operational concepts.

Chapter three explored the history of Geography as a discipline, the origin of Geographic Information Systems (GIS) and its inclusion into the Geography secondary school curriculum, as well as how it has been received globally and in South Africa. Moreover, it explored the origin and status of Inquiry-based learning as a teaching strategy. It

presented the opportunities and challenges that it brings to schooling across the globe by reviewing the literature on its use in different contexts.

Chapter four described the research design and methodology that was chosen for this study. In this chapter, I have noted my values as a researcher, the paradigm on which the study is premised, a detailed description of Participatory Action Research (PAR) as a research methodology, selection of co-researchers, methods of data generation, data analysis, issues of trustworthiness and ethical considerations such as gaining permission to conduct this research study and obtaining informed consent from the co-researchers that participated in this study.

Chapter five focused on presenting, analysing and interpreting data according to the objectives of this study. In this chapter, I presented data on the current situation of teaching in the rural learning ecology. This revealed that there was a need for an alternative approach to teaching GIS as the traditional approaches that were used were not producing the desired results in learner performance. Furthermore, I presented the circumstances under which the IBL approach may be used to teach GIS. I also discussed the benefits and challenges of using the IBL approach. Before ending the chapter, I commented on the implications for the use of IBL to teach GIS in a rural learning ecology.

Chapter six presented the discussion of findings. I presented the discussion of findings using the literature review and the Critical Emancipatory Research theory that I used to frame this study. I discussed findings on the current situation of teaching GIS in the rural learning ecology where the study was conducted. There were challenges with regard to the teaching of GIS in this context and most of these challenges concur with previous research that had been conducted. Divergences in terms of the lack of resources were that several studies mostly consider software, hardware and data challenges in the teachers of GIS. But in the rural learning ecology where this study was conducted, there were deeper challenges as there was a shortage of topographical maps and this threatened even the teaching of paper-based GIS in the rural learning ecology. Therefore, I discussed creative strategies to mitigate the latter barrier in this chapter before concluding it.

Chapter seven presented the proposed Inquiry-based learning framework for the teaching of GIS in a rural learning ecology, the contributions of the study and methodological and theorical considerations. I then presented the conclusions reached from conducting this study and implications for future research. I offered a summary of this study, before I reflected on my doctoral learning journey.

1.16 THE SYNTHESIS OF THE CHAPTER

In this chapter, I introduced the entire research study. I gave an account of the introduction of GIS in South African secondary schools and how it has been received in different parts of the country. The preliminary literature that I presented in this chapter under the rationale and motivation for conducting this study taught me that many schools struggled with the introduction of GIS due to the lack of software, hardware and of teacher training amongst other reasons. These challenges have led to an ineffective way of teaching GIS, where learners are taught about GIS instead of being exposed to GIS practically which would develop computer literacy skills that they need to fulfil their current and future roles in the 21st century.

After introducing the research problem. I presented the research objectives and questions, as they were crucial for achieving the aim of the study. Through developing research questions, I learnt that crafting questions is artistic in the sense that questions should be crafted in a way that they explain what is happening, why is it happening and how the situation can be improved, as well as the implications of the intervention. Moreover, I also provided a brief description of the theoretical framing where the study is situated, research design and methodology that underpinned the study. In this chapter, I also discussed the selection of co-researchers, methods of data generation and data analysis. As well as issues of trustworthiness and ethical considerations which are essential elements that are needed to conduct qualitative research.

I learnt that chapter one actually presents the summary of the whole study as it touches on every aspect of it. This became obvious when I wrote a brief chapter overview of every chapter in this thesis before ending the chapter with a synthesis. This chapter lays the foundation of the study by highlighting the background, problem statements as well as

the rationale for the focus of this study, which was the teaching of GIS using an Inquiry-based learning framework in a rural learning ecology. In the following chapter, I provide a detailed description of the Critical Emancipatory Research theory, which forms the foundation of this research study.

CHAPTER TWO
THEORETICAL FRAMING

2.1 INTRODUCTION

In the previous chapter, I outlined an overview of the entire research study. This study aimed at exploring the use of an Inquiry-Based Learning (hereafter referred to as IBL) framework for teaching Geographic Information Systems (hereafter referred to as GIS) in a rural learning ecology. This is because many secondary schools located in rural ecologies of South Africa are characterised by the lack of resources to teach GIS, effectively. As a result, learner performance in this section is very low. Furthermore, research suggests that Geography teachers were not trained adequately to teach this section when it was introduced into the Geography secondary school curriculum in 2006. Given this background, this study argues that the teachers and learners from rural ecologies are disadvantaged. Thus, this study needed to go beyond exploring Geography teachers' experiences of teaching GIS and learners' experiences of learning GIS in a rural learning ecology to change the situation.

Bringing about change in the teaching and learning of GIS in a rural learning ecology meant that an alternative pedagogical tool to teach GIS which draws from the emancipatory paradigm was needed. A convectional research paradigm such as positivism would not have allowed me to work collaboratively with the disadvantaged teachers and learners to bring about change in the teaching of GIS since their worldview is different from the critical paradigm. Given the nature of the aim of this study, its design had to be participatory, allowing me to work collaboratively with learners, teachers, student teachers, lecturers and the subject advisor from a rural learning ecology in order to bring about emancipation. It is against this background that the study draws from Critical Emancipatory Research (hereafter referred to as CER). In developing this chapter, firstly, I present CER as the theoretical framework which framed this study. Secondly, I define and discuss the key operational concepts in the context of this study and lastly, I present the synthesis of the chapter.

2.2 THEORETICAL FRAMING

A theoretical framework is the perspective from which a researcher views a phenomenon and it is one of the fundamental elements of a research process. Grant and Osanloo (2016, p. 12) view the theoretical framework as “the foundation from which all knowledge is constructed (metaphorically and literally) for a research study.” They further state that the theoretical framework supports the motivation for the study, the problem statement, the purpose and significance of the study as well as the research questions. Thus, it can be viewed as an anchor for the literature review as well as the research design and the methodology. Sperka (2018); Swanson and Chermack (2013) argue that theories are useful when a researcher intends to explain and understand a phenomenon in order to challenge the situation and to widen the body of knowledge, meaning that theories are used as theoretical frameworks that guide a researcher when he/she conducts research.

Ngulube (2018, p. 1) concurs with the above views regarding a theoretical framework by stating that “theoretical frameworks serve as the glue that holds the components of social research together, and in the absence of this glue, the research design falls apart.” Thus, as a researcher, I was required to select an appropriate theoretical framework for this study because, as mentioned, it is a glue that holds the different aspects of the research together. I adopted Critical Emancipatory Research (CER) as a theoretical perspective for this research as it aimed at exploring the use of an Inquiry-Based Learning Framework for teaching Geographic Information Systems in a rural learning ecology. The following section provides an outline of this theory.

2.2.1 Historical origins of Critical Emancipatory Research

Critical Emancipatory Research (CER) emerged from critical theory. Thus, an understanding of the critical theory is important because it led to the development of Critical Emancipatory Research. Castro-Gómez and Johnson (2000) refer to the ideas of Horkheimer to argue that the concept ‘critical theory’ was first used by Horkheimer when he presented his essay on the critical theory of society in the year 1937. This shows the long history of the critical theory, which is understood as “the theoretical tradition developed by the Frankfurt School, a group of writers connected to the Institute of Social

Research at the University of Frankfurt" (Kincheloe & McLaren, 2002, p. 84). Geuss (1981) and Sheddy and Brittian (2018) agree that critical theory originated from the Frankfurt School in Germany in the year 1923. The Frankfurt School was a philosophical and sociological institute. According to Dube and Hlalele (2018) and Rundell (2015) Felix Weil donated the money that was used to fund the institute. The aim behind the development of this institute was an attempt to develop Marxist studies in Germany.

Marxist studies foregrounded the work of a German philosopher Karl Marx and his theoretical contribution to the field is the criticism of the political economy. Marx argued that the political economy permitted capitalism which resulted in the oppression of the working class. He advocated for the emancipation of the working class (Marx & Engels, 2009; McLenna, 2000). This can be observed in the following statement from Chambre and McLenna (2018, p. 1), which provides an analysis of some of his work: "philosophy must become reality. One could no longer be content with interpreting the world; one must be concerned with transforming it, which meant transforming both the world itself and human consciousness of it." This suggests that Marx was concerned about the oppression of people. As a result, he argued for their emancipation. This gave rise to the questioning of research studies that placed an emphasis on interpreting what people were going through and not doing anything to solve the situation. To advance this ideology the Frankfurt School was established.

The Frankfurt School consists of different generations, the first generation of the school consisted of prominent intellectuals such as Marx, Horkheimer, Theodor Adorno, Herbert Marcuse, Walter Benjamin, Friedrich Pollock and Erich Fromm (Tarr, 2017). The latter mentioned critical theorists "were concerned with the dominance of positivist science and the degree to which it had become a powerful element in twentieth-century ideology" (Carr & Kemmis, 2003, p. 131). This relates to the call that was made by Marx regarding research that was not leading to the emancipation of the oppressed people. Therefore, a new approach to conducting social research was needed, this led to the establishment of the critical theory (Watkins, 1994). The field of education forms part of social research as it studies the lived experiences of people and people form part of a broader society. The

critical theory holds the assumption that society is governed by politics which reflects unequal power dynamics (ibid.).

Education is inseparable from political debates as schools form part of societies; thus it is used as a tool to promote certain ideologies of those that are in power. Lincoln, Lynham, and Guba (2011, p. 102) reveal that critical theory hopes to “create change to the benefit of those oppressed by power”. This implies that the critical theory can be applied in the context of education as it assumes that dominant political, economic and social structures have power over society. In the case of education those that are in power decide on the curriculum, which may contribute to the marginalisation of certain groups in society as only certain knowledge is promoted. Thus, a paradigm shift in conducting education research was needed and the critical theory is of significance because it seeks to expose this power and to bring about change (Giarelli, 1992).

The critical theory offers a new perspective to educational research as it argues for the emancipation of the oppressed people; thus it gives rise to emancipatory research. Emancipatory research is an approach to doing research that can be of value to the disadvantaged people (Noel, 2016). Emancipatory research is of importance in the context of education because it “has the intent to challenge inequities and disrupt the status quo where necessary” (Rose & Glass, 2008, p. 13). This view of education research is contrary to convectional paradigms such as positivism and interpretivism, as it sees them as “incomplete accounts of social behaviour by their neglect of the political and ideological contexts of much educational research” (Cohen, Manion, & Morrison, 2007, p. 26). Critical theorists argue that the critiques of the political and ideological contexts are imperative because they shape the way education research is conducted. This theory, therefore, calls for change in the way that social research is conducted. Scholars, such as Oliver (1992) reflected on the gaps presented by conducting social research using positivist and interpretivist theories and methods and argued:

> The development of such a theory stem from the gradual rejection of the positivist view of social research as the pursuit of absolute knowledge through the scientific method and the gradual disillusionment with the interpretive view of such

> research as the generation of socially useful knowledge within particular historical and social contexts. The emancipatory [theory], as the name implies, is about the facilitating of a politics of the possible by confronting social oppression at whatever levels it occurs (Oliver, 1992, p. 110).

From the discussion above, it becomes apparent that emancipatory research, a descendent of the critical theory, presented an alternative radical research approach to mainstream research employing positivism and interpretivism and introduced critical social research underpinned by the goal of emancipation (Watkins, 1994). Moreover, Asghar (2013) concurs with the latter by stating that non-critical paradigms such as positivism and interpretivism are concerned about knowledge that can be proven in a laboratory using scientific methods and understanding peoples' lived experiences, whereas the critical theory goes beyond the latter as it aims to create change, creating a better world for all (Giarelli, 1992). This is in alignment with the aims of the Frankfurt School.

As previously mentioned, the Frankfurt school spans many generations (Jay, 1973). The contribution of the second generation of the School is worth noting because it moved from the original ideas of Horkheimer and Adorno (Weiner, 1978), prioritising communicative action (Held, 1980; Kemmis, 2006; Murphy & Fleming, 2010). Giarelli (1992, pp. 3-4) attests to this by arguing that the "critical theory is … an effort to join empirical investigations, the task of interpretations, and a critique of this reality … to viewing knowledge for its emancipatory or repressive potential". The prominent scholars of the second generation of the School consisted of Gerhand Brandt, Ralf Dahrendorp, Ludwig von Friedeburg, Osca Negt, Alfred Schimdt and Jurgen Habermas (Tarr, 2017).

In 1957, Jurgen Habermas became the leader of the School and in that year he wrote about overcoming domination through the solidarity that resulted from creating space for dialogue (Held, 1980; Kemmis, 2006; Murphy & Fleming, 2010). Anderson (2000, p. 2) reveals that under his leadership "what began to emerge as Habermas's distinctive approach to critical theory was a focus on specifying the conditions under which human interaction would be free from domination. Whereas the first generation had looked to

various forms of economic, political, or psychoanalytic ‘crises’ as sites of emancipatory impulses” the new philosophy of Habermas emphasised the importance of critical thinking in communicating and understanding as he was of the view that the source of societal problems is the breakdown in communication and the inability to reason (Salerno, 2004). Therefore, it seems that Habermas viewed communication as an essential tool to promote emancipation, thus people should work collaboratively to communicate societal problems to bring about change.

The rationale behind zooming in on the second generation of the Frankfurt School, more especially on the work of Habermas, is that in South Africa Critical Emancipatory Research (CER) is said to draw from his work. CER draws on Habermas’s notion of emancipatory knowledge and Freire’s transformative emancipatory pedagogy (Nkoane, 2012). Critical researchers engage in CER to make sense of existing problems and to mitigate these problems. Dube and Hlalele (2018) and Mahlomaholo (2009) state that CER emanates from the work of the Frankfurt school. This study aimed at addressing the problem of the teaching of Geographic Information (GIS) Systems in a rural learning ecology as it has been a challenge since its inclusion in the Geography curriculum in 2006.

Emancipation is the core commitment of CER, Denzin and Lincoln (2011) stipulate that the critical framework is crucial in applying social justice methodologies, CER is embedded in the critical theory because it seeks to free society by confronting injustices which may occur within the society. This suggests that CER brings emancipation to society. Many universities around the world advocate for the usage of CER as a theory because the aim of CER is not merely to understand society and its behaviour but it hopes to bring about change in social ills. CER draws on Habermas’s notion of emancipatory knowledge and Freire’s transformative emancipatory pedagogy (Nkoane, 2012).

Emancipatory knowledge is self-knowledge which yields freedom from oppression and it can be practiced through self-reflective practices (Cranton, 2011). It, therefore, requires people to be conscious of the societal challenges that they face, to communicate possible solutions and to apply them. Thereafter, to engage in reflection practises which would

help them to establish what seems to be working and what the challenges that still need to be addressed are. Engaging in such reflective practises will enable society to bring about change to social pathologies that affect them. In light of this, the transformation of the society is initiated by members of the society to free themselves from the oppressive factors that dominate their lives.

A researcher that engages in CER is concerned with the experiences of societies that are oppressed. These researchers see themselves as playing an activist role to emancipate the society by working collaboratively to improve the undesirable situation (Reason & Bradbury, 2001). The CER philosophy is the belief that the society should be able to change its social circumstances. However, their ability to change the circumstances that they find themselves in is prevented by political, cultural and economic power (Myers & Klein, 2011). This suggests that the adoption of CER could transform social conditions created by the latter mentioned powers leading the society towards a democratic life. The purpose of this study was to propose an Inquiry-Based Learning framework to teach Geographic Information Systems (GIS) in a rural learning ecology, aimed at bringing about change in the teaching of GIS. The following section provides three principles of Critical Emancipatory Research that apply to this study, reciprocity, gain and empowerment.

2.2.2 Principles of Critical Emancipatory Research

This section presents the principles of Critical Emancipatory Research applicable to this study.

2.2.2.1 Reciprocity

Conversations regarding research ethics have been gaining on-going interest in humanities and social science research, where there have been calls for institutions of higher education to adopt reciprocal, collaborative and mutual relationships with the communities that they serve (Hammersley, 2017). CER shares the same sentiments, as it promotes collaboration between the researcher and co-researchers and it subscribes to ethical research. Ethical research foregrounds relationships that are based on the interchange of ideas, mutual respect and trust (Bourke, Loveridge, O'Neill, Erueti, &

Jamieson, 2017; van Delene & van der Graaf, 2017). Therefore, an ethical commitment to CER is the understanding that knowledge is co-constructed with the co-researchers.

Researchers operating under CER do not go into the field to generate their data without involving community members as equal contributors to the research project (Mahlomaholo & Nkoane, 2002). This is done to promote equity, social justice and to dismantle barriers between the researcher and the researched, allowing all to contribute to the study and to the production of knowledge collaboratively. This should promote a reciprocal researcher/co-researcher relationship. Jull, Giles, and Graham (2017) and Trainor and Bouchard (2013) reveal that a reciprocal relationship is one in which the research study benefits both from the researcher and from co-researchers. This implies that the latter sacrifice their effort, time and knowledge to inform and shape the study.

For this research study, the co-researchers included secondary school teachers, learners, lecturers, student teachers and the subject advisor who oversees the teaching of Geography in various secondary schools in the Pinetown District. Thus, there was an interaction amongst the researcher and the community since schools form part of a community. As a result, this study draws from the concept of social capital. The concept of social capital has many connotations (Bourdieu, 1986; Lin, 2017; Siisiainen, 2003), however, this study thinks of social capital as resources that are rooted in social structures. To gain access to these resources, social relations and networks must be formed within communities because they allow people to work in groups that trust each other and work collaboratively. This study aimed at bringing about change in the way that GIS is taught in a rural learning ecology. This required working collaboratively with the co-researchers who are affected by the teaching and learning of GIS and who endorsed the sharing of experiences, values and understandings in society in order to bring about a change in the way that GIS is taught.

The philosophy of social capital relates to reciprocity in the sense that they are both concerned with community wellbeing. Furthermore, they advocate for trust amongst the community and for working collaboratively to achieve a certain goal. Reciprocity is an integral process of CER, especially because the latter aims to bring about change. Whilst

reciprocity talks about the social exchange of ideas regarding social welfare, bringing about change requires the affected people to work collaboratively to address the undesirable situation. This study applied reciprocity by promoting active consultation between the researcher and the co-researchers. Active consultation began from the conceptualisation stage and it continued right up until the study was completed. This resulted, in a smooth ethical working relationship between the researcher and co-researchers that was meant to be beneficial to all parties involved. Moreover, an on-going relationship that extends beyond the scope of this study was formed between the researcher and co-researchers.

2.2.2.2 Gain

When interrogating the issue of gain in this kind of research project, I came across the comment by Wilmsen et al., (2008, p. xix) who note that this is "research most often done to, for or about, or even on behalf of rural communities and is occasionally bestowed upon them for their use". This shows that some research studies do not benefit the rural communities in which the studies are conducted. For instance, a study conducted by Williams et al., (2010) on the perspectives of communities regarding the ethics of health research found that the lack of beneficence was expressed by the community members that participated in the study. They supported this view by stating that researchers that come into the community to conduct research often do not communicate the findings of the study to follow through on the issues that they found. Therefore, such research studies do not benefit the community; meaning that it is only the researcher that gains from the process. More often than not such studies do not give participants an active role in formulating the research agenda (Huang & Coker, 2010).

When the research agenda is solely set by the researcher there is no accountability on the part of this researcher. As a result, opportunities for collaborative community development may be missed. Flicker (2008) argues that we must continually reflect on whether or not our research promotes community participation and empowerment. One example of how researchers miss opportunities for collaborative community development is the lack of consultation with participants regarding the research process resulting in the expert researcher determining the research goals (Fassinger & Morrow, 2013). Thus, the

expert researcher ends up being the one who gains from the research project together with his or her employer. Bromley, Mikesell, Jones, and Khodyakov (2015); Mfutso-Bengo, Masiye, Molyneux, Ndebele, and Chilungo (2008) reveal that many community members are refusing to participate in research studies due to several reasons, such as being treated as objects studied by outsiders with little or no gain for themselves and their communities. For me the lesson in this is that researchers should set research agendas with co-researchers so that all parties can benefit from the research project.

Research conducted in the transformative paradigm using CER presents an opportunity to gain for both the researcher and the co-researchers. This can be observed in the following studies that have made use of CER (Chidarikire, 2017; Mahlomaholo, 2009; Msimanga, 2017). Specifically for this study, as a researcher working collaboratively with the co-researchers, one of the benefits of taking part in this study was an opportunity for us to reflect on the usage of an IBL approach in teaching GIS in a rural learning ecology. Some of the potential gains for us in engaging in this was acquiring knowledge on GIS content knowledge and skills as well as developing communication skills since we scheduled many project meetings for planning and reflecting. The importance of reflective practice was emphasised throughout the research process because it enabled us to change our educational practice. Reflective practise is an essential tool that can be used by teachers to facilitate change in their practice (Ghaye, 2010; Roffey-Barentsen & Malthouse, 2013), as well as to soliciting learners' views on the teaching practice.

Communication is essential in studies that adopt CER (Nkoane, 2012), for it is when there are interactions between the research and co-researchers that meaningful change can come about. Learner co-researchers' perspectives were centred in this research, as they were given an opportunity to reflect on how they were taught GIS before the IBL approach was introduced as well as to evaluate the GIS. Learners were asked to share with us what worked/did not work when the IBL approach was used. This was done to ensure that learners benefited from the study as they were also co-researchers in the study. Therefore, gathering their views on trying to improve the teaching of GIS was imperative because at the end of the day they are the ones who are supposed to write assessments that include GIS and they have a choice to choose careers that are GIS-related.

Another important gain from the study was the development of this thesis, as it provides a report on how the research study was conducted and presents research findings and the implications for future research. Wood (2017) argues that community-based research does not generate knowledge, but it presents a learning process for all those that are involved in the research project and has the potential to change society through changing individuals who take part in the research project. This was applicable to this study because the co-researchers and myself gained a great deal of knowledge by participating in this study.

2.2.2.3 Empowerment

Empowerment is a subjective concept in academic literature because there is no consensus of what constitutes power. For instance, Mudambi and Navarra (2015) allude to the notion that power is knowledge. Whereas, Nikkhah, Redzuan, and Abu-Samah (2012, p. 39) argue that "power can be gained, nurtured, and sharpened" and that the process whereby the person gains power is referred to as empowerment. Bakhshi, Shojaeizadeh, Sadeghi, Taghdisi, and Nedjat (2017) and Blanchard, Carlos, and Randolph (1999) state that empowerment is creating a culture where people can be empowered. This entails creating space where people use their experience, knowledge and internal drive to reach a desired shared goal. It is apparent from the two definitions provided that there are many ways to define empowerment, especially since it is a concept shared by many fields such as education, gender studies, community development, psychology and economics. Therefore, this has given rise to numerous debates that are concerned about what constitutes empowerment.

For the purpose of this study, I subscribe to how Page and Czuba (1999) define empowerment. The latter defines empowerment as a multi-dimensional, social process. From this definition, one can observe that the authors talk about three different aspects that are necessary when defining empowerment. Firstly, empowerment is multi-dimensional in the sense that in a collaborative setting it may be concerned with the functioning, development and well-being of a community (Kitawi, 2015). Secondly, it is social because it can occur at an individual level as well when people work collectively as a group to improve a problematic situation (Bakhshi et al., 2017). Lastly, empowerment

is a continuous process because it requires a series of actions in order for the end goal to be reached (Perkins, 2010). For instance, marginalised groups in a society can work collaboratively to assess and take action to challenge the power imbalances which exist in their community. For this particular study, a group of stakeholders that had an interest in the teaching of GIS in a rural learning ecology came together to change the way that GIS is taught in a rural learning ecology.

Research studies have the potential to empower participants and part of the rationale behind research studies with an empowerment goal is to apply corrective measures to extractive research (Wilmsen, 2012). Extractive research is that research that does not benefit the community that participates in the research project. Examples of extractive research, include researchers that “position participants as vessels of information which the researcher, as expert, draws upon for his or her scholarship” (Ross, 2017, p. 1). Consequently, research findings that are generated from such research projects tend to benefit the researcher and leave communities unchanged or in a worse state than they found them. Authors such as Toomey (2011) alerts us to the fact that, depending on the researcher’s intentions, some research projects result in empowering/disempowering the community that participates in the research project. Thus, in my view, extractive research results in the disempowerment of co-researchers, while non-extractive research may contribute to the empowerment of co-researchers. CER which frames this study condemns extractive research because of its lack of emancipatory intent, which can be applied by creating an enabling environment whereby co-researchers can bring about change to a situation that they deem undesirable.

Researchers that are guided by CER are intentional about creating opportunities for self-empowerment (Tshelane & Mahlomaholo, 2015b). This is because they hold the view that empowerment comes from within a person, meaning that the choice to bring about change rests with the person concerned to take significant steps to improve their situation – it is an intrinsic state of being. In a research setting, this may involve the interaction between researchers(s) and co-researchers. For instance, Tshelane and Mahlomaholo (2015b, p. 202) report that on their journey of creating sustainable learning environments with five co-researchers in a school they “embarked on a self-empowerment project,

which involved a range of training events relating to data gathering, analysis and report writing". Damen and McCuistion (2010) and Oliver (1997) affirm this view of empowerment by stating that empowerment is not something that one gives because they are powerful. Rather it is something that people can do for themselves, individually or as a collective. Ross (2017) argues that a methodological design chosen for a study has the ability to facilitate empowerment. Consequently, participatory action research (PAR) has been chosen as a research methodology for this study because it intended to create a space where the researcher and the co-researchers could empower themselves to change the way that GIS was taught in a rural learning ecology.

Creating a space for empowerment for this study, necessitated that the co-researchers and myself had to work together in the conceptualisation of the study, which addressed the teaching of GIS in a rural learning ecology, an issue that we were all interested in. Also, we collaborated to generate data for the study. When this study had been written up as a draft, I gave the co-researchers an opportunity to review it and to comment on its contents. This was done in recognition that both the researcher and co-researchers had unique knowledge and skills that they had brought to the study. Thereafter, feedback from the co-researchers was incorporated into the final draft of the thesis that was submitted to the university. Involving co-researchers throughout the research process was necessary because as scholars such as Nikkhah et al., (2012) explain, empowerment is concerned with developing critical consciousness and with taking action to bring about positive change. This explanation of empowerment is in alignment with CER and PAR since it presupposes working with participants as co-researchers to initiate change, thus during the course of this study there was a constant interaction between the co-researchers and myself throughout the research process

2.2.3 Implementing Critical Emancipatory Research

Epistemological, ontological, and axiological decisions are determined by the theory that a researcher chooses to apply to his or her study (Asghar, 2013). As this study is undertaken from the Critical Emancipatory Research theoretical perspective, it is important to explore how the basic philosophies of Critical Emancipatory Research were

implemented in order to explore the use of an IBL approach for teaching GIS in a rural learning ecology.

2.2.3.1 Critical Emancipatory Research and epistemology

A vast body of literature recognises that knowledge is socially constructed (Andrews, 2012; Hamati-Ataya, 2018; Keahey, 2016), Critical Emancipatory Research agrees with this notion. Moreover, CER accepts that knowledge is true if it is applied to empowering and transforming the lives of people (Mahlomaholo & Nkoane, 2002); this is because of its emancipatory agenda. In CER, knowledge production is dependent on people working co-operatively, especially the people who are affected by a problem. A number of studies such as Chidarikire (2017); Mokotjo (2017) and Msimanga (2017) have applied this theory and they have collaborated with the people who were affected by the research problems that they were intending to solve. These studies ensured that the affected people became co-researchers and that they collectively worked together to bring about positive change. Thus, knowledge was constructed from the co-researchers' viewpoint rather than by the researchers assuming the role of experts during the research process.

Various scholars have written about the politics of knowledge production, dissemination and the power dynamics that are at play in the legitimatisation of knowledge (Kolawole, 2013; Moletsane, 2015; Tadajewski, 2016). CER's epistemic contribution is unique in the sense that it re-centres the researcher's and co-researcher's voices in the research process. Hence, this study involved different stakeholders who brought about different kinds of knowledges during the research process, which contributed to bringing about change in the teaching of GIS in a rural learning ecology. Working collaboratively with the co-researchers ensured that their voice was taken seriously throughout the research process. The co-researchers were involved in the conceptualisation of the study, laying out the research design, data generation and analysis as well as verifying the findings of the study. This allowed for the sharing of power during the research process, whereby the co-researchers were made to feel that their voices counted and that the knowledge that they possess matters. Moletsane (2015, p. 35) argues that to transform the unequal power relations which transpire during the research process, knowledge should be co-

created, co-analysed and co-communicated with the co-researchers. This is aligned with CER since it advocates for collaborative knowledge generation.

2.2.3.2 Critical Emancipatory Research and ontology

Ontologically, Critical Emancipatory Research (CER) assumes that reality is shaped by social, political, cultural, ethnic, historical, gender and power dynamics which constantly influence the society to change (Neuman, 2005). As a result, the society is not stagnant, it undergoes a variety of changes since people are active beings who can bring about change. The process of bringing about change in society is influenced by the different viewpoints that individuals within the society possess. Mertens (2008, p. 74) maintains that the "transformative emancipatory ontology assumption holds that there are diversities of viewpoints with regard to many social realities but that these viewpoints need to be placed within political, cultural, historical, and economic value system to understand the basis for the differences." The differences exist because the society has individuals within it who have differing views of reality.

CER views reality as a social construct because people use their experiences to understand and construct meaning which determines how they view themselves and the world around them (Knowles, Nieuwenhuis, & Smit, 2009). Since multiple people make up a society, multiple perspectives arise. Therefore, CER believes that there are multiple realities and this way of thinking suggests that "human experience is reality" (Levers, 2013, p. 2). These realities can be understood and changed through involving participants in research studies and in applying methodologies such as Participatory Action Research. The ontology of CER is therefore different from positivism which assumes that there is one reality waiting to be discovered by applying scientific methods.

2.2.3.3 Critical Emancipatory Research and axiology

Critical Emancipatory Research (CER) values change. The purpose of CER is not merely to name and to understand the issues that affect people but, it aims to bring about change, since it is positioned in the transformative paradigm (Kivunja & Kuyini, 2017). Furthermore, the latter mentioned authors suggest that axiology involves reflecting about right and wrong behaviour when conducting research, meaning that the researchers must

be clear about their regard for human values and ethics during the research process to ensure that the co-researchers rights are respected. Moreover, researchers should consider how they should conduct research using a socially just, respectfully and peaceful approach.

A researcher operating with CER should cultivate values such as democracy and social justice (Nkoane, 2012). To observe democracy and social justice, the co-researchers were invited to volunteer to partake in this study, which aimed at proposing an Inquiry-Based Learning framework for teaching GIS in a rural learning ecology. They were given informed consent letters that they were invited to sign if they were interested in partaking in the study. The letter explained that participation in the study was strictly on a voluntarily basis and they were advised that they were free to withdraw from the study at any time should they desire to do so without explaining the reasons for doing so. This was necessary to ensure that they co-researchers understood their rights prior to partaking in the study. The researcher has his or her own values that influence the way that they conduct research.

I value research that results in change of peoples' undesirable circumstances. Neuman (2013) draws our attention to the fact that the values of a researcher have the potential to influence the research. Therefore, I am passionate about emancipatory research and I believe that for emancipation to emanate, the affected people must play an active role by becoming partners in the research process. As a researcher, I cannot claim to know all about the societal dilemmas that people face while I am an outsider. As a result, I view the affected people as insiders since they are more knowledgeable about the issues that affect them. Thus, they are in a better position to suggest solutions that they think might work. So, when this research study was conducted, I gave the co-researchers a platform to express their concerns about the teaching of GIS in a rural learning ecology and allowed them to suggest solutions. CER was chosen to frame the study because it values co-researchers and views them as equals in the research process. Over and above this, CER respects cultural norms.

2.2.4 The role of the researcher

As the researcher I assumed several roles while carrying out the research to bring about change in the teaching of Geographic Information Systems within a rural learning ecology. I was an initiator, co-ordinator, a co-researcher and an interpreter.

Firstly, I had informal conversations with postgraduate students that were teaching Geography at the local secondary schools regarding the challenges that they faced when teaching the subject in a rural learning ecology. From these conversations it became apparent that GIS implementation was a challenge for them, I could relate to their frustrations because I was in a similar situation while I was still a Geography teacher at high school. Also, as a Geography lecturer I was struggling with GIS implementation. It was through these conversations that I assumed a role of being an initiator in the study because as we spoke with the teachers, we realised that we must do something to bring about change in the teaching of GIS in a rural learning ecology. The research studies by Arnaboldi, Azzone and Palermo (2010) and Hyvönen (2003) suggest that an initiator of a research project has a huge impact on the outcome of the project. As this was a participatory action research study, I was not solely responsible in the initiator role, other co-researchers were actively involved in the process thus they took ownership of the study as well.

Secondly, I also assumed the role of a co-ordinator for the study. During this period, I had to communicate with the co-researchers to confirm their availability for planning purposes. I had to schedule meetings with them in order to conceptualise and to carry out this research study. During these meetings I had to ensure that I created a conducive environment where everyone was free to express themselves openly. The aim was to initiate dialogue so that we would work with the various co-researchers to bring about change in the teaching of GIS in a rural learning ecology. Dold and Chapman (2012) argue that CER differs from the traditional research studies in the sense that it encourages co-researchers to have a say in the research study and their views are respected. Furthermore, McDonald, Kidney, and Patka (2012) argue that the voices of the people who face predicaments are solicited because they have lived through experiences of the phenomena. Therefore, for the purpose of this study, learners' voices, teachers' voices,

lecturers' voices, student teachers' voices and the subject advisor's voices were essential because they are all involved in the teaching and learning of GIS which is a predicament in the rural learning ecology that was studied.

Thirdly, I also assumed the role of being a co-researcher. This is because the methodology adopted for this CER study is participatory action research (PAR) and according to Postholm and Skrøvset (2013) action research is unique because the researcher also becomes the implementer of the intervention strategy. This meant that I had to adopt an attitude of seeing myself as a co-researcher in the study. Being a co-researcher meant that, we became equal partners with the other co-researchers in the research process in order to bring about change in the teaching of GIS in a rural learning ecology. We had to plan the study; this entailed identifying the problem then proposing an intervention strategy to mitigate the problem. We then applied the intervention strategy. Whist applying the intervention, we observed the process with the aim of identifying strengths and weaknesses of the intervention and this process involved reflective practice. This resulted in the adjustment and modification of the intervention strategy. As co-researchers for this study we had to work collaboratively because we all have a genuine interest in the teaching of GIS in a rural learning ecology.

Lastly, I assumed the role of an interpreter, this means that I had to assume the role of interpreting the findings. Mahlomaholo (2009) stipulates that in CER the researcher is expected to interpret other people's constructions of a phenomena. In so doing they try and make sense of the views and experiences of the co-researchers. For this study, I had to analyse the co-researchers perspectives on the teaching of GIS in a rural learning ecology. This meant that I had to listen closely to other people during discussions and I had to be cautious to ensure that the discussions went in the directions that were important to them.

During the research process, I came to realise that the research study was not about me only, but it was about us working co-operatively with the co-researchers aiming to bring about positive change in teaching practice, specifically, the teaching of GIS in a rural learning ecology. In order to bring about this change, I had to develop an understanding

of the meaning that co-researchers made of their lived experiences (Sutton & Austin, 2015). Thus, after interpreting the co-researchers meanings, I had to take the data back to them for them to verify whether I had captured their meanings correctly. This was an imperative task because according to Sutton and Austin (2015) researchers often interpret the co-researchers' narratives from their own point of view instead of presenting them from the co-researchers' point of view.

2.2.5 The relationship between the researcher and the co-researchers

Research studies are often conducted in a fashion where the researcher is portrayed as omniscient while the researched are not 'knowing'. Critical Emancipatory Research (CER) adopts a different approach to research as it advocates the essential interactive relationship between all participants; the researcher and the co-researchers. Mertens (2008, p. 99) suggests that the "interaction between the researchers and [co-researchers] is essential and requires a level of trust and understanding to accurately represent viewpoints of all groups fairly." The representation of every researcher's viewpoint is fairly important when conducting critical research because CER involves a process of reflection where the research participants become co-researchers in the study (Kemmis et al., 2013; Mahlomaholo, 2009). This suggests that CER calls for a collaborative relationship between the researcher and the co-researchers, where the co-researchers are viewed as equal partners in the study that aims to bring about change, as Msimanga (2017) argues. To achieve the purpose of this study, which was to propose an Inquiry-Based Learning framework to teach GIS in a rural learning ecology, we formed a partnership with the co-researchers to bring about change in the teaching of GIS that has been problematic ever since its introduction in the secondary school Geography curriculum.

CER calls for an active involvement by the researcher and the co-researchers (Breitbart, 2010), where everyone is accorded a chance to participate meaningfully in the research process. The co-researchers and I were actively involved by forming a partnership, whereby we selected the research topic, decided on the data generation methods and the type of analysis that was suitable for the study (Baum, MacDougall, & Smith, 2006). Creating such a partnership was necessary because the emancipatory research paradigm advocates for the creation of research coalitions. Moreover, we decided on the

action that was appropriate after engaging with the findings from the study. Essentially, our relationship was dependant in the sense that we worked together toward the same goal, CER should be based on trust and commitment because the objective of the theory is to bring about emancipation and transformation. Without trust and commitment it would be very unlikely for emancipation and transformation to take place (Pain, Kindon, & Kesby, 2007). Bringing about emancipation and transformation is a time-consuming process therefore it calls for trust and commitment from all the stakeholders that are involved in the research process.

Communication is key to enable change to take place. Boog (2003) and Krauss and Turnip (2013) reveal that for emancipation to occur there must be communicative interaction between the researcher and the [co-researchers]. This implies that there must be an on-going shared dialogue and regular interaction between the researcher and the co-researchers whilst working in collaboration to bring about change. For this study we had regular meetings with the various co-researchers in order to propose an Inquiry-Based Learning framework for teaching Geographic Information Systems (GIS) in a rural learning ecology. The meetings were essential for conceptualising the study, planning the intervention strategy and for evaluating the intervention strategy in order to improve it. Reflective practise by the researcher and the co-researchers necessitated regular interaction and participation from all stakeholders that were involved in the research study. Throughout the research process the relationship between the researcher and co-researchers was based on unity, co-dependency and mutual interconnectedness.

2.2.6 (Some) Reflections on using the Critical Emancipatory Research theory

The Critical Emancipatory Research theory, like other theories which are used to frame research projects is subject to ongoing examination and critique. After all, the researcher that uses this theory believes that there are multiple realities that exist out there. Thus, knowledge is contested. Furthermore, other authors have challenged the concept of knowledge by suggesting that there are different knowledges (Ndlovu-Gatsheni, 2015). Nevertheless, although this section presents some weaknesses of the Critical Emancipatory research theory, which a researcher operating under this theory needs to take note of, one cannot take away from the many advantages of conducting research

using this theory as it aims to empower marginalised people and to bring about change to the status quo where necessary. The section below presents three limitations that might hinder the application of the Critical Emancipatory Research theory.

The first limitation of applying the Critical Emancipatory Research theory in this study, is that although it is underpinned by a social justice ethic; this ethic being manifested in the situation whereby knowledge is co-constructed and ideas are collaboratively discussed and implemented. The challenge with the application of this theory in a schooling context is that the curriculum and pedagogy are strongly controlled by the Department of Basic Education (DBE), which plays a significant role in determining the lesson content, objectives as well as assessment criteria. This implies that the curriculum and the pedagogy are imposed by the DBE as there is no consultation with the teachers and learners regarding curriculum decisions. Therefore, teachers and learners' voices are marginalised because they do not have a say in the curriculum and pedagogy decisions that affect them daily, since the teachers are expected to teach the prescribed curriculum and learners are meant to learn it and be assessed on it. Carl (2005, p. 223) concurs by stating that "the practice of teachers simply implementing curricula, which have already been developed elsewhere, probably also holds true for the South African context." Even when GIS was introduced in South African secondary schools Geography learners and teachers were not consulted regarding this decision and yet they were and are frustrated by its introduction, hence this is why this study aimed at assessing the efficacy of using IBL in teaching GIS in a rural learning ecology.

Given the tenets of Critical Emancipatory Research already discussed in the previous sections (2.2.2), there is bound to be acrimony regarding the prescriptions of the Department of Basic Education. Critical Emancipatory Research neglects to appreciate that change cannot be initiated from the classroom (actively involving teachers and learners) since the Department of Basic Education controls the curriculum and the pedagogy. In other words, the Department of Basic Education favours the top-down approach whereas the Critical Emancipatory Research theory supports the bottom-up approach which gives the voice to the voiceless (teachers and learners). The acrimony

between the Department of Basic Education and critical Emancipatory research is aptly revealed in Figure 2.1 on the following page.

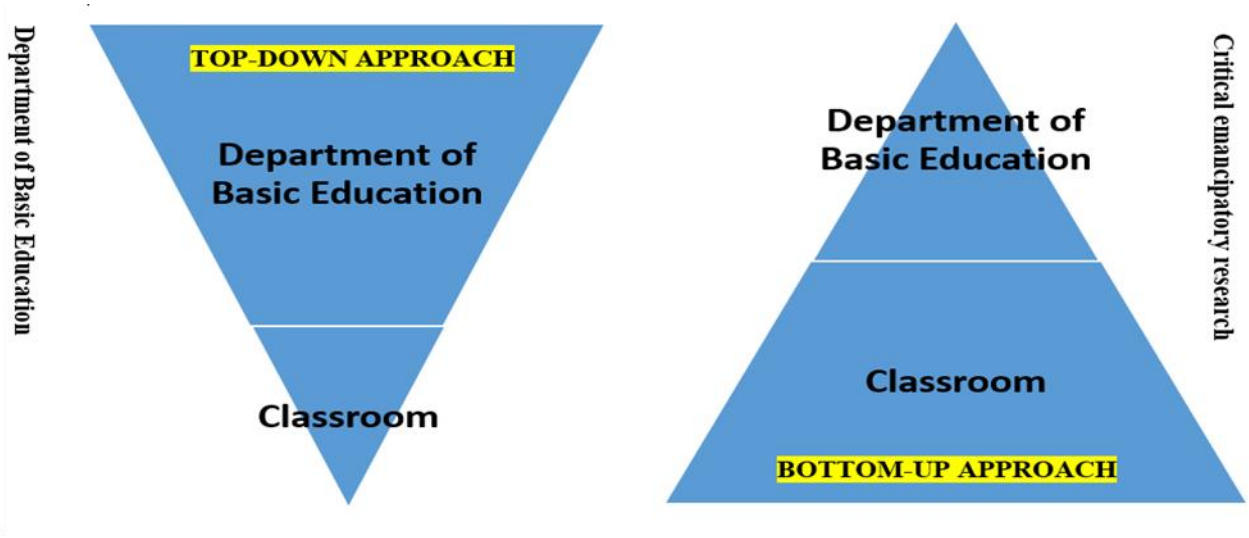


Figure 2.1 Department of Basic Education vs Critical Emancipatory Research

Figure 2.1 above reveals that decisions regarding the curriculum and what transpires in the classroom are made at the top by the Department of Basic Education, then teachers are expected to implement what is prescribed but this contradicts what the proponents of Critical Emancipatory Research advocate. This to some extent, limits both the epistemic and pedagogical possibilities of critical emancipatory theory as implemented and explored in the schooling context. However, we still managed to change the teaching of GIS by teaching the latter using an Inquiry-Based Learning Framework.

The second limitation in the application of Critical Emancipatory Research to this study, could be that the researcher was trained in the initial paradigms such as positivism, post-positivism and the interpretive paradigms, whereby the researcher is used to approach the research site as an expert. Additionally, in the initial research paradigms there is an unequal relationship between the researcher and the participants, since the researcher is considered to be an expert. Consequently, transforming from an interpretive mind-set

to viewing the participants as co-researchers was a challenge. Sandelowski (1998) is of the view that new modes of research, such as participatory research have challenged the role of being an expert and expertise in research. Critical Emancipatory Research is participatory as a result it required the researcher to view the co-researchers as equals. Thus, in order to give a voice to the voiceless (co-researchers) I had to adopt an attitude of reciprocity and acknowledge the voices of the co-researchers. Acknowledging that the study was ours and not mine alone, research for this study was undertaken together with the marginalised co-researchers from the rural learning ecology in order to change the way that GIS was taught.

The last limitation of the Critical Emancipatory Research theory is derived from emancipatory research since it draws from it. Consequently, it is important to explore the limitations of the latter. Hanley (2005, p. 53) states that “emancipatory research may not be seen as ‘real’ research because it focuses on people’s experiences and making changes.” As a result, a researcher operating under this theory might experience difficulties when applying for research funding because most funders are biased when it comes to the ways of conducting research. Hence, some of the approaches to conducting research are obsessed with the researcher being unbiased, objective and neutral.

Traditional types of research tend to be more valued than research that has an emancipatory agenda in terms of funding. Hanley (2005) further states that currently there have been only a few research emancipatory research studies that have been funded and in most cases this funding has been minimal. Macaulay (2016) holds a similar view by stating that participatory research has a long history of not being recognised as proper research. However, in recent times its status has improved and many researchers are using it to frame their research projects and they are publishing their work. Fortunately, for this particular study data generation costs were paid by the University Capacity Development Project (UCDP). This helped to ensure that there was enough petrol money for back-to-back meetings with the co-researchers.

2.3 DEFINITION AND DISCUSSION OF OPERATIONAL CONCEPTS

This section provides definitions and discussions of the operational concepts that have been used in this study. These include Inquiry-based learning, Geographic Information Systems and Rural learning ecology.

2.3.1 Inquiry-Based Learning

Even though IBL is highly regarded as an appropriate teaching approach, the literature search that I conducted on it shows that there is no universal definition for IBL. The same conclusion with regards to defining IBL was reached by Sikko, Lyngved, and Pepin (2012), who state that there is no clear-cut definition of IBL. Amongst other authors, Jakab et al., (2016, p. 289) state that IBL refers to a student-centred pedagogical approach where learning is achieved by asking questions, solving problems, communicating and thinking critically and creatively. I have adopted this definition of IBL because it speaks about active learning and the development of critical thinking skills, I believe that these skills are essential in the current era filled with major technological advancements. IBL was developed in the 1960s during the 'discovery learning' movement and one of its co-founders is a scholar named Joseph Schwab (Pappas, 2014). According to Michael Connelly (2013), Joseph Schwab was a biologist, a philosopher of education and he was well known for his enormous contribution to education as a curriculum scholar.

Other proponents of IBL include John Dewey, Paulo Freire, Jean Piaget and Lev Vygotsky (Hittie & Peterson, 2003), thus it belongs in the constructivist school of philosophy. IBL is used extensively in the Science curriculum, research projects and teaching (Pedaste et al., 2015). In the context of teaching, it is important to conceptualise IBL from a teacher and a learner perspective since they are partners in education. From a teacher's point of view, IBL aims to promote learner-centred lessons that require deep understanding and the development of critical thinking skills, teachers facilitate learning by encouraging learners to ask questions and by guiding them through the inquiry activity (Pappas, 2014). Furthermore, from a learner's point of view, IBL focuses on investigating a problem and learners have to formulate questions, develop methods and solve problems creatively, meaning that learners should be able to process information.

The development of Inquiry skills requires practice, as a result, there are different forms of inquiry that a teacher can facilitate, taking into consideration the level of development of learners and previous exposure to IBL. Banchi and Bell (2008) reveal that there are four levels of inquiry that a teacher can guide learners through; confirmation and structured, guided and open inquiry that is applicable to any activity. The authors further explain that: firstly, a *confirmation inquiry* is useful when a teacher wishes learners to apply previously learnt knowledge and secondly, in a *structured inquiry* the teacher provides questions and guidelines then the learners present a rationale emanating from the data that they have generated themselves, thus these are considered as low-level inquiry-based learning activities because a teacher provides more guidance in the completion of tasks.

Thirdly, *guided inquiry* differs from the low levels of inquiry-based learning activities in the sense that the learners are provided with research questions and the learners have to develop a method to obtain data and to analyse findings. This type of inquiry-based learning is suitable for learners who have had prior experience of the two low levels of inquiry. Lastly, *open inquiry* gives learners more freedom compared to the other levels of inquiry because learners formulate their own questions, choose their own methods of generating data and of reporting findings in any way that they deem appropriate. Guided and open inquiry are thus regarded as high levels of inquiry. Regardless, of the level of inquiry, the main goal of IBL is to enable learners to analyse, synthesise and evaluate information.

Anderson et al., (2001) state that the analysing, synthesising and the evaluation of information is regarded as an indication of a high level of reasoning according to Bloom's taxonomy. This taxonomy was developed in the 1950s and it is used to categorise the levels of reasoning skills that are required in classroom activities (Bloom, 1956), so it should be used with IBL because it also aims to create thinkers rather than information recall. Several scholars support the effectiveness of IBL as a teaching and learning approach (Alfieri, Brooks, Aldrich, & Tenenbaum, 2011; De Jong, Sotiriou, & Gillet, 2014; Furtak, Seidel, Iverson, & Briggs, 2012; Minner, Levy, & Century, 2010). These scholars have conducted a number of studies that reveal that IBL yields positive results for

teaching and learning in various education settings. This implies that teachers should be intentional about using IBL in their lessons.

The four levels of inquiry presented previously, indicate that IBL exposes learners to problem-based learning (PBL), as it requires learners to develop solutions to problems by applying previously acquired knowledge or by conducting research. More often than not, learning begins with posing questions, scenarios or problems rather than with presenting facts that learners are expected to memorise (Bunterm et al., 2014; Pappas, 2014; Přinosilová, Mechlová, & Kubicová, 2013). This suggests that when the Inquiry-based learning is applied learners are actively engaged. The amount of learner involvement varies depending on the level of inquiry that a teacher chooses for a specific task. The focus of this study is the teaching of Geographic Information Systems in a secondary school located in a rural learning ecology. In a few years, learners that graduate from this school are expected to attend institutions of higher education and to join the workforce. Thus, it is important for them to develop inquiry skills while they are still at school, given that there are different levels of inquiry that a learner should progress through.

According to Kuhlthau et al., (2015) schools must give learners a platform to engage in guided Inquiry daily in every subject. Therefore, I argue that a Geography classroom should nurture inquiry skills that should promote Geography Inquiry. Geographic inquiry, also referred to as thinking geographically, is concerned with theorising space (Cutchin, 2008), knowing where something is located, why it is there as well as the implication of its location (National Geographic, 2019). For instance, an inquiry might begin by asking where mountains and the sea are located, thereafter, a follow up question could be how the latter influence weather patterns around its location. These types of questions develop spatial thinking in learners which is a skill that every Geography learner should have since the South African Geography Curriculum and Assessment policy encourages the application of inquiry in Geography's four big aspects: place, spatial processes, spatial distribution patterns and human and environment interaction. Therefore, an application of IBL when teaching GIS is recommended by this study since GIS provides information about spatial processes and spatial distribution.

Geography Secondary school learners come from diverse backgrounds: rural areas, townships and urban environments and they need to be equally prepared to succeed in the modern world. This becomes a difficult task for any Geography teacher as there is a great deal written about which teaching methods are appropriate. For instance, traditional teaching methods that are based on the 20th century 'factory' model, which encouraged learners to memorise and reproduce knowledge, are heavily criticised (Boyd & Bargerhuff, 2009; Freire, 1970; Tan, 2015). They are criticised because they are said to give learners a passive role in education. It is against this backdrop that the current education debates are now focused on the development of 21st century skills that enable learners to survive and succeed in the modern world. Thus, Geography teachers should aim to develop learning and innovation skills, information media and technological skills as well as life and career skills amongst other skills. Using the inquiry-based learning framework allows for the development of such skills, which is why we propose it as a framework for teaching Geographic Information Systems in a rural learning ecology.

2.3.2 Geographic Information Systems

Mapping has always been an important part of civilisation because people have always been concerned about the location of features. Traditionally, maps were drawn by hand before the emergence of more advanced technology. Over the centuries, there have been significant changes in mapping such as the shift from paper maps to digital maps. However, the 19th century is known as the century that brought about the most significant technological development in mapping: the advent of the Geographic Information System (Harvey, Kwan, & Pavlovskaya, 2005; Tomlinson, 1987). The origin of the latter, commonly referred to as GIS, can be traced back to the late 1900s, whereby Roger Tomlinson first used it in a paper (Tulloch, 2000; Wing & Bettinger, 2003). GIS is of importance because it brought about major changes in digital mapping, allowing for spatial data to be represented more accurately.

The Council (2006, p. 159) defines GIS 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". As a result, it is a fast-growing technological tool (Goodchild,

2018) which is used in various fields that are concerned with spatial data (Fischer, 2019; Jung & Elwood, 2019; Noorollahi, Arjenaki, & Ghasempour, 2017). For instance, climatologists can use it to store natural disasters' data, retailers to map the distance their shoppers travel and the Health Department might use it for directions during an emergency response. Spatial thinking forms part of our daily lives and the most common usage of spatial thinking for the general public is the use of online mapping tools, GPS and navigators that can be installed in cars as well as in mobile phones.

Geography as a discipline is traditionally known as the home of maps since Mapwork forms part of its curriculum, thus the change brought about by GIS in mapping had to be introduced into the Geography curriculum. It is against this background, that institutions of higher learning and secondary schools adopted GIS into the Geography curriculum globally (Goldstein, 2010; Mzuza & van der Westhuizen, 2019). The focus of this study is on South African Basic Education's Geography curriculum. Thus, it is important to provide a background of the inclusion of GIS into South African secondary schools. In 2006, the Department of Basic Education (DBE) took an important decision to include GIS as part of the Geography grade ten curriculum (Scheepers, 2009; Tarisayi, 2018).

In 2007, GIS was offered to grade 11 and in 2008 the first Geography examination consisting of GIS was written by the matriculants nationally. Ever since then, learner performance in this section of Geography has been low (Department of Basic Education, 2015, 2016, 2018). As a result, a number of research studies focusing on the implementation of GIS have been conducted. This research revealed that its implementation is not going well due to a number of reasons such as the lack of computer resources, inadequate teacher training and teachers' unwillingness to change their pedagogy (Innes, 2012; Mzuza & van der Westhuizen, 2019). These challenges have led to low performance in this section in the national senior certificate matric examinations.

2.3.3 Rural Learning Ecology

In an attempt to define what a rural learning ecology (RLE) is, one has to first understand what a learning ecology is and in order to do so, one needs to trace the origin of the term ecology. Ecology is a word that originates from Greek *oikos*, that means 'household' and

logos which means study, thus, it is the study of the environmental house which includes all the living organisms and all the processes that make the house suitable to live in (Odum & Barrett, 1971). Ecology is, therefore, a study of 'life at home' which concerns itself with the relationship between organisms and the environment. Traditionally, ecology was viewed as a sub-discipline of Biology, presently, it has emerged as a new discipline that links physical and biological processes, connecting social and natural sciences (Ibid.). Thus, ecology draws from the foundations of geography, biology, mathematics, chemistry, physics and geology.

A German philosopher and biologist named Ernst Haeckel coined the term ecology in the year 1869 (Egerton, 2013). Ever since then it has been applied in various contexts, depending on who is using it and for whichever purpose. Having traced the origin of ecology, I shift attention to a learning ecology since it is the focus of this study. Some scholars conceptualise ecology from an educational perspective in which it is used as a metaphor to describe an environment in which learning occurs. For instance, Wilson (1996, p. 35) agrees with the idea of viewing the environment as a space for learning. The author reveals that "thinking of instruction as an environment gives emphasis to the 'place' or 'space' where learning occurs. At a minimum, a learning environment contains the learner [and] a 'setting' or a 'space' wherein the learner acts, using tools and devices, collecting and interpreting information, interacting perhaps with others, etc." This definition of the environment provides an emphasis on learning. However, it does not confine learning to a specific place such as a classroom that a large number of people normally associate learning with. Furthermore, it does not speak of the teacher that the general public considers as the presenter of knowledge in a formal setting. This implies that this space can be everywhere (formal or informal), where the learner has access to different resources and he or she can interact with anyone in order to access the desired knowledge.

The process of gaining knowledge cannot be confined to a specific place and time. As learners influence and are influenced by a variety of things throughout the day. Brown (2000, p. 11) is of the view that "learning can and should be happening everywhere" and he refers to this as a learning ecology. The author frames the web as a learning ecology

since it is a largely self-organised platform for social learning that is evolving. Furthermore, he states that the Web learning ecology permits everyone to learn at their convenience since a person decides when to log on and out of the Web. This author has extended the view of a learning ecology providing an example of the tools and devices that Wilson (1996) has mentioned above. The Web is a tool that a learner can access for learning.

From the above two definitions, it appears that there is a consensus on what the concept 'learning ecology' refers to. In line with the latter, I define a learning ecology drawing from Barron (2006, 195) who defines the notion of learning ecology as the "set of contexts found in physical or virtual spaces that provide opportunities for learning." Hence, a learning ecology is a space where learning occurs. These spaces can either be formal or informal and they can be physical such as a classroom and virtual like the internet. From my personal observation, ample physical spaces such as schools are available in the province of KwaZulu-Natal where the study was based. However, many of these physical spaces are constrained in the sense that they do not provide internet access to learners for them to access content knowledge online.

The Department of Basic Education is failing to provide virtual infrastructure to many schools and communities that are located in rural contexts, this can be observed in Alfreds (2015) where he reveals that "the government has conceded that there are significant institutional challenges in pushing technology in schools." This is apparent in many schools located in rural contexts. Hence, learners that attend such schools and such communities continue to be marginalised in terms of access to technology. Thus, the way that that they acquire knowledge is still confined to the physical classroom and the textbook, in some cases this limits the learners' potential to perform well in their studies as well at their overall outlook on life. Having established what a learning ecology is and the different opportunities it brings for learning, the following section is dedicated to developing a conceptual understanding of what a rural learning ecology is as the aim of the study was to explore the use of an IBL framework to teach GIS in a rural learning ecology.

Understanding the meaning of a rural learning ecology necessitates an understanding of how rural is conceptualised. In conceptualising 'rural', it is imperative to note that, there is no single definition of rural that is applicable to all geographies. However, different authors help us to understand the characteristics of rural areas better. Halfacree (1993) argues that the concept 'rural' is debatable in the sense that there are two main convectional approaches that are used to define it: descriptive and socio-cultural. This shows that there is no consensus in the way scholars define rural. Balfour, Mitchell and Moletsane (2008, p. 97) argue that notions regarding rurality in a South African context are concerned with "space, isolation, community, poverty, disease, neglect, backwardness, marginalization, depopulation, conservatism, racism, resettlement, corruption, entropy, and exclusion." This supports the argument made by (Halfacree, 1993) earlier regarding the approaches that are followed when defining rurality.

From the definition provided by Balfour et al., (2008) it is apparent that rural areas are characterised negatively as they are accused of racism, being vulnerable to diseases and marginalisation amongst other things. In terms of schooling, Hlalele (2014, p. 101) states that rural areas are prone to poor schooling and infrastructure. This implies that learners who attend such schools are marginalised as they do not have the opportunities that their peers who attend well-resourced schools in urban areas enjoy. Drawing from the definition of a learning ecology and the concept rural, this study defines a rural learning ecology as, space where learning occurs which can be accessed within a rural context. This space is characterised by resources, it can be physical or virtual, formal or informal and it is a space where learners learn through social interactions.

2.4 SYNTHESIS

In this chapter, I presented the theoretical framework that guided this study, namely Critical Emancipatory Research. To better understand the Critical Emancipatory Research, I had to go back to its origin which is the Critical Theory of the Frankfurt school (Germany). I learnt that the Frankfurt School had different leaders over time. However, Critical Emancipatory Research is based on the ideas of Jürgen Habermas, known as the leader of the second generation of the Frankfurt School. Habermas speaks of three

spheres of human concern which give rise to technical, practical and emancipatory knowledge. Emancipatory knowledge is important because of its ability to transform society.

What made Critical Emancipatory research a suitable theory for this study is that it was based on the provision of education which is a human concern because it contributes to personal and socio-economic development. More specifically, the study was based on exploring the use of the IBL framework for teaching GIS in a rural learning ecology, it had an emancipatory agenda. As the teaching of GIS was not going well in this context due to several systemic reasons. Therefore, I worked collaboratively with the co-researchers to change the situation.

As the co-researchers and I were interacting, we were guided by three principles of this theory; reciprocity, gain and empowerment. I have explained these principles in this chapter and indicated how the co-researchers and I observed these principles as we were changing the way that GIS was taught in a rural learning ecology. Moreover, In this chapter I explored the philosophical foundations of Critical Emancipatory Research. For example, I learnt that it assumes that reality is socially constructed, that there are multiple realities, as well as power that shapes society and that the people in power often want to portray their own views of reality.

Upon realising the influence of power and its influence on society, I understood the importance of working with the co-researchers so that they would share their realities and participate meaningfully in the study. As a result, I was able to build rapport and open communication so that every co-researcher's views would be heard throughout the research process. In this chapter, I also included some reflections on applying this theory, as theory and practice are two different things. I believe that as a researcher it was my duty as well as the co-researchers' task to minimise the gap between the theory and the practice. After presenting the reflection of applying this theory, I went onto defining and discussing the key operational concepts: 1) Inquiry-Based Learning (IBL), 2) Geographic information Systems (GIS) and 3) Rural learning ecology. Thereafter, I provided a synthesis of the chapter. The following chapter presents the literature review.

CHAPTER THREE
LITERATURE REVIEW

3.1 INTRODUCTION

In the previous chapter, I introduced the concept of Critical Emancipatory Research (CER) and its philosophical assumptions because I used it to frame this study on exploring the use of an Inquiry-Based Learning framework for teaching Geographic Information Systems (GIS) in a rural learning ecology. In this chapter, I attempt to provide an understanding of the discipline of Geography, the origin of GIS, its usage in other fields and the recurring debates related to GIS's adoption into the secondary school curriculum. I have also provided an account of teaching approaches such as the Inquiry-Based Learning, which is deemed suitable for preparing learners for their future roles in the 21st century. In this chapter, I also shared insights with regard to the differences between urban and rural learning ecology in order to highlight their uniqueness since this study was based in a rural learning ecology. Also, the research questions informed the selection of the relevant literature which is presented in this section.

3.2 UNDERSTANDING THE DISCIPLINE OF GEOGRAPHY

People are born with intrinsic curiosity, the evidence of this is when one studies babies as they grow older, they are always curious about the limits of the space that they occupy. A few years after this, their imagination 'stretches' and they share ambitious ideas and funny stories about the world (Bonnett, 2008). For one to understand the nature of Geography, he/she needs to realise that Geography is fascinating in terms of wanting to know more about the world that we live in. The concept 'Geography' can be broken down to two words: *Geo* and *graphy*, *Geo* comes from the Greek meaning "Earth" and graphy comes from the Greek word *graphein* which means to write, as a result, Geography means to write about the Earth (Corson, Doe, Thomas, & Thomas, 2018; Robinson, 1976). Furthermore, the latter indicates that the Geographers have come to understand the discipline of Geography as writing about the earth.

Writing about the Earth includes describing and mapping the Earth, this implies that Geography is also concerned with mapping different features that occur on Earth. Therefore, Tambassi (2019) sees the discipline of Geography being concerned with writing and drawing with the Earth as a subject. The author further states that Geography as a discipline is constantly changing over time as there are different kinds of geographies which have led to many geographic branches. Meaning that what is considered Geographic currently might not be considered geographic in future. Thus, it can be concluded that the discipline of Geography is not static as various events and people shape it, which made me curious to learn more about this discipline.

In my quest to gain a better understanding of the discipline of Geography I came across a very informative book entitled *Perspective on the Nature of Geography*, it was first published in 1939, thereafter, the revised version was published twenty years later (Hartshorne, 1959). From this book, I learnt that the discipline of Geography is a science that aims to provide an accurate interpretation of the Earth's surface, meaning that it is concerned with the landforms which occur on Earth as well the composition of the Earth. With regards to the composition of the Earth, everything on Earth can be divided into four broad categories such as the biosphere - living things, hydrosphere – water, lithosphere – land and the atmosphere - air (Brown & Chartrand, 1983; Martin & Johnson, 2012). Geographers study how these different spheres interact to produce life on Earth and how humans have an impact on each of these spheres. This links with Broek's (1967) view of Geography as a discipline. The latter author states that Geography is also interested in the relationship between people and the environment, meaning that it is concerned with where people are located and how they affect the environment.

In an attempt to learn more about the discipline of Geography, I also came across Tuan (1991), who conceptualises Geography as the study of the Earth as a home for people. The latter states that the concept 'home' is important in understanding Geography because home is physical earth and one's expectation of a home environment is the provision that is associated with a home so that one experiences a sense of belonging. In the case of Geography, a home is the actual physical earth. Similarly, Poole (2010) views the earth as a home, where the people's needs are catered for. For example,

people need money which can be translated as the economy, they live by certain values and morals which are largely influenced by culture (Crang, 2013). People also require freedom of movement so that space or place feels homely.

The Earth as a home is also characterised by different weather conditions, which determines how people experience home and in turn, people are able to influence weather conditions with their action, hence, that is why we speak of the relationship between people and the environment. A perfect example of this would be the occurrence of global warming, Brown and Leonard (2004) and Promduangsri and Crookall (2018) believe that global warming is one of the greatest environmental threats facing the Earth today. This is why many countries throughout the world are concerned about this phenomenon and yet research indicates that the major causes of global warming are anthropogenic. Promduangsri and Crookall (2018, p. 5017) attest to this by stating that "humans are killing the very thing that provides for their life. Human lifestyle is killing human lifestyle." Meaning that humans are contributing mostly to destroy the very earth that is considered their home.

From how different authors conceptualise Geography, I have come to understand that the latter can be broken down into two main areas of focus: there is Physical and Human Geography. Physical Geography is a spatial study as it concerns itself with what occupies the natural space on Earth (Strahler & Strahler, 2007; Wang & Rainbow, 2020). Geography, therefore, studies the natural features of the Earth such as the climate, ocean, the location of landforms and the soil as well as plant and animal species that are found in a specific area (Clifford, French, & Valentine, 2010; Smith, Carrivick, & Quincey, 2016). Human Geography is concerned with who, what, where, why, when and how humans and studies their interrelationship and relationship with the environment (Clifford, Cope, Gillespie, & French, 2016; Pattison, 1990).

Human Geography reflects the conditions and developments of the contemporary world. Examining the settings in which people live, their lived experiences (social, economic, political and cultural processes), including human-environmental processes that they face on a daily basis (Knox, Martson, & Imort, 2016). Physical and Human Geography are

similar in the sense that they are both concerned with how people make use of space and compare different places and map this data, Thrower (2008); Plantin (2018) attest to this by stating that cartography (map making) is concerned with how people make use of space and that the Earth is under constant surveillance by different satellites which lead to the production of different types of maps.

In the context of this study, I conceptualise Geography as a secondary school subject which helps learners to understand the relationship between people and the environment, it also serves as a foundation for the development of map skills amongst secondary school learners (Innes, 2012). Additionally, I share the sentiments of Unlu (2011), when the author expresses the view that understanding the relationship between human beings and the location is essential for learning Geography. As part of the Geography curriculum, MacEachren (2000) states that Geographic Information systems (GIS) is a computerised extension of cartography, that is taught in secondary schools across the world (Kerski & Demirci, 2013; Lambert & Balderstone, 2012). The focus of this study was to explore the use of an Inquiry-Based Framework for teaching GIS in a rural learning ecology. Therefore, the view of Geography as a disciple will be focused on map making as GIS is a mapping tool that collects, stores, analysis spatial information to solve problems (Corson et al., 2018; Lambert & Balderstone, 2012). Pattison (1990) states that geographers around the world have made a significant impact in developing spatial tools that are referred to as geographic techniques. Geographic techniques involve the skill of determination and display of spatial aspects through creating maps and they include the sub-disciplines of cartography, remote sensing, GIS and global positioning systems (Padmanabhan & Subramanian, 2001). The following section presents the origin of GIS which is the focus of this study.

3.3 ORIGIN OF GIS

Geographic Information Systems (GIS) is a software that is installed on a computer that allows people to work with digital maps efficiently (Faxier & van der Schee, 2012). GIS as a concept came to life in the 1960s in Canada (Kerski, Demirci, & Milson, 2013; Yeh, 1999). Dr Roger Tomlinson coined the term and is known as the father of GIS since he

introduced the transition of manual map marking to a computerised system. In the following quotation Tomlinson (1967, p. 23) gives his personal account on the events that led him to migrate from manual to computerised map making:

> "In 1960, Spartan Air Services of Ottawa, Canada, was a large surveying and mapping company whose business included topographic mapping, geophysical survey, land resource surveys, and other projects would wide […] George Brown, chief of Spartan's land resources division permitted me to try digital methods as a potentially cost effective alternative. I created two small test maps in numerical coordinate from – each 5 x 5 inches and containing five polygons. I found that these could be digitally overlaid and that I could measure the resulting areas from the digital record. Efforts to interest Ottawa computer companies (Computing devices of Canada, IBM, Sperry and Univac) to partner with Spartan for future development were not successful. However, in 1962, at an ASPRS conference in Washington, DC, John Sharp, a consultant to IBM, introduced Spartan to the digital photogrammetric research being done at IBM in Poughkeepsie, New York, in the United States. That, along with subsequent contacts with the previously reluctant staff in the IBM office in Ottawa, was the beginning of a pivotal relationship that was to grow significantly over the years. IBM brought about early experience with computers and programming to the table. I brought an understanding of the needs, as well as the geographical training needed to formulate the new concepts and to spell out the requirements for the system."

From the above quotation, it is clear how Tomlinson brought about change in map making by creating a system (GIS) that allows maps to be created using a computer software in the 1960s in Canada and later he partnered with an organisation in the United States. By 1980s, GIS technology began to gain popularity worldwide. Its growth was supported by decreasing computer hardware prices (Longley, Goodchild, Maguire, & Rhind, 2005), allowing people and companies to purchase the necessary hardware such as computers, printers and scanners. Longley et al., (2005, p. ix) reveal that "the use of GIS was pioneered in the USA, Canada, various countries in Europe and Australia." This is probably because the level of development of these countries is higher when compared to countries in the global south. As a result, they were able to purchase the necessary computer hardware and software that is required in order to operate GIS. Musakwa (2017) asserts that the use of GIS began in developed countries and filtered into developing countries.

By the 1990s GIS was used at all levels of the government and in many sectors of the society around the world (MacDevette, Fincham, & Forsyth, 1999). Concurrently, university departments which offered Geography began advancing their curriculum to include GIS training (du Plessis & van Niekerk, 2012), to produce GIS practitioners to work in industry as well as in various government sectors. However, there was a gap in knowledge as students enrolled in higher education institutions without the background knowledge of GIS, thus, a decision was taken to include GIS as part of the Geography secondary school curriculum since map skills were already part of this curriculum (Innes, 2012). Authors such as Goodchild and Kemp (1990) attest to this by stating that GIS was introduced in the Geography curriculum in the 1990s with the aim of developing an interest in secondary school learners to pursue careers in engineering and science. The following section provides more details regarding the incorporation of GIS in the secondary school Geography curriculum.

3.4 GIS INCORPORATION INTO THE SECONDARY SCHOOL CURRICULUM

GIS was an add-on to the pre-existing mapwork content in the secondary school Geography curriculum. Bednarz (2004, pp. 192-193) states the three main reasons for incorporating GIS into the curriculum: (1) An educative justification which was that the teaching of GIS is able to enhance learners' ability to think spatially as well as to develop their geographic skills in general. Moreover, learners benefit from using GIS to design maps as this practice sharpens their cognitive mapping skills; (2) A workplace justification, involves the development of GIS skills during secondary schooling which anticipates a need in the workplace. Thus, studying GIS would open up employment opportunities in future for the learners given the rapid expansion in global markets and the rapid technological advancements in the 21st century (3) A place-based justification, where GIS is seen as an ideal tool to study the local environment of a local community. This enables Geography teachers to use the learners' experiences as a point of departure for his/her teaching through actively involving learners in the lesson. Furthermore, learners can be given a space to solve local problems such as environmental problems since they understand their context better than those operating from the outside.

The workplace justification of including GIS as part of the secondary school has been cited by various authors. For instance, Innes (2012) and Kerski (2003) have written about GIS implementation in secondary schools. Moreover, Tomlinson (2012, p. v) states that:

> "Millions of people work in the geospatial industry, estimated at $64 billion per year by the US Department of Labor, and growing at 20% per year. However, in my estimate, the current production of GIS trained students from all educational institutions, secondary and tertiary, does not keep up with the growing demand. In fact, the global uptake of this productive and exciting technology is determined by the supply of trained people able to use it effectively."

Given the above statement, one can argue that GIS education in secondary school is essential as it provides the necessary foundation skills for learners to pursue GIS careers, meaning that Geography teachers should be trained to teach GIS so that they may pass on GIS skills to learners. The following section is dedicated to providing narratives of select developed countries such as the United States of America and Finland as well as select developing countries such as Turkey and Rwanda regarding their experiences of introducing GIS into the secondary school curriculum.

3.4.1 GIS implementation in secondary schools in the United States of America

The education system of the United States of America (USA) is unique compared to other countries in the sense that it does not have a uniform official national curriculum. Rather this is determined by the local states. Their educational offerings are not standardised, resulting in the decline of common core state standards (Liu, Navarrete, & Wivagg, 2014; Spring, 2017). Each state decides on its educational offerings hence it is difficult to achieve common core state education standards. These variations in core state education standards had an impact on the introduction of GIS into the USA secondary school system. For instance, Milson, Demirci, and Kerski (2012, p. 306) state that "the integration of GIS and other geospatial technologies into USA secondary classrooms remains haphazard". One of the causes for this is the unstandardised national curriculum, already mentioned, which has resulted in only two per cent of the high schools in America adopting GIS technology by the year 1999 (Kerski, 1999). GIS was, at that time, a recent phenomenon in American secondary education. Bednarz and Audet (1999) affirm that GIS was incorporated into the American secondary school education in the 1990s.

Several reasons have been cited for the slow introduction of GIS into the USA secondary school education. These reasons include time and effort. It appears that teachers and student teachers do not necessarily invest time and effort in learning the new technology, given the fact that there is a lack of support from the institutions that they work for as well as the ones which provide initial teacher training to student teachers (Audet & Paris, 1997; Bednarz & Ludwig, 1997). This is also confirmed by research conducted by Bednarz and Audet (1999) who found that lack of teacher training and the lack of appropriate curriculum materials for GIS in the form of both hardware and software resulted in the slow introduction of GIS into American secondary school education. This implies that there is a need for more professional development for teachers and student teachers that includes curriculum support to assist with GIS content and pedagogy.

The early 2000s were still characterised by a low percentage of teachers that were making use of GIS technology in the classroom. Teacher training had been slow in the USA, the study on the national assessment of GIS in American schools carried out by Kerski (2001) revealed that nearly 17 per cent of teachers that participated had trained themselves while others were trained by various institutions and the private sector and others did not receive training at all. For those that received training GIS implementation was going well in their classroom. This was also influenced by the teacher's qualifications. For instance, the teachers that possessed a Master's degree coped well with teaching GIS. Moreover, the latter study revealed that nearly half of the participants that participated in the survey were still not using GIS in their teaching. This was attributed to the following reasons including teacher training that has been mentioned above. In addition, the preparation time was too long, there was a lack of appropriate software and hardware, a lack of access to computers as well as a difficulty in implementation (Ibid.). However, select elite primary and secondary classrooms are coping well with GIS implementation (Bednarz & Schee, 2006). This reveals that the most benefits of learning GIS were experienced by learners that attend select elite primary and secondary schools.

Given the fact that teacher training is cited in literature as one of the major reasons that impedes adoption, I decided to zoom in on this issue to understand the root cause for such. This is where I discovered that Geography is not offered as a stand-alone subject

in the USA secondary schools. Instead it is offered under Social Studies which is an umbrella school subject under which geography is taught, along with subjects like history, government and economics (Knowles, Hawkman, & Nielsen, 2020; Russell, Waters, & Turner, 2017). Offering Geography under Social Studies has implications for pre-service teacher training since they are expected to teach four subjects that fall under Social Studies.

Bednarz and Schee (2006, p. 194) state that ongoing teacher training is key in the USA as it is fundamental given that for "teacher preparation methods oriented toward preparing broadly educated social studies teachers and state certification requirements, there are very few well-trained, specialist geography teachers with substantial coursework in the subject." This implies that a great deal of teachers that are teaching Geography may not have the specialist Geography content knowledge and pedagogy, that Bednarz and Schee (2006) describe as the best way to teach the subject. As a result, they might be discouraged to teach GIS if they do not see the value of teaching it. Also, they cannot teach GIS content and skills that they themselves might not have given the background of being trained to teach Social Studies rather than Geography as a stand-alone subject.

An additional factor that hinders GIS implementation in the USA secondary schools is a lack of technological support, resulting in a limited number of teachers that used GIS in their teaching (Kerski & Demirci, 2013). In order to overcome such barriers, Hong (2016) collaborated with a group of teachers to design a user-centred design (UCD) approach for assisting teachers in learning about GIS and to assist them to implement it in their classrooms. The findings of the study reveal that the majority of teachers that participated in the study felt that the UCD based materials were easy to understand and implement. I believe that this was a meaningful collaboration as it involved teachers that are responsible for teaching GIS rather than strategies that are developed without the assistance of teachers where teachers are just expected to implement the curriculum without shaping it in any way. Other stakeholders such as private companies are also contributing to encourage GIS implementation is USA secondary schools.

The environmental systems research institute (ESRI) which is a GIS software vendor has played a major role in training and in advancing the USA secondary school GIS. ESRI "has a longstanding commitment to supporting the use of GIS to enhance learning. Dating from Esri's earliest years, this support initially came in the form of software discounts and donations, a continually expanding inventory of teaching materials, the Education User Conference" (ESRI, 2018, p. 1). This implies that GIS teacher training is not only provided by the Ministry of Education in the USA, as private companies and universities have also collaborated to address the problem of GIS implementation in the USA secondary schools and this has resulted in an increase in GIS implementation to date. However, many more initiatives are needed to ensure that GIS is implemented effectively in USA secondary schools.

3.4.2 GIS implementation in Finnish secondary schools

Conversations regarding the implementation of GIS began in 2003, where Johansson (2003) indicates that GIS had not been introduced in the secondary schools of Finland. However, in the renewed national curriculum that was released, it was stated that GIS was to be included in an elective advanced Geography course, named Regional Studies (Finnish National Board of Education, 2003). The latter author conducted a survey to explore the readiness of the country to introduce GIS and found that many schools were lacking the necessary resources to implement GIS. Also, teachers had not been trained to teach GIS at that time. Nonetheless, years went by until 2005 when the national curriculum prescribed that it was compulsory for every upper secondary school to offer an elective Geography course that incorporated GIS for students that choose to elect it (Ratinen & Johansson, 2005). This was how GIS was introduced in secondary schools of Finland.

Finland took a democratic approach to introducing GIS in schools because students had a choice to enrol for the advanced Geography course which included GIS or not. This means that in Finnish schools GIS education is provided on an as needed basis. However, they have not been exempted from the GIS implementation challenges that have been experienced by various countries that have adopted GIS into their secondary school curriculums. Such as teachers experiencing difficulties in planning GIS lessons

given the lack of training that teachers have been exposed to. Teachers also lack curriculum material to teach GIS and there is an unavailability of GIS hardware and software in schools coupled with the lack of technological support (Ratinen & Keinonen, 2011; Riihela & Maki, 2015). This is corroborated by Anđelković and Pavlović (2015, p. 178) who conducted a literature search on GIS implementation in schools. They came across papers which revealed that "the survey results show that teachers, even in developed countries, such as Finland, during this period (2000-2010) were not adequately prepared for the use of GIS." However, there was funding provided by the Finnish Ministry of Education to facilitate the introduction of GIS (Kerski & Demirci, 2013).

From reviewing the literature above regarding the introduction of GIS in Finland, it becomes apparent that GIS implementation challenges are not experienced by developing countries only. Rather it is a global predicament. Kerski and Demirci (2013) point out that despite having GIS resources, countries like Finland, Denmark, Japan and the UK face GIS implementation challenges which are societal and technological. Social and technological challenges include teacher training and on-going technical support which is required by teachers to teach GIS effectively in schools. Thus, teacher training initiatives became a priority as Johansson (2013, p. 93) pointed out that the majority of current Geography teachers in Finland have not studied the use of GIS during their teacher training. In order to close this gap, the Ministry of Education and some municipalities collaborated to fund a project that concentrated on training pioneer teachers and on establishing a network of schools to facilitate the use of GIS in the upper secondary school classrooms. At a later stage the project grew nationwide (Ibid.). This project has yielded positive results with regard to the teaching of GIS in Finland's upper secondary schools.

GIS teacher training in Finland has been continuing over the years to the extent that it has been extended to an on-line platform where teachers have on-line resources that they can use for GIS training (Riihela & Maki, 2015). Extending GIS teacher training to an online platform is a good initiative as many teachers in studies that have been conducted on the teaching of GIS in secondary school, often cited time as a hindrance to GIS implementation (Hong, 2015; Kerski & Demirci, 2013). Teachers often complained about

not having enough time to attend GIS training workshops. Therefore, the online training platform allows them to access GIS training sessions at times that are suitable for them and allows them to acquire knowledge at their own pace. A study conducted by Riihela and Maki (2015) on designing and implementing a tool for teaching GIS in Finnish secondary schools using online resources, reveals that an online GIS tool for supporting teachers came into effect in the year 2008. Many lessons can be learnt from the way GIS was introduced in Finnish secondary schools as well as from how they have provided support for teachers to teach GIS in upper secondary schools.

3.4.3 GIS implementation in Turkish secondary schools

In the year 2005, Turkey took a progressive decision to introduce GIS in their secondary school classrooms. This was under the new curriculum that came into effect in that year (Arslan, 2011; Demirci, 2008; Karatepe & Tuna, 2012). The inclusion of GIS into the new Geography curriculum showed that the Ministry of Education of Turkey recognised the importance of GIS. Consequently, due to the changes that were presented by the new curriculum, Geography teachers began to regard GIS as an important tool and this led them to want to acquire GIS skills in order for them to make use of these in their classrooms (Arslan, 2011; Demirci, 2009). It is against this background that in-service teachers had to be taught GIS content and skills because GIS did not form part of their initial teacher training since it was not in the curriculum when they were student teachers. However, the new curriculum did not tell teachers what GIS was and the way to go about teaching it (Demirci, 2009).

To develop teachers' knowledge of GIS, teacher development workshops began to emerge in Turkey. For instance, Demirci (2008) conducted a study that aimed to evaluate the implementation of a GIS-based application in Geography secondary school lessons. This revealed that in the year 2006, fourteen teachers from schools with computer labs attended a teacher development workshop in which they were given basic GIS information and trained to use a GIS application. In this workshop, teachers were also given support documentation describing how the GIS application works. However, the results of the study show that out of the fourteen teachers, there were only two teachers who were able to implement the GIS exercise with success in their classrooms. The rest

could not do so for several reasons such as lack of time (ibid.). The results of the study show that GIS implementation challenges are complex given the fact that at times teachers might have the necessary resources but still struggle to teach this section due to time constraints and other factors that will be discussed in the following section.

Factors that have been cited as a hindrance to smooth GIS implementation in Turkey secondary school include large class sizes, lack of software and hardware, lack of interest displayed by teachers to make use of the new technology and the lack of GIS curriculum material to support the teaching of GIS (Demirci, 2008). I will elaborate on these hindrances in the sections that follow, as it is necessary to understand how the introduction of GIS was received in Turkish secondary schools. Arslan (2011) argues that large sized classes hinder proper GIS implementation in Turkey Geography classrooms because when the teacher is teaching GIS it is imperative for every learner to have access to a computer to keep up with the teacher's activities and to experiment with the GIS software, as this allows learners to learn the necessary practical skills of operating the software. For them to do so they need to have access to a computer with GIS software.

This may not always be the case because Tong (2014) reveals that more often than not the number of computers available in the computer lab is far less than the number of learners that are enrolled for a certain class. This, in turn, hinders proper GIS implementation as some learners might end up not having access to a computer, as a result, a teacher would not be able to take learners through a GIS practical exercise where they actively participate in the lesson. However, Demirci (2011) conducted a study in two schools that do not have enough computers and found that "implementing GIS exercises in a classroom with one teacher demonstrating it on a single computer can be an effective teaching and learning method especially for schools in which there is a lack of computing resources available to geography teachers." I agree with this finding, but I argue that it is necessary for learners to have access to computers in order for them to engage in practical GIS experience so that they can experience GIS for themselves rather than having them observe the actions of a teacher.

The inclusion of GIS in Geography classrooms meant that teachers had to be familiar with the technology and computers to teach GIS content and skills effectively. Arslan (2011); Demirci (2009); Kerski and Demirci (2013) argue that although teachers have a positive attitude towards the introduction of GIS into the Geography curriculum, they experience difficulties in adopting GIS technology due to not having enough GIS knowledge and skills, not having access to GIS software, a lack of GIS curriculum material and a lack of GIS lesson plans. All these factors have contributed to teachers' lack of confidence to adopt GIS in their classrooms, Bingimlas (2009, p. 235) remarks that "since confidence, competency and accessibility have been found to be critical components of technology integration in schools, ICT resources including software and hardware, effective professional development, sufficient time and technical support need to be provided to teachers". I agree with this view of providing support to teachers to implement GIS in their classrooms effectively in order for them to be able to pass on GIS skills to learners that are necessary for the 21st century. Thus, there have been a number of significant steps taken to address GIS implementation challenges that have been indicated already.

One of the fundamental steps was taken back in 2008 to mitigate the challenge of lack of GIS curriculum materials and the development of GIS lesson plans for teachers. This was the publication of the book *GIS for teachers* (Demirci, 2009), this was book that was published in Turkish for the teachers to grasp GIS content in their mother tongue. This was necessary to provide access to knowledge so that the teachers would be more confident to teach GIS. I think that this is a valuable lesson for other developing countries like Turkey given the fact that research shows that a large number of learners lag behind in terms of academic success because they are taught in a non-mother tongue language (Piper, Zuilkowski, & Ong'ele, 2016). This can be attributed to the fact that some teachers also struggle with the non-mother tongue language. Hence, providing teachers will content that they can clearly understand in their mother tongue should enable them to deliver the content effectively to learners. The book contains lesson plans, data and GIS software since it was published by Fatih University with the assistance of ESRI, an international GIS vendor and other national and international institutions (Kerski & Demirci, 2013). However, teachers should be involved in development initiatives

pertaining to them because they are the ones who are expected to implement GIS in the classrooms and they are regarded as experts in pedagogy and in the curriculum as a whole.

After the launch of the book project discussed above, efforts to address GIS implementation challenges did not stop. There was an introduction of the Fatih University project which aimed to equip all primary and secondary schools in Turkey with GIS hardware, access to the internet as well as advanced whiteboards (Demirci, 2012). This project was targeted at addressing GIS hardware shortages. This project clearly shows the importance of collaboration between universities and schools to help solve educational problems. This was an effective move to help address GIS software shortages in Turkey. However, it was not enough as there are numerous GIS implementation challenges that have been presented in the above sections, such as technical support and teacher training. These barriers should be attended to holistically so that GIS may be taught effectively.

With regard to teacher training, the good news is that there are on-going workshops, training programmes, courses and seminars which provide teachers with the necessary GIS teaching skills and the experience of experimenting with the GIS software (Kerski & Demirci, 2013), I have not come across any sources that speak of technical assistance. However, this does not take away from the efforts that have been made in Turkey to overcome the obstacles that hinder proper GIS implementation in their secondary schools. Demirci (2015) argues that it is only after removing pedagogical obstacles of GIS implementation that all the other challenges will be lifted, thus, allowing GIS implementation to flourish in Turkish secondary schools. This implies that the author sees teachers as a very important component in the success of GIS implementation and recommends that greater efforts should be made towards training Geography teachers to implement GIS.

3.4.4 GIS implementation in Rwandan secondary schools

Rwanda determined the development of ICT skills for its society as a national goal for 2020 (Forster, Schilling, & McConnell, 2007). GIS and remote sensing form part of the

ICT skills that the country aims to develop. Therefore, the acquisition of GIS skills is recognised as one of the fundamental 21st century skills that teachers and learners in Rwanda were to acquire as it teaches them computer skills and spatial reasoning. As the development of GIS was a national mandate various stakeholders in Rwanda put measures in place to ensure the realisation of the 2020 vision. These stakeholders were: the Centre for Geographic Information Systems and Remote Sensing of the National University of Rwanda (CGIS-NUR), the Rwandan Ministry of Education, ESRI Germany/Switzerland as well as ESRI's president and his wife (Jack and Laura Dangermond) and the Kigali Institute of Education (Forster, Burikoko, & Nsengiyumva, 2012; Forster et al., 2007). All these stakeholders collaborated to cultivate GIS skills in the country. For the purpose of this study, I will focus on how GIS became part of the secondary school curriculum.

The initial GIS implementation in education in Rwanda was not part of the official curriculum. Instead, it was launched as a project in which the Ministry of Education collaborated with the CGIS-NUR to provide GIS training to teachers that had some experience of teaching Information Technology (IT) and who were based in schools that had a significant number of computers and a stable electricity supply (Forster, 2008). Ten teachers were trained at the outset of the project. After the teachers had been trained, they were expected to train other teachers from nearby schools with the hope of increasing GIS awareness and skills across the country. It was only in 2007 where GIS was officially introduced in Rwandan secondary schools (Forster, 2008; Forster et al., 2012).

Each of the stakeholders mentioned previously had a unique role to play in ensuring the sustainability of the introduction of GIS in Rwandan secondary schools. ESRI played a major role in the roll-out of GIS by providing GIS software to every secondary school in Rwanda (Forster et al., 2007). This has given Rwanda an advantage in terms of the availability of software compared to other countries that are implementing GIS in secondary schools worldwide, as the unavailability of software is listed as one of the main hindrances to implementing GIS (Kerski & Demirci, 2013). Similarly, Conroy, Anemone, Van Regenmorter and Addison (2008) state that GIS software is expensive, thus,

receiving GIS software for free from ESRI took away some of the financial responsibilities that go hand-in-hand with the introduction of GIS in secondary schools worldwide. With the burden being lifted from the stakeholders they had to prioritise other necessities that enable effective GIS implementation such as providing training to teachers and learners.

Teacher training is provided in a format of three consecutive courses: a) a basic short GIS course, which includes an introduction to GIS concepts, provides basic GIS software tools such as creating maps and thereafter teachers were given reading material that they could refer to after the course; b) an advanced GIS course, which covers different types of data, deriving data from different sources so that it may be used with the GIS software, as well as spatial analysis and data management exercises; c) upon completing the basic and advanced courses the teachers have access to the last course which is a workshop that exposes them to teaching materials and to the planning of GIS lessons (Forster et al., 2007).

Over and above the above-mentioned GIS courses and training, training opportunities are available through the Kigali Institute of Education (KIE) in collaboration with Rwanda's Ministry of Education. The KIE is a teacher development programme which aims to upskill in-service teachers (Mukamusoni, 2006). KIE produces professionally qualified teachers and trains most teachers in Rwanda (Emile, Bosco, & Karine, 2013). This was a necessary step to achieve effective GIS implementation as teachers cannot impart knowledge that they do not have whilst the provision of or lack of training affects their attitudes and beliefs about technology (Akinyemi, 2016). Thus, if they are provided with sufficient GIS training, they should be empowered to teach the section. Interestingly, learners are also provided with GIS training outside of school in Rwanda.

The stakeholders who decided to launch GIS in secondary schools have provided learners with an opportunity to attend GIS camps. An example of a project that addresses the latter is a one-week GIS camp sponsored by ESRI in collaboration with the National Parks' Department for Environmental Education that trains secondary school learners to use GIS, GPS and mobile computers to analyse data that they collect during their stay at the camp and they present their findings (Schober, 2010). Two summer camps have

been held in Rwanda and the response was positive because the camp developed GIS skills in learners who had no prior exposure to GIS software before.

According to Schmidt (2013) there have been ongoing GIS summer camps on an annual basis hosted by ESRI Rwanda, working in collaboration with the Ministry of Education and local and international GIS experts to allow secondary school learners to apply GIS theory (concepts) that they learn at school. Learners must apply to partake in the camp by producing a map and a motivational letter. During the learners' stay at the camp, they learn how to use a global positioning system (GPS), generate data using questionnaires and GPS, prepare and analyse data using GIS and present findings.

The GIS summer camps are a good initiative as they expose learners to GIS practice and skills that they require for secondary school education and beyond. These are essential lifelong skills which could enable learners to occupy meaningful careers that are in demand in the 21st century. Therefore, the partnership of the various stakeholders has yielded positive results in introducing GIS in Rwandan's secondary schools and has helped to build towards their 2020 goal to transform the country into an IT society. With regard to technical support and the availability of computing hardware (Tomaszewski, Maurice, Vodacek, Vodacek, & Holt, 2015), and the availability of reliable electricity especially in rural areas (Akinyemi, 2015), more measures should be put in place to achieve the country's IT goal so that both the rural and urban contexts can be exposed to GIS education and the opportunities it presents.

3.5 CHARACTERISTICS OF THE SOUTH AFRICAN EDUCATION SYSTEM

In this section, I provide a contextualisation of this study by unpacking the key features of the South African education system. The schooling system of South Africa consists of eight years of schooling including grade R, five years in secondary schools, one to seven years higher education (depending on the choice of the student as there are various options to choose from, from a certificate qualification to a bachelor's degree (Eksteen et al., 2012). Thereafter, a student may choose to enrol for a postgraduate programme that offers qualifications up to a PhD. In this section, I will focus more on secondary schools as the focus of this study was exploring the use of an IBL framework for teaching GIS in

a rural learning ecology. The introduction of GIS in South Africa happens in secondary schools under a subject called Geography.

In the past, the South African education system produced inequalities as there were schools that catered for some races while excluding others. This resulted in unequal funding and unequal resource distribution in schools (Economist, 2017). This left many schools that are located in rural ecologies under-resourced (Madida, Naidoo, & Rugbeer, 2019), whilst the majority of schools that are located in urban ecologies are well resourced. Consequently, this led to unequal education opportunities provided to learners that attended school in these different settings. Many learners attending urban schools received quality education while the majority of learners attending rural schools received poor education (Myende & Chikoko, 2014). Evidence of this was reported in cases of some rural schools operating under harsh conditions such as teaching and learning that is taking place under trees due to lack of infrastructure (Madida et al., 2019).

Although much work has been done by the government to redress past inequities, the legacy of this past continues to linger as many schools that are located in rural ecologies in South African are still poorly resourced (du Plessis & Mestry, 2019; Gqirana, 2016), compared to schools that are located in urban ecologies. Due to this, some rural schools still struggle to attract and retain quality teachers. To attract and retain quality teachers the DBE launched the Funza Lushaka bursary (Department of Basic Education, 2020) which covers student teachers' higher education costs on condition that when they become certified to teach the government would deploy them to where there is a need. In most cases the shortage of qualified teachers is in rural learning ecologies. The teacher deployment is based on the number of years of funding, meaning that the newly appointed teachers would be expected to teach in the assigned post for a minimum number of years that is equivalent to the years of funding, most of these posts are in schools that are based in rural areas and these are prioritised.

Despite some of the education challenges mentioned above, the South African DBE strives to develop ICT skills in schools. One of the ways of achieving this goal was to modify the official curriculum so that learners are taught ICT skills whilst at school (Madida

et al., 2019). Geography is one of the subjects offered in secondary schools which has been affected by this change, through the introduction of GIS in grade 10, 11 and 12 (Department of Basic Education, 2011), given South Africa's centralised basic education system all Geography learners are expected to write a national examination that includes GIS in their final year of secondary school (Innes, 2012; Zondi & Tarisayi, 2020). The following section highlights how GIS was introduced into secondary schools of South Africa as well as the successes and challenges of taking the decision to introduce GIS at secondary school level.

3.6 GIS IMPLEMENTATION IN SECONDARY SCHOOLS OF SOUTH AFRICA

South Africa as a developing country also adopted GIS following the trend that was occurring globally. During the 1980s, the national and provincial departments were not well aware of the practice and the availability of spatial data (Schwabe, O'Leary, & Sukai, 1997). As a result, the usage of GIS technology was very limited during this time. It was only in the 1990s that the national and provincial departments started promoting the growth of GIS in South Africa (Zietsman, 2002). At this time, GIS was used by government departments, semi-privatised institutions and the private sector (Breetzke, 2006). The DBE introduced GIS in education at a later stage compared to other sectors, the introduction of GIS in secondary schools in South Africa took place in the late 2000s, 2006 to be more precise (Innes, 2012; Scheepers, 2009). The inclusion of GIS in the Geography Further Education and Training (FET) curriculum was an attempt aimed at laying a foundation to empower Geography school leavers with spatial technological skills (Innes, 2012) so that they may pursue GIS courses at higher education in order for them to contribute meaningfully to the geospatial industry.

GIS was introduced for the first time in the grade 10 Geography syllabus in the year 2006. Thereafter, it was offered to grade 11 in 2007 and then offered to Grade 12 in 2008 (Breetzke et al., 2011). Ever since then, growing research has been conducted on the implementation of GIS in South African secondary schools as this has been problematic ever since its introduction (Cilliers et al., 2013; Mzuza & van der Westhuizen, 2019; Scheepers, 2009). The secondary school GIS curriculum for grade 10 and 11 covers the

concept of GIS, reasons for the development of GIS, the concept of remote sensing and how remote sensing works, satellite images related to meteorology and climatology, GIS concepts: spatial objects, lines, points, nodes and scales, spatially referenced data, spatial and spectral resolution, different types of data - line, point, area, attribute raster and vector data and capturing different types of data from existing maps, photographs, fieldwork or other records on tracing paper (Department of Basic Education, 2011).

The above outline of the GIS curriculum for grades 10 and 11 implies that learners should be equipped with both theoretical and practical knowledge of GIS, but unfortunately, Geography teachers end up teaching about GIS instead of teaching with GIS (Wilmot & Dube, 2016). Teaching about GIS only results in many learners not being exposed to computer literacy skills and new careers in the field of Geography that require geospatial skills that are necessary for the further development of South Africa. The following section discusses GIS implementation challenges in secondary schools.

3.6.1 Successes of implementing GIS in South African secondary schools

Currently, there are a number of successful GIS interventions in secondary schools across South Africa. This can be attributed to several GIS training initiatives provided to teachers by the private sector and the DBE in various provinces as well as the National Department of Rural Development and Land Reform. Moreover, secondary school learners are not left behind as there are interventions that target them directly. This can be termed a holistic approach to developing GIS skills in both teachers and learners, teachers need these skills for teaching Geography in the FET phase. While for learners GIS is a skill to be acquired in the 21st century as it lays a foundation for geospatial careers that they might pursue in the future.

The Western Cape DBE managed to secure some funding that they allocated to teacher training workshops that took place over two days (Fleming, 2016). The overall feedback provided by teachers on attending the three-day workshops was positive. On the other hand, the teachers that participated in the workshop were concerned about the shortage of GIS software and hardware in the schools given the new skills that they had acquired. This shows that although training is provided to some teachers, there are also GIS

structural challenges that must be addressed for effective teaching to take place. Also, in the Western Cape, some schools have also taken a decision to invest in GIS teacher training. For instance, Fleming (2016) notes that the Independent Schools Association of Southern Africa provides funding for their teachers to attend GIS training that takes the form of the three-day workshops. This is a good initiative that is taken by these schools because they prioritise on-going professional development of their teachers. An additional benefit for the teachers who attend such workshops is that these GIS workshops are awarded points by the South African Council of Educators (SACE). The continuous development points (CDP) are awarded on the basis that teachers attend courses that have been approved by the council (SACE, 2014). The CDP serve as additional motivation for teachers to attend such workshops.

With regard to accessing GIS data, teachers who attend the three-day training workshops are given information on how to access local data sets from the National Geospatial Information (Fleming, 2016). This is done because a number of teachers claimed that they do not know where to access GIS data that is localised. Over and above the three-day teacher training workshops other interventions have been put forward for sustaining GIS implementation in South African secondary schools such as the teacher and learner resources that are provided by local publishers and companies that supply GIS software (Fleming, 2016). Macmillan which is a publishing company of a number of textbooks that are used in South African Secondary schools published a book called *Solutions for all Map Skills*. This book is aimed at developing map and GIS skills for both teachers and learners. The book comes with a disc providing Quantum GIS and local data sets. It covers GIS as a concept, paper GIS, different types of data, remote sensing, data manipulation and data capturing (Louw, 2014).

Pearson the home of Heinemann and Maskew Miller Longman is known for producing learning content and tools for schools in South Africa (Pearson, 2018). The latter has also been instrumental in developing CAPS-compliant GIS tools which are suitable for Geography secondary school learners. They have launched a *'Platinum Interactive Skills Atlas'* which provides learners with both mapwork and GIS skills. The interactive skills atlas provides an engaging online GIS learning experience for a learner. It works on both

computers and tablets and through the interactive atlas learners have access to maps and over 130 skills-based activities that they can complete digitally (ibid.). In this digital interactive atlas, learners also have access to over 1500 questions to help assess the skills that they have acquired, they are awarded a silver/gold/bronze badge based on the level of proficiency that they achieve in each skill. According to Pearson, the interactive skills atlas was developed by education specialists who understand the South African education context and they have included material from all the provinces of South Africa. Thus, learners should be able to relate to the content as they engage in the activities.

Another initiative that is geared towards the development of GIS in South African secondary schools is provided by the National Department of Rural Development and Land Reform in partnership with the National Geospatial Information. This partnership runs a programme called MapAware that is aimed at promoting map usage and spatial awareness in the country. The programme is delivered through capacity building workshops for secondary school teachers and curriculum facilitators to enable them to better apply map use and interpretation skills (Wumasi, 2013). Furthermore, the latter stakeholders also run a MapPacks project, which aims to display localised maps in South African Geography classrooms. Each MapPack has five maps which highlight the local area where the school is located, the pack also consists of a provincial map of where the school is located and a map that covers the whole of South Africa. All these maps help learners to learn more about the places that they live in so that mapping should become more meaningful to them. A teacher can fill out a form to request the MapPack and facsimile it to the National Department of Rural Development and Land Reform.

Other major private companies who are industry leaders in GIS such as ESRI South Africa have also made available GIS skills training. One of their recent initiatives is FundaLula Mapwork with GIS: A new dimension to teaching and learning Geography. ESRI (2016, p. 1) reports that “FundaLula aims to develop geospatial critical thinking, reasoning, investigative, & creative skills that learners can use in all areas of their lives”. The FundaLula is delivered as a package that includes multimedia (videos, images and extra content), teacher and learner notes, different types of maps, interactive activities and power point slides. In short, FundaLula is a Mapwork and GIS program that is computer-

based and it allows teachers and learners to access GIS content and to develop their skills. The program can be purchased directly from ESRI South Africa. ESRI is also making available GIS training available to some of the unemployed youth in South African.

Some South African universities have also played a role in capacitating secondary schools to enable them to implement GIS. For instance, ESRI South Africa worked with the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria to introduce a paper-based GIS educational package for resource-poor schools in the country (Breetzke et al., 2011). This package was meant to facilitate the teaching and learning of GIS in secondary schools that lack the necessary hardware and software to teach GIS. The paper-based GIS package comprised maps, tracing paper, coloured crayons, adhesive, an exercise book for learners and a handbook that serves as a teachers' guide (ibid.). The usage of a paper-based GIS package was piloted in the Eastern Cape, where twenty teachers and subject advisors were given training on how it can be applied in a classroom setting.

The pilot in the Eastern Cape was followed by a three-day training course in Gauteng, where about 100 teachers and subject advisors witnessed a demonstration of how the facilitators utilised the paper-based GIS package. Furthermore, some learners were also given an opportunity to partake in paper-based GIS activities. While discussing initiatives that target GIS implementation in resource poor-schools, one cannot forget to mention the Interactive-GIS-Tutor which offers teachers an option to present GIS lessons using a computer and a data projector (Fleischmann & van der Westhuizen, 2017; Fleischmann et al., 2015). Despite these noted successes, there are still more GIS implementation challenges in southern African secondary schools to date (Mzuza & van der Westhuizen, 2019). Some of the challenges that are apparent in South Africa have been presented below.

3.6.2 Challenges of implementing GIS in South African secondary schools

Despite the numerous successes in the implementation of GIS in South African secondary schools highlighted in the preceding section, several challenges have also been encountered. This section seeks to interrogate the GIS education implementation challenges that have led to poor learner performance in GIS: (1) *Lack of financial resources to purchase GIS software and hardware,* (2) *Teacher training and its impact on the teachers' attitude towards GIS.*

3.6.2.1 Lack of financial resources to purchase GIS software and hardware

Research cites several reasons why GIS implementation is not going well in secondary schools worldwide and in South Africa such as the lack of money to purchase GIS software and hardware (Breetzke et al., 2011; Fleischmann et al., 2015; Kerski, 2003). Before 1994, South African education was racially segregated and this unequal education system resulted in unequal funds being allocated to schools. For instance, Nkabinde (1997, p. 44) presented an analysis of the challenges that are faced by South Africa based on previous inequities. He reminds us that in 1993 the government allocated R1 659.00 for Black learners, R2 902,00 for Coloured learners, R3 702.00 for Indian learners and R4 372.00 for White learners. Fiske and Ladd (2004) attest to this by stating that schools that were attended by White learners received funding that was ten times more than the funding that was allocated to schools that were attended by Black learners.

The unequal distribution of funds resulted in both well-resourced and poorly-resourced public schools. When the ANC government came into power in 1994 a decision was taken to redress the past inequities. New policies were put in place for funding public schools. For instance, Bush and Heystek (2003) and Mestry and Ndhlovu (2014) reveal that presently public schools are classified into five groups (quintiles) from the poorest to the least poor, whereby the poorest (Quintile 1) is allocated more money from the government while least poor (Quintile 5) receives less money from the government. Since this is a new strategy for allocating funds to schools, implemented after 1994, the gap in terms of infrastructure that was opened by the unequal funding before 1994 has not yet been closed. This means that many schools remain well-resourced compared to others across various contexts.

As previously stated, GIS hardware and software are necessary for effective teaching in secondary schools. Given the unequal state education funding, urban schools continue to be more developed in terms of infrastructure compared to rural schools. Meaning that some urban schools possess the necessary hardware for GIS implementation thus, their struggle is different because they only need to acquire the software while many rural schools do not have both GIS software and Hardware. Mestry and Ndhlovu (2014, p. 3) attest to this by stating that “poor schools and learners are persistently disadvantaged and will take much longer to overcome the barriers of the past, thus prolonging the cycle of poor quality education.” This clearly shows that there is a link between resources and the quality of education, whereby learners who attend well-resourced schools are more likely to achieve better results compared to learners that attend poorly resourced schools. However, the concept of poorly-resourced is understood differently by different scholars.

As I was reading about GIS implementation in poorly-resourced schools, I came to understand that poorly-resourced is understood differently by different scholars. For instance, Breetzke et al., (2011) view poorly-resourced schools as schools without the necessary software and hardware for teaching GIS which is why they have recommended that schools who are characterised by such conditions should make use of paper-based GIS. Whereas Fleischmann and van der Westhuizen (2017) view resource-poor schools as schools that have a projector and perhaps a single computer where the teacher can demonstrate what GIS is to learners. Demirci (2011) attests to this, as findings for his study that explored the teaching of GIS in schools that do not have computer labs found that demonstrating GIS on a single computer for schools with a lack of computing resources is effective. For this study, I identify with the view of Breetzke et al., (2011) that a poorly-resourced school as a school that did not have a computer lab. Thus, teaching about GIS was the only option for teaching GIS in the rural learning ecology.

Research suggests that teachers that teach GIS in poorly-resourced schools (mainly located in rural learning ecologies) end up using a textbook to cope with the above-mentioned challenges (Breetzke et al., 2011; Fleischmann et al., 2015; Innes, 2012). Textbooks are one of the common resources that are found in South African classrooms (Ramnarain & Padayachee, 2015). This is because the South African DBE allocates a

budget every year to its schools so that they may purchase textbooks. Teachers have autonomy in choosing which textbook they wish to prescribe to learners for that current year. However, they must select a book from the approved list of textbooks which is provided by DBE.

Given the list and funding for textbooks by DBE, textbooks are common teaching aids that Geography teachers use to teach geographic content including GIS. Although, textbook shortages have been reported in the country (Jimes, Weiss, & Keep, 2013). Teachers end up relying on the available textbooks to teach GIS as it is the only resource that is readily available to them in the school (Fleischmann & van der Westhuizen, 2017; Innes, 2012). When this happens a great deal of teaching approaches remain underutilised in the teaching of GIS as a textbook that a teacher is using might not mention them. Thus, it is important for a geography teacher to make decisions consistently regarding which textbooks are appropriate for teaching GIS content and to reflect on his/her teaching approaches so that he/she may address some limitations that are presented by some textbooks.

Textbook usage limitations include the fact that the textbook may be regarded as the sole source of GIS content. Also, the textbook content might be outdated, as GIS as technology keeps evolving (March & Scarletto, 2017; Ricker & Thatcher, 2017), so learners must be provided with updated content. In my personal view, I suggest that Geography teachers should carefully consider the content that each textbook presents before choosing a textbook to choose the right textbook and find ways to supplement whatever may be missing in a textbook. If this is done correctly, it might enable the effective teaching of GIS in a classroom where the textbook is the only available resource for teaching GIS.

3.6.2.2 Teacher training and its impact on the teachers' attitude towards GIS

Even though GIS was introduced in the South African Geography curriculum over thirteen years ago, the majority of Geography teachers continue to lack GIS training (Fleischmann & van der Westhuizen, 2017; Mzuza & van der Westhuizen, 2019). This has led many teachers to develop a negative attitude towards Geography. For instance, Innes (2012,

p. 102) states that “in some areas in South Africa (notably in the Free State province) Geography has been withdrawn from the subject offering at some schools, the main reason given was teachers’ unwillingness to engage with the technology.” The technology in question is GIS, the teachers' unwillingness to engage in GIS technology speaks volumes with regard to what qualifications the teachers have that are presently teaching Geography in South African secondary schools. To further interrogate this question, I conducted a literature search into how teacher training is and was conducted in a South African context. Through this search, I came across Wolhuter (2006) who wrote about teacher training in South Africa (past, present and future) in the year that GIS was introduced and he discovered that some teachers possess a three-year diploma in teaching whilst some of these teachers were trained over 30 years ago. This was before GIS was introduced into the Geography curriculum. Thus, it makes sense for some of those teachers to be unwilling to engage with technology as they were not trained to teach GIS.

Another set of practising teachers in South Africa possess a four-year bachelor’s degree in education (Carstens, 2012) and some of these teachers similar to those who have diplomas in teaching were trained before the introduction of GIS in the secondary school Geography curriculum in 2006 and thus some of them might be unwilling to engage with technology given that their teacher preparation training did not include the usage of educational technology. Jantijies (2019) wrote about five things that South African schools must get right to enable an environment for educational technology and one of these is ongoing teacher training. This clearly shows that there is a gap in teacher training in the use of educational technology in teaching and therefore, teachers struggle to incorporate technology into their lessons (Rienties, Brouwer, & Lygo-Baker, 2013).

The last set of teachers in South Africa to be considered here are teachers that possess a postgraduate certificate in education (PGCE), these teachers come from different disciplines depending on what they studied in their initial University training (Bertram, Mthiyane, & Mukeredzi, 2013; Verbeek, 2014). For instance, some may come from pure Geography and thus, they might have been exposed to GIS content in their initial training but the problem is that they do not have GIS pedagogy skills, as a result, even though

they might be willing to engage with technology the problem could be the teaching skills as well as the lack of GIS software and hardware that has been discussed above. Understanding who the Geography teachers are would assist the DBE, Higher education institutions and private industry who have an interest in developing GIS skills to provide the necessary support to Geography teachers given the various backgrounds that they have.

Teacher attitude has also been cited as key for GIS implementation to flourish in the Geography classroom. Hence, authors such as Kerski (2003) who sought to understand the implementation and effectiveness of GIS technology in secondary schools argue that student teachers are given little opportunity to learn GIS in the USA. Akinyemi (2016, p. 21) conducted a study that examined teachers' attitudes towards GIS implementation in Rwandan secondary schools and found that "often, challenges encountered in technology use in schools revolve around teacher training in pedagogy, curriculum and technical skills." This corroborates the former authors findings related to the training of student teachers. It is evident from the arguments that are raised by the two authors, that some higher education institutions that provide initial teacher training are not producing teachers that are competent in teaching GIS.

In my opinion, a teacher that is qualified to teach GIS is the one that possesses the GIS content, pedagogy and technical skills. I am saying this because I have come to understand that a Geography teacher is not necessarily a computer literacy teacher so he or she may not be computer literate especially if he/she was trained before the introduction of GIS, Fleischmann and van der Westhuizen (2017) concur by stating that there is a shortage of teachers that possess an education qualification and geospatial skills. As a result, many teachers struggle with incorporating the practical side of GIS when delivering lessons because they were not trained to do so. For instance, in some institutions of higher learning in South Africa, student teachers are taught computer literacy by Computer lecturers who do not specialise in GIS and then they are taught GIS by Geography lecturers, this disadvantages the students because they are expected to link the two sets of skills when they qualify as Geography teachers while there are not

taught the combination in their training. Geography education lecturers need to close this gap.

A similar case is reported in Australia, whereby Kinniburgh (2012, p. 16) reports that in Australia “generally, very little is taught to undergraduate education students about the merits of using GIS as an educational tool within the geography curriculum area”. This suggests that some university education lecturers are either not trained in GIS, have limited IT skills, or are simply not interested in showcasing the importance of GIS to student teachers. This places the student teachers at a disadvantage because when they qualify as Geography teachers, they struggle to teach GIS to learners. Thus, it can be argued from the literature reviewed above that Geography teachers must have GIS content and technological and pedagogical skills to teach GIS effectively. The following section presents the historical developments of the IBL teaching approach.

3.7 THE NEED FOR AN INQUIRY-BASED LEARNING APPROACH FOR TEACHING GIS

Numerous teaching approaches have been applied in the teaching of Geography in general and GIS in particular. However, it is evident from the conversations above regarding the challenges of teaching GIS in a South African context that an effective teaching approach is required to facilitate GIS implementation in a classroom. Hence the study aimed to explore the use of IBL in teaching GIS in a rural learning ecology. This section interrogates Inquiry Based Learning and argues that its strengths resonate with the demands of Geographic inquiry. Geographic inquiry calls for the asking of geographic questions; acquiring geographic information; organising geographic information; analysing geographic information and answering geographic questions (ESRI, 2003; Merja, 2018). These criteria show that a teacher should be able to guide learners to achieve all the latter steps.

The 20th century was particularly concerned with the accumulation of knowledge. Thus, the teaching approaches that were used back then were traditional, meaning that they were centered on the mechanist world view; modernist and behaviourist approaches where teachers were viewed as bureaucrats who were meant just to deliver the

curriculum (Pitsoe & Maila, 2012). During this time, learners were expected to assimilate knowledge and reproduce what the teacher had presented to them. This is referred to as the telling method (Ojo & Adu, 2018). Moreover, this is what Paulo Freire termed a 'banking' concept of education (Freire, 1970), whereby learners were seen as empty vessels and the teacher attempted to fill them up with knowledge. The banking concept of education promoted rote learning as the learners were meant to reproduce facts presented by the teacher. This was the only form of participation that was required from a learner. This teaching approach was oppressive in the sense that learners did not have a say in their education, as they only had to absorb the information provided by the teacher. Meaning that they were not required to apply their minds because they were just expected to reproduce what the teacher had taught. This approach to teaching had to change given the needs of the 21st century.

The 21st century is known as a knowledge society (Häkkinen et al., 2017; Ranga & Etzkowitz, 2015), meaning that it is concerned with generating and sharing knowledge to all members of society to improve the human condition. Knowledge can improve the human condition if it brings justice, solidarity, peace and democracy. Thus, knowledge is power in the sense that it can change society. UNESCO (2019) states that a knowledge society should provide equitable access to information. This view of knowledge suggests that the teaching approaches that were used in the 20th century are no longer relevant in the 21st century since learners are required to construct knowledge that will enable them to bring about change in society. This meant that the teaching approaches used in the 20th century had to shift to produce a learner that can acquire knowledge and apply it in different contexts (Voogt, Erstad, Dede, & Mishra, 2013). The knowledge society requires new kinds of knowledge such as Information and Communications Technology (ICT). Yeung (2010) argues that the long-term tradition of teacher-centered education is slowly turning towards learner-centered education as there is an increase in the use of ICT tools globally. Due to the introduction of ICT, learners are to possess 21st century skills.

One of the essential 21st century skills is that learners should be able to use ICT to access knowledge and adapt to the new ways of communication which are centered on technology (Häkkinen et al., 2017; Trilling & Fadel, 2009). These authors have termed

the development of 21st century skills as ‘learning for life in our times’. Meaning that learners should possess these skills to live meaningful lives and to solve problems in the 21st century. Due to this demand, advancements had to be made in how one approaches education as this called for teaching approaches that promoted active learning and collaboration. IBL is one of the teaching approaches that can cultivate the latter (Haq, 2017; Hwang, Chiu, & Chen, 2015). Thus, it has since gained popularity around the world as one of the prominent teaching approaches that can produce a learner that is relevant in the 21st century. Given the fact that it originates from the practice of scientific inquiry (research), it is driven by posing questions, generating and analysing data and presenting evidence-based arguments (Boukhobza, 2015; Krajcik & Blumenfeld, 2006). IBL enables learners to work collaboratively to conduct research, which enables them to acquire knowledge to mitigate problems that they face daily depending on their context (Botha, 2016). Thus, it is based on the idea of constructivism.

Constructivism is concerned with how learners learn. Piaget (1929) argues that learners learn through assimilation and accommodation. Assimilation is where a learner incorporates the newly learnt knowledge into prior knowledge and accommodation occurs when the learner modifies the prior knowledge to fit the newly learnt knowledge. Constructivism as a theory of learning advocates for active learning (Mayer, 2004; Ratinen & Keinonen, 2011). In short, active learning refers to ‘learning by doing’ (Gibbs, 1988). The IBL approach draws from the constructivist theory (Buchanan, Harlan, Bruce, & Edwards, 2016; Kinniburgh, 2010). Thus, it is a form of active learning as it is driven by questions or some form of research. As this is a Geography study, it is important to note that “documented use of IBL in geography is limited when compared with other disciplines; however, it is likely that IBL in its broadest sense is, in fact, widely used.” (Spronken-Smith, Bullard, Ray, Roberts, & Keiffer, 2008, p. 74). Therefore, the benefits and challenges discussed below draw from research studies which have been conducted across different disciplines pertaining the use of the IBL teaching approach.

3.8 BENEFITS OF APPLYING THE INQUIRY-BASED LEARNING APPROACH

Nowadays, there is consensus concerning the benefits of using the IBL approach in teaching. For instance, Aditomo, Goodyear, Bliuc, and Ellis (2013) and Krämer, Nessler, and Schlüter (2015) agree that teachers make use of the IBL approach to ask questions to solicit what learners already know, this is commonly known as assessing learners' prior knowledge. This is essential when introducing a new GIS topic because learners come to class with previously learnt knowledge, the teacher's questions allow them to make a connection between prior knowledge and the new information being presented (Wang, Wang, Tai, & Chen, 2010). Therefore, a teacher needs to be aware of the knowledge that learners possess to foster learner engagement (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010) because the foundation of new learning is premised on prior knowledge. For example, in the case of Geography mapwork serves as foundational knowledge for teaching GIS, so the teacher has to question learners constantly for them to connect the two topics.

IBL is an innovative approach to education that positions learning to solve complex problems. Thus, the teacher can make use of this approach to promote higher-order thinking skills (Madhuri, Kantamreddi, & Prakash Goteti, 2012). Higher-order skills can be translated into critical thinking, which is regarded as one of the essential educational goals as it allows students to engage in reflective thinking (Cottrell, 2017) which should enable them to make decisions about personal, societal, political, economic and environmental issues (Panasan & Nuangchalerm, 2010) as teaching using the IBL approach permits learners to engage in GIS projects that require them to generate data by observing the local natural environment. Thereafter, they use GIS to display, analyse, interpret and present findings. The findings may be used to come up with mitigation strategies. Such projects would enable Geography learners to become lifelong learners as they engage in solving real-life problems (Jakab et al., 2016). This is essential because success in today's world requires learners to engage in critical thinking and problem-solving (Holland, 2018; Thaiposri & Wannapiroon, 2015), as well as for them to be creative and innovative.

The use of the IBL approach develops learners' content knowledge and skills to apply what has been learnt (Panasan & Nuangchalerm, 2010) as they are allowed to reflect on their learning as they build and rebuild their understanding of GIS and its application to solve real-life issues. The IBL approach is practical in the sense that it allows learners to ask questions and to find their own answers. Thus, its application in the teaching of GIS has merit because GIS is a combination of theory and practice. GIS is used in different fields such as marine spatial planning, as well as in studying the environment (Zhu, 2016). This is evident in the work of Stelzenmuller, Lee, Garnacho and Rogers (2010), who researched using GIS as a tool to support marine spatial planning by studying the relationship between human activities and their impact on marine habitats. Therefore, exposing students to IBL can expose learners to thinking about GIS as a practical tool and as they use it their content knowledge is developed.

The IBL approach develops self-directed learning and collaboration skills (Hmelo-Silver, Duncan, & Chinn, 2007; Jakab et al., 2016). This means that teaching using this approach gives the teacher flexibility to design individual GIS tasks, that require a learner to complete the task individually whilst other GIS tasks require learners to work as a collective. Employing the IBL approach requires teachers that are responsible for the "creation of a classroom where learners are engaged in (essentially) open-ended and learner-centered hands-on activities" (Botha, 2017, p. 39). When learners are provided with such opportunities, their communication skills may improve as they are required to engage with the other group members to complete the tasks. Communication skills are important in the workforce, so engaging in group work helps to develop these skills which they will need in their careers. Just like any other teaching approach, some challenges have been documented regarding making use of this approach for teaching GIS.

3.9 CHALLENGES OF APPLYING THE INQUIRY-BASED LEARNING APPROACH

Political, historical, cultural, economic and religious issues have an impact on the teachers' beliefs about their teaching (Brighton, 2003). This is because teachers align their teaching with their beliefs about teaching and learning a particular subject based on their experience of their schooling, initial teacher training (Solis, 2015) and professional

development, that are often shaped by politics, history, culture, economics or religion. Šapkova (2014) carried out a study that explored the relationship between mathematics teachers' traditional beliefs and practices which revealed that there was a contradiction regarding the teachers' beliefs about constructivism and the way that they were teaching in the classroom as they would often fall onto the traditional ways of teaching. A similar conclusion was reached by Kaymakamoglu (2018) who researched teachers' beliefs and classroom practice. Findings from these two studies show that at times teachers may claim to be teaching from a constructivist perspective, however, in their practice they tend to fall back on the traditional teacher-centered approaches.

The IBL approach flips the traditional teaching approach on its head as it shifts the responsibility of learning to learners. Meaning that it is student-centered (Aparicio-Ting, Slater, & Kurz, 2019; Matthews & Hodge, 2016). With this being said teachers might lose the security of their teaching as the IBL approach is open-ended, allowing learners to be actively involved in a classroom. This is evident in Hayward, Kogan and Laursen (2016, p. 72) who researched instructors' adoption of IBL. One of the findings of the study was that "[teachers] shared their fears such as "IBL is hard" or being scared of "relinquishing control of their classroom." This indicates that some teachers may feel insecure about adopting the IBL approach in their teaching because it opens up opportunities for learners to ask questions, which is not always the case in traditional teaching approaches. Thus, when learners ask questions, the teacher may feel exposed when he/she cannot adequately respond to the students' questions. As a result, using this approach might be challenging to a teacher that still holds traditional beliefs about teaching and learning.

As it has been established that teaching using the IBL approach means that the lessons would be more student-centered, teachers have to monitor that learning is taking place (Newman, 2014). Consequently, extra time is also needed to ensure that learners have the necessary resources and that the social dynamics within the group provide an enabling environment for them to accomplish the task at hand collectively (Fitzgerald, Danaia, & McKinnon, 2019; Poon, Tan, & Tan, 2009). This means that the teacher has to develop skills in managing small groups and attend to behavioural problems that might arise now that learners would have autonomy in their learning (Poon & Lim, 2014). Hence,

noise levels must be managed so that it does not disturb learning in nearby classrooms, also, managing noise levels would ensure that learners can be able to listen to the teacher when he/she provides guidance and encouragement as the facilitator in an IBL classroom. Therefore, professional development opportunities might close this gap to assist a teacher to assume the role of being a facilitator of learning.

Adequate time is a necessity to ensure effective professional development for practising teachers. However, in most cases, the professional development opportunities that are provided to teachers are not always enough due to the limited time being allocated to it. It often occurs over one/two days sessions. Akinyemi, Rembe, Shumba, Adewumi, and Serpa (2019, p. 4) researched time allocated for professional teacher development and argue that “allocation of time in communities of practice has to do with the number of hours’ teachers spend in the learning and professional development and over what time the activity takes place, needs to be considered.” This shows that one of the big challenges for professional teacher development is the availability of time. This may be due to high teaching workloads (Goodnough, 2016). As a result, teachers who attend professional development workshops focused on teaching approaches that promote active learning might not receive sufficient training and support to enable them to experiment with student-centered approaches to teach such as IBL, limiting its use in many secondary school classrooms. Thus, Darling-Hammond, Hyler and Gardner (2017) recommend that school schedules should be adjusted to accommodate professional development opportunities for teachers. If teachers are not provided with the professional development opportunities, they might keep using the teaching approaches that they are mainly comfortable with and might not be open to any changes.

Rejection of change by teachers promotes the traditionalist pedagogy (transmissive teaching approaches dominate classrooms). This is often because teachers lack support to implement the IBL approach (Hayward et al., 2016; Ramnarain, 2016). Thus transitioning from traditional teaching approaches to IBL has proven to be difficult. Hence, the adoption of the IBL approach is not common in many classrooms (Lotter, Yow, & Peters, 2014; Voet & De Wever, 2016). Similary, Raja and Najmonnisa (2018) affirm that many teachers still follow the traditional route of conducting a lesson, while it is rare to

see the usage of teaching approaches that enable learners to work in small groups to solve problems, engage in projects and debate. One of the ways of overcoming this challenge is providing professional development workshops for teachers. These workshops are needed because they may help promote teachers' awareness of IBL and provide on-going support for teachers to use the IBL approach (Lotter et al., 2014), thus on-going support may enable teachers to transform the way that they teach.

Adopting the IBL approach for the first time requires teachers to allocate a substantial amount of time for planning purposes (Newman, 2014; Ramnarain, 2016). So that he/she may decide on the most suitable IBL exercises, the assessment criteria and the preparation of the necessary resources. Concerning developing an assessment criterion, it might take more time to develop rubrics that are more suitable for inquiry exercises (Fitzgerald et al., 2019; Zhang et al., 2005). Teaching using the IBL approach might even open up a teacher to the possibility of using other forms of assessment (Chu, Reynolds, Tavares, Notari, & Lee, 2017), such as self and peer assessment because the IBL approach caters for individual exercises and for learners to work collaboratively. These forms of assessment are often under-utilised in classrooms that make use of traditional approaches as the teacher maintains total control of the classroom. Self and peer assessment are student-centred and they require careful planning so that they may be used appropriately in a classroom (Birjandi & Hadidi Tamjid, 2012), which is why teachers have to allocate enough time for planning IBL lessons, assessments and have the necessary resources.

The availability of resources is a fundamental component of teaching using the IBL approach. This implies that the lack of resources is a major impediment to using the IBL approach (Fitzgerald et al., 2019; Silm et al., 2017). Scholars such as Ramnarain (2014, p. 65) attest to this through a research study which aimed to explore teachers' perceptions of using IBL across different contexts in South Africa. Findings of this study reveal that inadequate resources, large classes and lack of exposure limits the usage of IBL in the township and rural secondary schools. This shows that at times teachers are not always supported to use the IBL approach as they might lack adequate resources (Fitzgerald et al., 2019). Such challenges are outside the teachers' control because he/she must send

requests for the necessary resources to members of the school management team. Thereafter, it becomes the responsibility of the school management team as well as the DBE to ensure that teachers are supported with resources that they need to teach the subjects that they are assigned to effectively. Hence, if their requests are not granted for whatever reasons, teachers cannot teach effectively using the IBL approach.

National examinations may also pose a challenge because they often determine the teaching approaches that are used. For example, Zhang et al., (2005, p. 494) state that "currently, the exam functions as one of the barriers to implementing inquiry-based science because it is difficult for the exam to evaluate students' learning in the process." This implies that the way that national examinations are structured in a way that they mainly test the learners' content knowledge rather than application skills that learners are exposed to when the IBL approached is used. As a result, many teachers would neglect the IBL approach because they cannot afford to spend time developing learner's skills which would not be assessed in the national exam. Research shows that many teachers teach for the national examinations to ensure that learners get sufficient marks for post-secondary education rather than developing life-long skills (New York State Education Department, 2004). Meaning that many teachers find themselves engaging more with preparing learners for the examination rather than with providing them access to depth of knowledge. This was evident in a study that explored the impact of examinations on teaching and learning and found that "teachers adopt examination-orientated pedagogies to deliver the necessary content to learners" (Rind & Mari, 2019, p. 7). Consequently, teaching for the examination undermines teaching approaches such as IBL because it is intentional about deep and active learning.

3.7 SYNTHESIS

In the literature review, I discussed the historical origins of the discipline of Geography, the history of GIS and the recurring debates related to GIS's adoption into the secondary school curriculum. I also reported on assessing the need for teaching approaches that enable the teaching GIS, such as the Inquiry-Based Learning approach which is deemed suitable for preparing learners for their future roles in the 21st century. I was guided by

the research questions in selecting the relevant literature. The literature that I reviewed showed the complexities of introducing GIS in secondary schools as well as the amazing work that has been done to mitigate these challenges world-wide. For instance, partnerships have been formed between learners, teachers, government departments, institutions of higher education and the GIS vendors to improve the situation. I observed such partnerships in developing and developed countries, which shows that GIS education is a global movement rather than being for the select few.

In the literature review, I also observed the disparities in the provision of education in South Africa. Where we have well-resourced schools and poorly-resourced schools due to the apartheid legacy. When presenting the literature, I showed how these differences had an impact on how schools received the introduction of GIS, where many schools located in urban learning ecologies have the necessary computer resources as a result some make use of Quantum Geographic Information Systems (QGIS) to teach GIS. In contrast, most schools located in rural learning ecologies do not have the necessary computer resources to teach GIS so they cannot make use of QGIS. Yet, learners that attend these schools write the same school leaving exam regardless of the resources that are available in their school. Hence, this study's contribution was to supplement the ongoing efforts to improve the teaching of GIS.

With regard to teaching using the IBL approach, studies showed that there is a need to teach from this perspective as it cultivates the essential 21st century skills. These include creative and critical thinking, working collaboratively and the use of sound communication skills. However, for teachers to develop these skills they need to be trained to use the IBL approach. This is because the majority of the teachers did not receive training in the use of the IBL approach in their initial training. Also, most of them are not given adequate time off work to attend professional development workshops, so that they may form professional working communities. Thus, the study can guide Geography in-service and pre-service teachers' professional development activities for teaching Geographic Information Systems. The following chapter presents the research methodology that explains how the research was conducted.

CHAPTER FOUR
RESEARCH DESIGN AND METHODOLOGY

4.1 INTRODUCTION

The preceding chapter introduced the conversations on teaching approaches in general, the origin and the use of IBL as a teaching approach as well the origin of GIS and how it became part of the field of education and also, an understanding of a rural learning ecology was presented. To recap concisely with the purpose of bringing in the theory into the research design and methodology chapter, this study adopted CER as a theoretical framework. Thus, it is important because it had implications on how this study was carried out.

CER advocates a reciprocal relationship between the researcher and the co-researchers, as this enables the empowerment of both parties during the research process in the sense that there was a potential gain for both the researcher and co-researchers in exploring the use of an IBL approach for teaching GIS in a rural learning ecology. In this chapter, I begin by re-stating the aims, objectives and the main research questions of the study with the aim of reminding the reader of what the study sought to achieve. Thereafter, I move on to discuss my values as a researcher and the philosophical stance, the research design, the methodology, gaining access to the research site, selection of co-researchers, data generation and analysis methods, trustworthiness, ethical considerations as well as the limitations of the study.

4.2 RESTATING THE AIMS AND OBJECTIVES OF THE STUDY

The study aimed to explore the use of an IBL approach for teaching GIS in a rural learning ecology.

To recap, the objectives of the study were:

- To explore the current situation in teaching Geographic Information Systems in a rural learning ecology;

- To assess the need for an Inquiry-Based Learning framework for teaching Geographic Information Systems in a rural learning ecology;
- To understand the circumstances under which an Inquiry-Based Learning framework may be used to teach Geographic Information Systems in a rural learning ecology;
- To describe the benefits and challenges of using an Inquiry-Based Learning framework in the teaching of Geographic Information Systems in a rural learning ecology and
- To demonstrate the implications for the use of an Inquiry-Based Learning framework to teach Geographic Information Systems in a rural learning ecology.

The critical research question that lay at the foundation for this study is: How can we teach GIS in a rural learning ecology from an Inquiry-based learning perspective?

To respond to the aims and objectives of the study and to the latter question, I had to choose an appropriate research design to suit the aim of the study. However, before choosing the appropriate design I had to remind myself of my values as a researcher and how they have influenced the philosophical stance that I have adopted in this study.

4.3 RESEARCH PARADIGM

Research is concerned with generating knowledge. This is consistent with Simth (2012, p. 5) in her seminal work on decolonising methodologies, where she argues that “research is not an innocent or distant academic exercise but an activity that has something at stake and that occurs in a set of political and social conditions.” Therefore, every research study is premised on a paradigm (Gonzalez-Acevedo, 2019). In research terms, a world view is referred to as a paradigm. The word paradigm first appeared in Kuhn’s publication in 1962, where he analysed the structure of scientific revolutions and defined a paradigm as an ‘an accepted model or pattern’ of viewing the world (Kuhn, 1962, p. 23). Kuhn’s view of a paradigm is substantiated by Kivunja and Kuyini (2017), who state that the concept of a ‘paradigm’ is derived from the Latin word ‘paradigm’ and in Greek, it appears as ‘paradeigma’ which means pattern.

A pattern can be understood as a model used as a guide to perform an activity. For instance, Guba (1990) and Lincoln and Lynham and Guba (2018) view a paradigm as a set of fundamental beliefs that guide the action of the researcher and define his/her worldview. This emphasises that a paradigm in educational research serves as a guide to a researcher and provides ideas on how to conduct research (Tummons, 2013). From the latter views of a paradigm, I have come to understand that a paradigm is essential for educational research as it is concerned with how humans interpret, understand and experience the social world (Babbie, 2011). Therefore, a researcher is confronted with a choice of different paradigmatic perspectives (Cohen, Manion, & Morrison, 2018), as they embark on conducting educational research because there are several paradigmatic perspectives to choose from.

While reviewing the literature on paradigms, I came to a conclusion that views that are presented about different paradigmatic perspectives are not in alignment. For instance, Carr and Kemmis (1986) and Scotland (2012) state that there are three paradigmatic perspectives that are used in educational research, namely the critical paradigm, positivism and interpretivism. Whereas Chilisa and Kawulich (2012) state that the renowned paradigms are transformativism, positivism, post-positivism, constructivism and postcolonial Indigenous research. Furthermore, Denzin and Lincoln (2011) recognise six paradigms: critical theory, constructivism, interpretivism, feminism, positivism and post-positivism. Lincoln, Lynham and Guba (2018) state that in social science research there are post-modern paradigms (postmodernism, critical theory and constructivism) that challenge positivist and post-positivist paradigms.

Each of the paradigms presented above offer different ontological, epistemological and methodological assumptions that guide how a researcher conducts research (Babbie, 2011; Gonzalez-Acevedo, 2019; Guba, 1990). This study is premised on the transformative paradigm and its “central tenant is that power is an issue that must be addressed at each stage of the research process” (Mertens, 2007, p. 213). The transformative paradigm is suitable for research studies that have a focus on social justice and equity (Mertens & Wilson, 2012; Romm, 2018). The following sections present the epistemological, ontological and axiological aspects of the transformative paradigm.

4.3.1 Epistemology of the transformative paradigm

Epistemology in research is defined as “the relationship between what we know and what we see. The truths we seek and believe as researchers” (Lincoln et al., 2018, p. 103). This implies that as researchers we are guided by philosophical assumptions as we approach research. For instance, Taylor (2013, p. 247) argues that “in educational research, epistemology is also used to refer to the philosophical stance of the researcher in relation to research, the methods used for producing research and the justification of knowledge claims made in research reports, articles, and outcomes”. Proponents of the transformative paradigm beliefs about research are in contradiction with positivism, post-positivism and constructivism worldviews (Chilisa & Kawulich, 2012), mainly due to their research designs and epistemological assumptions in which research is only created by the “dominant or elite researcher” (Noel, 2016b, p. 455). Whereas the transformative paradigm assumes that the researcher and co-researchers should work collaboratively to generate knowledge. Therefore, the role of the researcher in this paradigm is inevitably subjective.

The transformative paradigm’s epistemology is unique in the sense that, it advocates the ‘transformation of research relationships’ as it seeks to bring about change (Mertens, 2010). Thus, it provides space for the empowerment of co-researchers through involving them in all phases of the research study. In this paradigm, empowerment of co-researchers is understood on the basis that the transformative paradigm considers how things ought to be (Scotland, 2012). Thus, the people who are affected by a problem are in a better position to respond to how things ought to be since they understand their context better. The transformative paradigm’s epistemology speaks to understanding people’s realities in order to change it (Mertens, 2007, 2015). Therefore, this paradigm was more suitable for this study because it was crucial for me to work collaboratively with the co-researchers to explore the use of IBL approach to teach GIS in a rural learning ecology. Working collaboratively with the co-researchers enabled them to contribute valuable insights about the teaching of GIS is a rural learning ecology. In this context, knowledge is social and historically deeply rooted in culture. As a result, I respected the different cultural identities and I had to have an awareness of power relations in this

context (Mertens, 2007). This was necessary to generate knowledge that would enable change in the teaching of GIS and to bring about this change I had to maintain an on-going relationship with the co-researchers to explore the use of an IBL approach to teach GIS in a rural learning ecology.

4.3.2 Ontology of the transformative paradigm

Ontology is interwoven with epistemology, as it is defined as the nature of existence (Ansari, Panhwar, & Mahesar, 2016; Taylor, 2013). It is concerned with questions about what is there to know (Cohen et al., 2018; Willig, 2019). Hence, I suggested earlier on that it is connected to epistemology. The transformative paradigm's ontology assumes that reality is shaped by social, political, historical, cultural, economic, ethnic and gender values that have power over society (Chilisa & Kawulich, 2012; Cram & Mertens, 2015). Additionally, the ontology of the latter assumes that there are multiple realities that are context-based given the different experiences and values that people have and that those in power in a society tend to prioritise their own view of reality (Mertens & Wilson, 2012). Given this background, the transformative paradigm was better suited for this study because it calls for action to change the lives of co-researchers (Mertens, 2010). Particularly for this study, it aimed to bring about change in education practice by exploring the use of an IBL approach in the teaching of GIS.

Framing this study under the transformative paradigm permitted the co-researchers to share their views of reality, their experiences and to actively participate in all stages of the research process. This resulted in the sharing of power during all phases of the research process. Therefore, the co-researchers and myself generated knowledge that was of benefit to all of us. Romm (2014) states that the transformative paradigm's intention is to contribute to social justice. This implied that as a researcher working in the transformative paradigm, I had to ensure that the co-researchers' voices were heard as we engaged in changing the way that GIS was taught in a rural learning ecology through a dialectical and negotiated approach.

4.3.3 Axiology of the transformative paradigm

Axiology in educational research is understood as the values and beliefs that we hold as researchers which lead us to favour certain research methodologies over others (Cohen et al., 2018). It is also concerned with research ethics. The transformative paradigm's axiology is based on three basic principles that guide ethics in a research study (Mertens, 2007). These principles are respect, beneficence and justice. In terms of respect, first, I had to obtain informed consent from the co-researchers, second, I had to respect the co-researchers' cultural norms as I engaged with them, and last, I also had to respect their privacy and protect confidential information that they shared (Jahn, 2011). Throughout the research process the rights of the co-researchers were respected and the values of social justice were observed by the co-researchers and myself (Cassell, 2000; Mertens, 2012). My values and beliefs as an educational researcher have been shaped by my experience of being a secondary school teacher and by being a lecturer.

My experience of being a secondary school teacher and a lecturer has taught me about the value of education as it has improved my quality of life over the years. Thus, my worldview, my conceptions of knowledge and my values regarding research are that change is possible if people come together to negotiate ways to overcome an undesirable situation. The same principle can be applied to problems that are related to education. I argue that the current South African education system is dehumanising and oppressive especially to learners that are in rural contexts where they are taught with inadequate resources. My argument is based on a report that explored the research conducted on education in South African rural communities. It revealed that the majority of children in rural poor communities are receiving less than is their right in terms of education provision as they "often [struggle] in resource deficient environments with teachers feeling helpless to influence their professional world" (Allsop, 2006, p. 561). Furthermore, Gina (2015) states that the DBE has begun prioritising changes in rural education given the fact that it was neglected under apartheid.

The challenges mentioned above regarding rural education suggest that change is needed in terms of improving the rural education system. However, the systemic change would not be possible without ongoing, multiple and collaborate efforts from various

stakeholders such as Departmental officials, lecturers, student teachers, teachers and learners where they come together to discuss educational challenges and engage in action to overcome them. The foundation of this study is based on research that has been conducted into GIS implementation in rural schools, ever since its inception in 2006. This reveals that learner performance is low in this section (Department of Basic Education, 2013, 2018). Therefore, to answer the research questions that were posed in this study, I approached this research study from an emancipatory perspective (Noel, 2016b), which is aligned with the transformative paradigm, critical emancipatory research (theoretical framework) as well as participatory action research (methodology). The section below presents the research design that was chosen in this study, the transformative paradigm and critical emancipatory research influenced the choice of the selected research design.

4.4 RESEARCH DESIGN

Researchers are guided by the plan when conducting research, these plans are referred to as a research design. A research design is a procedure of inquiry, where a researcher provides details of the steps that he/she has followed to conduct the research study and the reasons for making the choices that were made regarding the research design (Creswell, 2014). This procedure of inquiry is grounded on the researcher's philosophical worldview as it influences his/her assumptions about knowledge production. The procedure of inquiry also provides the methodology that was followed to conduct research as well as the data generation and analysis processes. For this study, a qualitative research design was followed. Therefore, qualitative data generation methods and analysis processes were utilised in this study.

In the literature that I reviewed regarding research designs, three designs are identified, namely qualitative, quantitative and mixed methods (Corbin & Strauss, 2015). Therefore, I had to first understand how researchers make use of such designs before deciding with the co-researchers which design would be appropriate for this study. While reviewing the literature I learnt that the qualitative research design is concerned with understanding people's lived experiences. As a result, it presents a descriptive narrative analysis of data (Leavy, 2017), thus, it made sense for me to choose this approach as my paradigm states

that there are multiple realities and that reality is socially constructed therefore, I needed to engage the co-researchers in order to understand how GIS was taught in the rural learning ecology and the qualitative research approach enabled me to do this. In contrast, I discovered that the quantitative research design tends to be more suitable for studies that are in the natural sciences, meaning that it is often associated with the positivist and the post-positivist paradigms. As a result, it presents a statistical analysis of data (Creswell & Poth, 2018). Consequently, it would have been in contradiction with my research paradigm because the conversations that we had about teaching GIS in a rural learning ecology and the action that we took to change the situation could not be quantified to be presented as statistics.

As I engaged more with the literature, I saw that the qualitative research design is often presented as the opposite of the quantitative research design and Creswell (2014) cautions against this by stating that the two approaches are different in a sense that a study may have more qualitative characteristics than quantitative or vice versa and this has led some researchers to combine both the designs to form a mixed methods research design. The mixed methods research design is relatively new when compared to the qualitative and quantitative research design. Denzin (2010) alludes to the fact that there has been an emerging scholarship that recognises the importance of both the qualitative and quantitative research design, particularly in social science research. This means that researchers that choose the mixed methods research design combine the elements of both the qualitative and quantitative research design. As a result, they generate both descriptive and numerical data (Creswell, 2014). Once more, the mixed methods design would have been in contradiction with my paradigm due to its focus that would still involve as it still comprises the quantitative data analysis, which would limit the aim of this study which is to explore the use of IBL in teaching GIS in a rural learning ecology.

The qualitative design is more aligned to the transformative paradigm and the study's research questions. Qualitative research is complex in a sense that many scholars have admitted that it is not easy to provide a single definition of this research design (Cohen, Manion, & Morrison, 2011; Creswell & Creswell, 2018; Pathak, Jena, & Kalra, 2013).

Nonetheless, I draw on the following definition of qualitative research. Denzin and Lincoln (2011) define qualitative research as:

> "a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, including field notes, interviews, conversations, photographs, recordings and memos to self …qualitative researchers study things in their natural settings, attempting to make sense of or interpret phenomena in terms of the meanings people bring to them" (p. 3).

Drawing from the above definition, this study adopted a qualitative research design in order to explore the use of an IBL framework in teaching GIS in a rural learning ecology because it enabled us to gather and analyse descriptive data, specifically words shared during conversations and recorded in reflective journals. The latter qualitative data generation methods enabled me to gain a comprehensive understanding of the co-researchers lived experiences, Creswell (2014) believes that qualitative research enables the voices of [co-researchers] to be heard. Hence, the co-researchers were given a platform to share their lived experiences with regard to the teaching of and being taught GIS in a rural learning ecology as the study aimed to bring about change in this regard. Pathak et al., (2013) shares a similar view of the qualitative research design by stating that it is utilised to understand peoples' experiences, beliefs, attitudes and interactions. The co-researchers' experiences, beliefs, attitudes and interactions with GIS were necessary in exploring the use of IBL in teaching GIS because we were all working towards the same goal of changing the way that GIS was being taught. Therefore, the qualitative research design gave a voice to the co-researchers of this study as they had a say in developing and applying the intervention strategy (IBL approach).

4.5 METHODOLOGY

While searching for a suitable methodology for this study, I have come to understand that methodology in research refers to well defined procedures and practices that a researcher follows when conducting research (Kivunja & Kuyini, 2017; Simth, 2012). It outlines how research is conducted in a scientific manner. A research methodology addresses the following two questions, how was data generated and how was it analysed (Labaree, 2019). Meaning that researchers must explain how they obtained data as well as the

procedures that they followed to analyse it. There are many options that a researcher may choose from when deciding on which methodology to use for his/her study and often the decision is dependent on the type of data that they wish to generate through their research (Labaree, 2019; Simth, 2012) as well as their research paradigm. Consequently, there is no definitive way of conducting research since research is not a one size fits all enterprise, and there is no research methodology that is superior to the others (Walliman, 2011) as they all have their unique strengths and weaknesses. What I have learnt from this is that, depending on the aim of the research as well as the researcher's paradigm, the researcher has to think carefully about which research methodology will be suitable for his/her study and provide a rationale for making his or her selection. Therefore, the following section provides an overview of PAR methodology and the reasons why I have chosen it for this particular study.

4.5.1 Participatory Action Research as a methodology

Participatory Action Research (PAR) is a qualitative methodological approach that is empirical, whereby the people who are affected by a problem which is being researched engage as co-researchers in the research process. As co-researchers the affected people are expected to take action in order to address the problem (Barros, Tavares, & Martins, 2019; Rodríguez & Brown, 2009). Authors such as Gillis and Jackson (2002) and Breda (2015) agree with the latter by stating that PAR is a type of research that involves the co-researchers in every step of the research project which aims to effect social change. This understanding of PAR implies that when the methodology is applied in research, there should be an active collaboration between the researcher and co-researchers from the design of the study up until completion. The meaningful participation of participants as co-researchers in finding solutions to the research problem would ensure that they benefit from research as well as other members in a community (Higginbottom, Rivers, & Story, 2014).

While consulting literature on PAR, I came to an understanding that it belongs to a participatory research paradigm which encompasses many methodological terms such as action research, community-based participatory research as well youth empowered research and each name differs depending on the participants of the research study.

However, these approaches share many co-principles, key theories and objectives (Minkler & Wallerstein, 2008). For this particular study those who participated in this study as co-researchers were various stakeholders such as lecturers, student teachers, teachers, learners and a Department of Education official (subject advisor). That is why PAR was adopted as a methodology for this study. PAR combines the elements of participatory research and action research and it is concerned with the empowerment of the co-researchers (Dudgeon, Scrine, Cox, & Walker, 2017).

4.5.1.1 Historical roots of Participatory Action Research

Action research can be described as “proceeding in a spiral of steps, each of which is composed of planning, acting, observing and the evaluation of the result of action” (Kemmis and McTaggart 1990, p. 8). Simply put, the four steps are planning, acting, observing and reflecting (McClintock, Ison, & Armson, 2003). The spiral steps form a cycle of research that has to be applied and re-applied throughout the research process (see figure 4.1). The cycle helps to facilitate action, as the aim of action researchers is to improve practice, thus the elements of action research were appropriate for the aim of this study as it sought to explore the use of an IBL for teaching GIS in a rural learning ecology, with the aim of bringing about change to the way that GIS was taught.

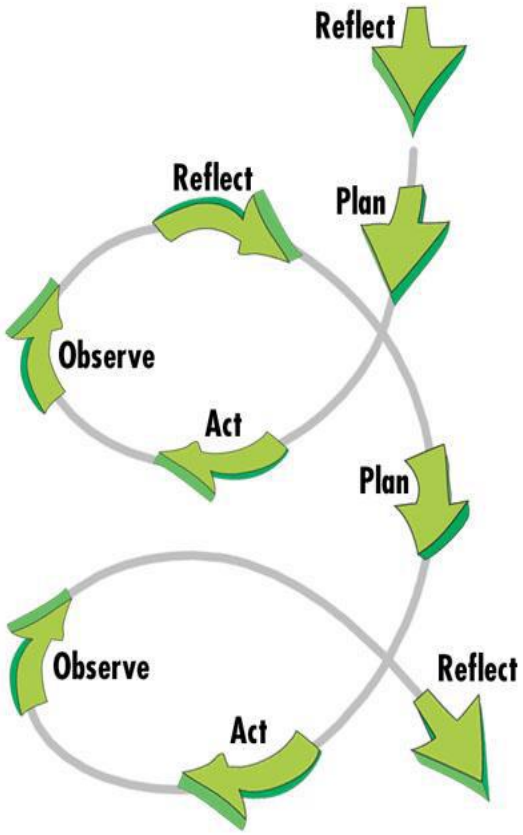


Figure 4.1 Cycles of action research presented by Kurt Lewin. Retrieved from http://cei.ust.hk/teaching-resources/action-research

Bringing about change in the teaching of GIS would not have been possible without the active participation of the co-researchers in observing the cycles of action research presented in figure 4.1 above. Participation in research brings us to the 'Southern' tradition that PAR draws from. The 'Southern' tradition that has given rise to PAR can be traced back to the Brazilian philosopher named Paulo Freire (Macaulay, 2016), during the 1970s he authored a book titled *Pedagogy of the oppressed* and in this book, Freire provided a critique of education and research values with reference to oppression and political power (Freire, 1972). He suggested that members of society should not be treated as empty vessels and objects of inquiry but they should assume the roles of being co-researchers and actively participate in the research study.

Freire transformed the hierarchy of doing research from one that saw community members as objects of study to the one that saw them as partners in the research process (Minkler & Wallerstein, 2008). Higginbottom et al., (2014) attest to this by stating that participatory research provides an opportunity for the marginalised people to engage in research and to find solutions that benefit themselves and their communities (Higginbottom et al., 2014). That is why the people that participate in a study are referred to as co-researchers and they play an active role and engage during the research process. PAR "intentionally ascribes a position of power to the research participant [co-researcher]" (Gonzales & Rincones, 2013, p. 6). Therefore, it can be concluded that PAR methodology provides an alternative to the traditional methods of conducting research because it prioritises participation of various stakeholders as co-researchers throughout the research process rather than the expert researcher who goes out to the research site to collect data.

PAR comes in various forms depending on the intentions of those that are conducting research. Conducting PAR is dependent on many factors such as the research context, the research questions as well as the research team, therefore there are no universal formulae of conducting a PAR study. PAR is used in many fields such as health, anthropology as well as education yet there is little consensus on the definition of this methodology which outlines how PAR studies should be conducted. What is agreed on is that the common goal of this methodology is to change the social reality on the basis of gaining insights by working collaboratively with the co-researchers. Baum (2016) argues that the common theme in participatory research is that it does not treat people as objects of study as the traditional forms of research. Instead it involves the co-researchers in the study where they assume an equal role to that of the researcher. Moreover, PAR focuses on social change by working in partnership with the co-researchers in an iterative cycle of research, which involves planning, acting, observing and reflecting (Kemmis et al., 2014) in order to change an undesirable situation.

Out of all the research methodologies that I came across, PAR resonated with the research paradigm and the research questions of the study because it prioritises action. Taking action was necessary where the teaching of GIS is concerned because ever since

its introduction into the Geography curriculum especially in rural ecologies, teachers were not provided with adequate GIS training. As a result, they were not confident in teaching this section, and the learners were disadvantaged because they were expected to write an examination which included GIS while they were not taught this section properly. Solutions were needed to mitigate the problem. Given that many research studies have focused on presenting the challenges of teaching GIS, very few studies in a South African context have attempted to bring about change in the way that GIS is taught in a rural learning ecology.

I choose PAR because my goal was to use a humanising research methodology (Irizarry & Brown, 2013; Paris & Winn, 2013), and it helped me to recognise the knowledge of the disadvantaged learner, teacher and student-teacher co-researchers with whom I collaborated in this study. PAR recognises power relations and inequities in the world. Thus, it was better suited for this study because it allowed me to present the narratives of the learner and teacher co-researchers who have been historically oppressed. The PAR methodology distances itself from the traditional ways of creating knowledge, which reminds me of the work of Potts and Brown (2015, p. 258) where they wrote about anti-oppressive research, highlighting that people have the "capacity to act and alter the relations of oppression in [their] own world." This implies that when various stakeholders (co-researchers) collaborate in research they become agents of change as they are able to address the challenges that they face, in this study I worked collaboratively with the co-researchers to change the way that GIS was taught in a rural learning ecology.

4.5.2 Tenets of Participatory Action Research

This section below presents some tenets of PAR, namely sharing of power, mutual respect for lived experiences and expertise, informed decision-making and maximum involvement. These tenets have been suggested by McTaggart (1991), who argues that it is important for PAR practitioners to be aware of these principles since they have emerged from the theory and practice of conducting research with different communities.

4.5.2.1 Sharing of Power

Power-sharing in PAR is understood as shared decision-making between the researcher and the co-researchers throughout the research process. Researchers that make use of PAR understand that the co-researchers possess knowledge from their everyday lived experiences. Thus, they are in a better position to contribute meaningfully to the research study as they are familiar with the context and the problem under study (Rodríguez & Brown, 2009). As a result, the co-researchers provided guidance on ways that they think are best in addressing the research problem given the background knowledge that they possess. PAR opens up learning opportunities for the researcher and the co-researchers because they share their knowledge as equals (Bradbury, 2015). Power-sharing in PAR implies that there is an exchange of knowledge and ideas through a dialogue between the parties involved in research and this results in the mutual development of knowledge. This can only be achieved if there is mutual respect between the researcher and the co-researchers. For this study, each co-researcher had an important role to play to ensure that we took equal responsibility and ownership of the study.

4.5.2.2 Mutual respect for lived experiences and expertise

PAR as a research methodology that opposes the traditional scientific paradigm because traditionally all the power, knowledge and authority lie with the researcher (Rodríguez & Brown, 2009). Hence, the traditional scientific paradigm gives the researcher primacy as he/she has total control of the research study. As a result, the viewpoints of the participants are marginalised as they have no say in the design and the implementation of the research. PAR, on the other hand, is more aligned to qualitative research according to Macaulay (2016) and to MacDonald (2012) because it allows for multiple realities and thus it permits the participation of the community in the research study. Meaning that in PAR research, there are two main actors in the research process the researcher and the co-researchers and each of them has a unique role to play and an equally fundamental contribution to make to the research process.

PAR is concerned with relationship building between the various stakeholders, as it brings people together from various knowledges and lived experiences and it aims to promote relationships that are collaborative and non-hierarchical (Cook, Brandon, Zonouzi, &

Thomson, 2019). Furthermore, it involves gaining entry to the community where the study is based (Vaughan, Boerum, & Whitehead, 2018). For this study, in particular, every co-researcher's contribution was welcomed and treated with respect as I was aware that the teachers and learner co-researchers are the parties that were mainly affected by the teaching of GIS in a rural learning ecology. Thus, their voices were necessary for the study as we were hoping to bring about change. The teacher and learner co-researchers provided a direction for the study, by indicating their strengths and weaknesses in terms of the requirements for teaching GIS. From there, we were able to respond to their needs by asking a GIS lecturer to share his expertise in conducting GIS practicals. During these sessions, there were critical engagements between all the co-researchers that were present and this resulted in learning and sharing of information by all parties that were involved. This would not have been possible without recognising and valuing the co-researchers' experiences and expertise in making all the decisions pertaining to exploring the use of an IBL Framework for teaching GIS in a rural learning ecology.

4.5.2.3 Informed decision-making

I understand informed decision-making in research as a process whereby the various co-researchers involved in the research study are made aware of the purpose of the study and the different roles that they are expected to fulfill. This allows them to participate meaningfully in the study so that when it comes to making certain decisions, they have sufficient knowledge to bring to their decision-making (Kemmis, 2010; McTaggart, 1991). The decision to embark on this study was as a consequence of a conversation that I had with a postgraduate student who was a Geography teacher at a local secondary school as well as a result of discussions held with my supervisor about the teaching of GIS in secondary schools. From there, I worked towards developing a research proposal in consultation with my supervisor and the teacher. Thereafter, the teacher suggested people that he thought would contribute meaningfully to the study. We then requested permission to conduct the study from the school where the research was to be conducted. This was the school where the teacher worked. Upon receiving ethical clearance, I scheduled appointments with the various co-researchers to make them aware of the intentions of the study and to establish whether or not they would be willing to take part

in the study. This was done to ensure that all the co-researchers had sufficient information regarding the purpose of the study.

During these initial conversations, I explained that the study was not mine per se but I was inviting them to be part of a PAR journey aimed at bringing about change in the teaching of GIS. I struggled to teach GIS because I was not trained to teach this and I learnt that the teachers shared similar experiences. Through dialogue, I made the rest of the co-researchers aware of the ideas that we had regarding the study, explaining that they were free to suggest any changes that felt would benefit them. This was done in order to create an environment that provided empowerment opportunities for the co-researchers to implement the changes that they wished to see. Working collaboratively was imperative because they were all affected by the teaching of GIS in a rural learning ecology. From their input, I was able to establish that they needed training in terms of GIS content, teaching pedagogies and PAR. Thus, training workshops (McTaggart, 1991) focusing on the latter were conducted and from there we were able to proceed with lesson planning as planning is an essential element of the action research cycle (Kemmis, 2010). Thereafter, we were able to teach and observe the lessons followed by reflective sessions to discuss the strengths and weaknesses of the taught lessons with the aim of improving the subsequent lessons. This process required the co-researchers to be well-informed about the purpose of the study and about their overall contribution to the study.

4.5.2.4 Maximum Involvement

Participatory action research brings different people together during a research process. During the research process, collaborative relationships develop amongst the co-researchers throughout the study, hence, everyone has a role to play in the study. This implies that the role of the participants is not passive like in the traditional scientific paradigm. Instead, the participants assume active roles of being co-researchers in the study where they have a say in the research process as they are involved in conceptualising the study with the researcher. Thereafter, they implement action and reflect on it in order to improve the action (Carr & Kemmis, 1986). Moreover, the co-researchers are also involved in presenting and interpreting the research findings. This helps in that every one that is involved in the research assumes ownership of the

research, thus, contributing to their own emancipation as participatory action research links theory and practice. According to Kemmis (2010) the aim of action research is to change people's practices. This study focused on bringing about change in the teaching of GIS and it was important to involve different stakeholders to contribute to changing the educational practice in a rural learning ecology.

The principle of involving co-researchers in the research process also relates to the northern tradition of PAR, action research because Lewin (1946) was of the view that in order for a researcher to understand and change social practice they have to involve the people who are affected by the problem in all phases of the research process. Thus, since PAR encourages participation and the involvement of co-researchers in the study one can argue that PAR is practical and this sets it apart from the traditional scientific paradigm in the sense that it promotes a joint process of knowledge production. It is against this background that one can argue that PAR advocates for maximum involvement of different stakeholders that have an interest in the phenomena under study, as they bring different perspectives, lived experiences and meanings that contribute meaningfully to improve practice. This, in turn, provides empowerment opportunities for all those that are involved in the research process.

4.6 THE RELATIONSHIP BETWEEN GIS, POWER, EMANCIPATION AND PARTICIPATORY ACTION RESEARCH

GIS is an extension of mapping since it brought about the advancement of manual map making to computerised map-making through the usage of computer software. Maps are a tool for organising thoughts and experiences in a visual manner, geographic maps tell us how societies live and function in the world by studying the relationship that they have with one another and the environment (Pacheco & Velez, 2009; Powell, 2010). The authors further state that people navigate the world with value systems and relationships of power, as a result, maps reflect power because they cannot speak for themselves, it is the cartographer's motivations that are central to the construction, function and analysis of the map.

According to Powell (2010, p. 553) “maps can shed light on the ways in which we traverse, encounter, and construct racial, ethnic, gendered, and political boundaries.” This clearly shows that maps and GIS are not neutral, thus, they can be used as a tool for oppression if local communities are not consulted when the development of maps takes place, as the political powers, cartographers [including GIS users] are privileged (Powell, 2010), as they get to make decisions on naming places, moreover, they decide on the location of spatial boundaries. Often when communities are not consulted when maps are created it results in conflicts as communities fight for their identities to be acknowledged because outsiders may name their place(s) differently.

Maps and GIS have created spatial boundaries which have divided places into urban and rural learning ecologies, where some schools that are located in urban ecologies have the power to implement GIS and some schools located in rural ecologies are regarded as have-nots because they do not have power to implement GIS that is prescribed by the national South African Geography curriculum properly. For some schools in KwaZulu-Natal, marginalisation occurs as a result of location, whereby more education opportunities and resources are allocated to schools within urban ecologies while some schools in rural ecologies contain limited opportunities and resources. Learners who attend such schools are disadvantaged as they are not taught GIS effectively.

Another concern that makes matters worse in some rural ecologies is that according to Breetzke et al., (2011, p. 150) “GIS educator-training programmes are often located in major cities, which adds to the cost of educators attending them, particularly those educators coming from rural areas.” Due to such circumstances, some teachers are disempowered as they lack knowledge on how to teach GIS effectively. As a result, learners are disadvantaged because they are expected to write common examinations with learners that have been taught GIS effectively. Most importantly, learners' voices are being suppressed in terms of map-making as they will not have the GIS skills that would enable them to create their own maps. Thus political powers, cartographers and GIS users continue to maintain the power of map-mapping. PAR was thus a more suitable methodology to mitigate the situation as it priorities action and it recognises the issues of power and emancipation, advocating for those who are affected by a problem to bring

forth solutions to address the problem. Hence, I worked with different co-researchers in this study to bring about change in the teaching of GIS in a rural learning ecology.

4.7 SELECTION OF CO-RESEARCHERS

Reconnaissance is aligned with the selection of co-researchers for a PAR study. My understanding of reconnaissance draws upon the ideas of Kemmis et al., (2014), where they reveal that more often than not the participatory action research team consists of university educated researchers and teachers that work collaboratively to initiate change. This was the case for this research study as it was initiated by a conversation that I had with a Geography teacher and we were discussing research and challenges that are experienced by Geography teachers in general. I found that some of these challenges such as the teaching of GIS that he was encountering were similar to the experiences that I had faced while I was still a secondary school Geography teacher. From this discussion, it became apparent that we needed to do something to change the situation hence this led to the birth of this study.

Various co-researchers were selected to partake in the study, the rationale for this was because it intended to bring about change in the way that GIS was taught in a rural learning ecology. Thus, it was important for everyone who had an interest in the teaching of the latter in this context to have a say in the way that it is taught and in how it could change. The co-researchers were teachers, learners, a Department of Basic Education official (subject advisor), lecturers and student teachers and they were invited and agreed to take part in the study as co-researchers. Being co-researchers in the study meant that we were collective owners of the study. To select co-researchers the teacher suggested potential stakeholders that he believed had an interest in the teaching of GIS.

The teacher suggested that we invite the Department of Basic Education official (subject advisor), learners and the other Geography teacher at his school to partake in this study. I suggested that we invite lecturers and student teachers as GIS is taught at higher education level and the student teachers were going to be Geography teachers in the future, so we wanted a better experience for them in terms of GIS teaching. This method of selecting co-researchers is similar to the one that various authors refer to as the

snowball technique of selecting co-researchers. This where interpersonal relations and connections between people are used to access specific populations (Sadler, Lee, Lim, & Fullerton, 2010). Thus, the co-researchers were selected on the basis that they had an interest in the teaching of GIS is a rural learning ecology.

In order to select co-researchers from the secondary school, I scheduled a meeting with the school principal to explain the purpose of the study. Then I requested permission to conduct research in the school that he manages. During the meeting, I explained that I had spoken informally with one of the teachers that taught Geography in his school regarding the teaching of GIS and he indicated that he had some challenges. As a result, I explained that I would like to partner with the school to see how we can change the situation by exploring the use of an IBL framework for teaching GIS. The principal seemed excited about the initiative and gave me gatekeeper permission to conduct research at the school.

I used the gatekeeper permission letter that the principal had signed to apply for ethical clearance at the university. Upon receiving ethical clearance for the study, I arranged a meeting with the two Geography teachers, the one that I had met previously and one that I was meeting for the first time. During this meeting, I went over the purpose of the study and obtained informed consent from both the teachers to participate as co-researchers in the study. Thereafter, I asked them to nominate learners from grade 10 and 11 that they thought would participate as co-researchers in the study. The participation of learners in the study was fundamental because learners are on the receiving end of the GIS knowledge that is taught by a teacher, thus, they were able to provide input about the teaching of GIS. The teacher co-researchers were in a better position to nominate suitable learners because they know learners well since they interact with them on a daily basis.

The meeting with the teachers was a success as they agreed to participate in this study. One of the teacher co-researchers, even ended up giving me contact details for the Geography subject advisor that oversees the teaching of Geography in their school. I called the Geography subject advisor for Pinetown District to schedule an appointment, he indicated his availability for the meeting and we met. During the meeting, there were

introductions and then I explained the purpose of the study and requested him to participate as a co-researcher in the study. He agreed to this request and said that he was available to help wherever he could. The Geography subject advisor was selected as a co-researcher because he is responsible for developing the Geography curriculum, offering support and developing Geography teachers in his district. Thus, he is knowledgeable about the implementation of GIS because he is involved in making Geography curriculum decisions. This study was needed to bring about emancipation in the teaching of GIS in a rural learning ecology.

I also invited two university lecturers to be co-researchers in this study; a Geography education lecturer and a GIS lecturer. Geography modules include some aspects of GIS, therefore, the Geography education lecturer was requested to be a co-researcher because he is responsible for teaching GIS to prospective Geography teachers that will be responsible for teaching GIS at secondary school level in the future. The GIS lecturer was invited to be a co-researcher because he is responsible for training potential GIS specialists. He is knowledgeable about GIS because he is based in the pure Geography discipline. Both lecturers were able to share their unique experiences of teaching GIS to undergraduate students and to offer advice regarding the GIS content and Inquiry-Based Learning. I sent the lecturers an e-mail to schedule an appointment and they responded to my request. In the initial meetings, I explained the purpose of the study and requested permission from them to be co-researchers in the study and they consented.

The selection of student teachers happened on the basis that they had elected to do their practice teaching in the school where the study was to be conducted. There were four Geography student teachers that conducted their teaching practice at the school and they were all in their final year of study. The teacher co-researchers who were mentor teachers the students explained the purpose of the study to them and they seemed interested. They then invited me to the school to meet the students and to provide them with letters of informed consent. At this meeting, the student teachers signed the informed consent letters, indicating that they were willing to take part in the study as co-researchers. The student-teacher component in this research study is important because they had a basic

knowledge of GIS from basic education (grades 10-12) and higher education level. Also, as prospective Geography teachers, they will be expected to teach GIS in the near future.

Gaining informed consent and assent from the various co-researchers was quite a long process because they were located in different places. Nonetheless, we were all excited about this participatory action research as it is sought to address everyone's felt concern which was the teaching of GIS. Together we explored the use of an IBL framework to teach GIS in a rural learning ecology. The following section presents the participants' profiles and outlines their potential roles as co-researchers in this study. The co-researchers as stakeholders were: teachers, secondary school learners, a subject advisor, university lecturers as well as student teachers.

Table 4.1: Co-researchers' profile

Participant	Contribution	Experience
Teachers	The Geography teachers are mindful of GIS implementation challenges since they are responsible for delivering GIS content to Geography secondary school learners. The teachers were instrumental in exploring the use of an Inquiry-Based Learning framework for teaching GIS because they selected some of the co-researchers, mentored student teachers, planned, taught and observed GIS lessons.	The teachers have experience in teaching Geography at secondary school and they have also witnessed the introduction of GIS in the Geography curriculum.
Secondary School Learners	Exploring the use of an Inquiry-Based Learning framework for teaching GIS has a direct impact on learner performance as they have written assessments that comprise of GIS. Learners represent the grade 10 and 11 learner population	The Geography grade 10 and 11 learners have been taught GIS for a minimum of six months and they

	at the school and they were expected to evaluate the IBL teaching approach that was used to teach GIS.	have written assessments that comprise GIS.
Subject advisor	The Geography subject advisor was aware of the GIS implementation challenges especially in a rural learning ecology as his job description entails offering support and mentorship to Geography teachers in his district. Therefore, his contribution to exploring the use of Inquiry-Based Learning framework for teaching GIS was crucial. His role is the study was to offer guidance with regard to GIS content and teaching approaches.	The Geography subject advisor is involved in curriculum development as well as offering content support and professional development to Geography teachers.
Education Lecturer	The Geography education lecturer possesses knowledge pertaining to GIS since he teaches student teachers from varying backgrounds. This lecture's experience is crucial in identifying and solving GIS implementation challenges because he is able to see the strengths and weaknesses of student teachers that choose to specialise in Geography education. The lecturers' contribution to exploring the use of an Inquiry-Based Learning framework for teaching GIS involved mentoring student teachers, planning and observing GIS lessons.	This lecturer is responsible for teaching Geography education modules, which include GIS content to student teachers that are studying to become Geography teachers. The students come from various secondary schools with different backgrounds. As a result, she has a broad overview of GIS knowledge that student teachers possess from secondary schools.

GIS Lecturer	The GIS lecturer possesses extensive GIS knowledge as well as the practical aspect of GIS since they train future GIS specialists that will be employed in various governmental departments and the private sector. This lecturer also encounters students from different backgrounds. As a result, he has observed the students' strengths and weaknesses of those that have elected to become GIS specialists. GIS lecturers' contribution to the study was to share GIS content knowledge and to demonstrate how GIS software is used by GIS specialists.	This lecturer is responsible for teaching GIS to second-year university students who are studying to become GIS specialists. As a result, this lecturer has GIS teaching experience since he is responsible for training future GIS professionals.
Student Teachers	The student-teachers possess GIS knowledge because they have been taught GIS in secondary school and at higher education level. As a result, they able to provide insight when exploring the use of an Inquiry-Based Learning framework to teach GIS. The student-teachers contribution was to share their knowledge of GIS as well as to plan, teach and observe GIS lessons.	The student teachers have a good deal of experience of learning GIS because they were taught GIS at secondary school for three years. Moreover, they have been taught GIS at a higher education level and the IBL teaching approach.

4.8 DATA GENERATION PROCEDURES

PAR was employed as a research methodology for the study, this means that the research process was collaborative in nature. Collaboration in this study involved activities related to exploring the use of IBL approach to teaching GIS in a rural learning ecology with the co-researchers in order to improve teaching skills. Collaboration in this

study involved four phases a) initial planning; b) planning the intervention; c) acting and observing; d) reflecting on the whole process. These are aligned with the PAR cycle (Kemmis et al., 2014).

Phase One: Initial planning

This phase followed the procedure that was described above regarding the selection of co-researchers as the initial school and office visits involved explaining the purpose of the study to the various co-researchers and obtaining informed consent and assent forms from them. As previously mentioned, the process was lengthy as co-researchers were in different locations. Nonetheless, the process was necessary to ensure that all the co-researchers understood the purpose of the study. I also made them aware that they were free to add anything or anyone that they felt would contribute positively to the study and that there was a need for regular meetings so that we could achieve the aim of the study, therefore, their commitment was crucial. Everyone seemed happy with this arrangement. The following step was to arrange a meeting where we would decide how the research would unfold.

The first meeting was held at the school during break time. Teachers, learners and student teachers were the only co-researchers that were present. The GIS lecturer and subject advisor sent in apologies excusing themselves from the meeting. The purpose of this meeting was to gain an understanding of how GIS was taught at the school. From our deliberations, it became apparent that the teachers and student teachers were not confident to teach GIS and the learners indicated that they did not like GIS much. The outcome of the meeting was that the next step was to teach one GIS lesson to both grades so that we would all have a practical understanding of how GIS is taught in the school.

The second meeting happened during teaching time, where the student teachers and I were given the opportunity to observe a grade ten lesson. We then deliberated as a group after the lesson to reflect on the process. The third meeting also happened during teaching time on another day, where the students and I were given an opportunity to observe a grade eleven lesson. Thereafter, we met as a group to reflect on the process. In this phase, data were generated from classroom observations and focus group

discussions with the co-researchers (teachers, learners and student teachers). Data generated from this phase helped us (as co-researchers) to identify GIS and to establish how GIS was taught and we were able to identify implementation challenges that were experienced in the school.

Firstly, both the teachers were not engaging learners during the two lessons and the only resource that they were using was the textbook. Secondly, for both the lessons GIS concepts were taught to learners without any reference to prior learning or to learners' experiences. We discussed the latter challenges during our reflection and we decided on organising a workshop that would help to address some of the challenges that were identified. The initial meetings were very useful as they helped to establish rapport amongst the co-researchers and to decide on an intervention to elevate the GIS implementation challenges that were identified.

After the reflective session at the school, I decided to schedule a meeting with the subject advisor to gather his views about the teaching of GIS in rural ecologies. From our conversation, it became apparent that indeed many teachers were struggling to teach GIS in this context. He felt that this was because teachers were not adequately trained to teach GIS content and that the schools lacked computer resources that are necessary to teach this section. So, he recommended that they should teach concepts only as a coping mechanism. I then shared our idea about hosting a workshop at the school, he really liked the idea and said that he was available to help. I then asked him what he thought we should include as part of the workshop agenda and he advised that GIS content and information on teaching approaches that might be used to teach GIS content should be included.

I then arranged other meetings with the GIS and education lecturers at their offices to explain what had transpired in our last session at the school. They were both excited about the workshop and volunteered to share their expertise with the rest of the co-researchers during the workshop. Meanwhile, the student teachers, learners and the teachers were planning the workshop, they met during break times to put together the workshop programme. Thereafter, the programme was circulated to all the co-

researchers for them to have an input on what had been proposed. When everyone was happy with the programme, we then proposed a date and everyone agreed on the date. The workshop was to be held at the school. The teachers negotiated with other teachers for us to host the workshop after the school break till the end of the school day. All the co-researchers were present during the workshop except for the subject advisor, he sent an apology in the morning to excuse himself for personal reasons.

Phase Two: Planning the Intervention

Phase two of this research study was to negotiate ways to overcome the problems that were identified in phase one with regards to GIS implementation. We deliberated with the co-researchers through focus group discussions and decided to host a workshop focusing on grade ten and eleven GIS curriculum. Also, we decided to explore the use of the Inquiry-Based Learning (IBL) approach as an intervention to change how GIS was taught, given the background that the teacher co-researchers were not using engaging teaching approaches to teach this section. IBL seemed like an appropriate approach because it engages learners unlike the traditional approach of delivering the content that the teachers used when phase one was implemented.

For the workshop, we decided to invite the other co-researchers so that they would share their skills with the whole research team. The GIS lecturers' contribution to the workshop was sharing GIS content with us. Also, he demonstrated how GIS software works – introducing the practical component of GIS. The education lecturer shared some of the research findings with regards to the teaching of GIS in South African secondary schools and internationally, from there we learnt that other contexts are also struggling with implementing GIS. The student teacher co-researchers' role was to facilitate a discussion about teaching using the IBL approach. After the workshop, we had a reflective session whereby the co-researchers and I evaluated the workshop using focus group discussions. From these discussions, teachers and the student teachers indicated that they were ready to incorporate the IBL approach into teaching GIS. Also, learners were looking forward to the change in the delivery of lessons. Therefore, the next step was to plan GIS lessons that would be taught using the IBL approach. Another meeting was arranged for this.

The lesson planning meetings took place at the school during break times. What worked well during this process was that the student teachers were still at the school. So, I did not have to worry about transport logistics. During the process, decisions were made on which content was to be taught and which resources would be appropriate to make the lesson engaging as IBL requires learners to be involved during lesson delivery. We started planning two lessons initially because we knew that after teaching the lesson we would have to reflect and use the feedback from the session to plan subsequent lessons. As we reflected on the planning process the co-researchers seemed excited about this intervention and we were all looking forward to seeing how teaching the two lessons would unfold. The following step was to teach the planned lessons.

Phase Three: Acting and observing

Acting is understood as the actual delivery of the GIS lessons which incorporate IBL. The lessons lasted for an hour on average. The teachers and student teachers were involved in teaching the lessons and while others were teaching, others would be observing the lessons. Thereafter, when the lesson had been concluded the teachers and student teachers would have a meeting where they would discuss what they think went well during the lessons and what they think needs to improve. It was not easy to include learners in these meetings because they have a different schedule compared to teachers, for example, teachers sometimes have ‘free-periods’ on their timetables while the learners' timetables are full for a day. Thus, an alternative method of reflection was necessary. Therefore, reflective journals were introduced as one of the data generation methods for this study.

Phase Four: Reflecting

Reflective journals are a significant qualitative data generation method and they help the researcher to access rich qualitative data (Hayman, Wilkes, & Jackson, 2012; Janesick, 1998). A reflective journal is a tool where [co-researchers] of a study record in a form of writing, experiences, ideas, thoughts and feelings, as well as reflections that they have about the teaching of a specific topic (Hong, 2015). This implies that writing a reflective journal required the learner co-researchers to think deeply and to synthesise the content

that they are taught, for instance, the GIS content which was the focus of this study. The reflective journals were suitable in eliciting learners' experiences of being taught GIS, as they were expected to keep a journal for the duration of the GIS teaching, in which they reflected on how they were taught GIS in a rural learning ecology and their experiences of being involved in a PAR study. Insights gained from the learner co-researchers journal entries were useful in exploring the use of an IBL approach for teaching GIS in a rural learning ecology.

When I initially presented the idea of reflective journals as a data generation method, I became aware that the learner co-researchers were not familiar with the procedure of writing reflective journals. Hence, I needed to induct the learner co-researchers into journal writing through and I considered that the best way to do this was through a focus group discussion with the learner co-researchers. So, I arranged a meeting with the learner co-researchers during break time. In preparing for the focus group discussions, I learnt that reflective journals can either be structured or unstructured. Structured journals were more suitable for the aim of this study because the learner co-researchers had not been exposed to journaling before engaging in this research. Okeke (2017) stipulates that journals can be structured in such a way that items can be listed for the research participant to indicate how each of the items impacts on his or her own life. Thus, a journaling schedule (see appendix J) was provided to learners to help structure their reflections about the teaching of GIS in a rural learning ecology.

During the meeting, we had a conversation about what a reflective journal is and we also discussed the purpose of journaling, more particularly for the purpose of this study, as they were expected to reflect on the teaching of GIS and being involved in a PAR study. While engaging the learner co-researchers on reflective journaling they raised confidentiality issues. They were worried about their teachers having access to what they had written in their journals. I then explained to them that I was the only one who would have access to their journal entries as I would require their reflections to understand the impact of teaching GIS using the IBL approach on them and also for them to suggest the changes that they wished to see in subsequent lessons. I also explained that their journal entries would be used for the purpose of presenting the findings of the study. I assured

them there was no way that the teacher co-researchers would be able to pinpoint who said what in the journal entry as their identities would be protected by the usage of pseudonyms when the findings were presented. I also explained that they would have access to the material when the analysis was done so that they could verify if their perspectives and meanings were captured correctly or not.

Upon reaching a consensus on the confidentiality issues, the learner co-researchers were each given an exercise book to write in and I asked them to make entries of their experiences and thoughts related to the teaching of GIS on a regular basis. This was because Janesick (1998) states that it is important to make regular entries in the journal. The learner co-researchers were expected to keep the journal for a period of not less than seven months returning them two days after a lesson had been taught, this allowed me to interact with their views on the previous lesson before we planned another lesson. The learner voices were necessary throughout the study as the aim was to change the way that GIS was taught. Journaling allowed the learner co-researchers to express themselves freely as they could write their journal entries at their leisure even when I was not in contact with them, thus they were free to express what their thoughts about the teaching of GIS and about the PAR research process as a whole. I also arranged focus group discussions to engage with learners face-to-face in order to probe their journal entries. During these focus group discussions, I found that the learner co-researchers were getting attached to their journals, as a result, when the data generation period ended, I took the exercise books from them to make copies of the journal entries. Thereafter, I returned their exercise books to them and I saw that they were quite excited to have them back.

The reflective journals allowed the learner co-researchers to express themselves freely as they could write the journal entries at their leisure even when I am not in contact with them (as mentioned earlier), so it was a safe space for them to freely express themselves about what they thought and felt about the teaching of GIS as well as about the PAR process. Dwyer, Piquette, Buckle, and McCaslin (2013) and Toros and Medar (2015) argue that data obtained from journals provides significant insights that would not be attainable from using other data generation methods. Other scholars such as Mshelia et

al., (2016) have done research using action research and they refer to a journal as a diary as they argue that it is fundamentally for the co-researchers to take ownership of the diary since they are responsible for filling it in and that the purpose of keeping a diary must be clearly understood by the researcher and co-researchers which is why I had a meeting with the learner co-researchers to clarify the intention of keeping a reflective journal and to explain how journal entries can be made as well as to address the issues of confidentiality.

Three lessons which incorporated IBL were taught to both grade ten and eleven. We identified gaps from teaching the first lessons and incorporated feedback from the reflective sessions and journals in planning the second lessons. Thereafter, we deliberated to reflect on the second lessons also using feedback from the journals to improve the third lesson. Once more in planning this lesson, we incorporated feedback from the reflective session and the reflective journals. The reason why we taught and observed six lessons altogether is that GIS content is limited in the CAPS document compared to other Geography topics. So, we covered everything that is prescribed in grade ten and eleven curricula. Also, the teachers had already taught several concepts previously, the GIS lessons which incorporate IBL lessons were more focused on providing practical GIS experience to learners to help them apply the concepts. Kemmis et al., (2014) caution that following the PAR cycle is not a linear process of planning, implementing and observing because at times the process overlaps as the intended plan may have to be modified given the experiences which are encountered during the initial implementation of the plan. The following section presents how the data generated from the study was analysed.

4.9 DATA ANALYSIS

Data analysis is regarded as one of the most important parts of the research process as it is concerned with the examination of data in order to answer the research questions, Qualitative data analysis refers to the analysis of textual, visual or audiotaped data (Mihas, 2019). Furthermore, careful analysis of data brings about a solution to a problem that was identified at the initial stages of the research process (proposal development).

Data analysis ensures that the raw data generated during the course of the study is interpreted to determine patterns and relationships (Belotto, 2018). Therefore, a researcher must ensure that they choose an appropriate data analysis method which would help him or her to make sense of the generated data. In this study, I used thematic analysis to analyse data.

Thematic analysis is a procedure for identifying themes in qualitative research. Braun and Clarke (2006, p. 78) argue that qualitative researchers should learn thematic analysis because "… it provides core skills that will be useful for conducting many other kinds of analysis". This implies that thematic analysis is foundational because other data analysis methods flow from it. The history of thematic analysis is unclear and there are many ways of performing thematic data analysis (Javadi & Zaera, 2016). Vaismoradi, Turunen and Bondas (2013) opine that thematic analysis provides a purely qualitative, detailed, and nuanced account of data. Braun and Clarke (2006) discuss two types of thematic analysis: theoretical thematic analysis and an inducive thematic analysis. The authors state that theoretical thematic analysis is deductive (top-down) in the sense that specific research questions drive it. In contrast, inducive thematic analysis is bottom-up as it is driven by data. I applied theoretical thematic analysis in this study because I looked for data responding to the study's research questions rather than letting data speak for itself. They were five research questions that the study addressed.

I followed Braun and Clarke (2006) six step framework to analyse data. Firstly, I familiarised myself with data by transcribing the data verbatim. After that, I read and reread the transcripts while making notes and jotting down thoughts that came while I was reading. Secondly, I generated initial codes. A code is "a word or a short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data (Saldana, 2015, p. 3). As a result, I could reduce lots of data into words and short phrases. Since the analysis aimed to address the research questions, I kept the research questions in mind as I analysed the data. I coded data relevant to the research questions – this was not a straightforward process. I had to go back and forth in creating and modifying the codes. I coded each transcript separately

on Microsoft word and used the text highlighter colour button to highlight the text in different colours. At the end of this step, I created the initial codes.

Thirdly, I searched for themes by carefully studying the codes and realised that some of the codes were similar and they overlapped, so I turned them into themes. According to Braun and Clarke (2019, p.2) a theme "captures a common, recurring pattern across a dataset, organised around a central organising concept". This definition of the theme suggests that themes are recurring concepts that describe similar experiences or views of the participants. At the end of this stage, I turned the codes into themes that addressed the research questions.

Fourthly, I reviewed and revised the themes I identified in the previous step to see if they were understandable. I gathered all the data relevant to the theme to establish if the data aligned with the theme. I made revisions in cases where the data did not align with the theme. Fifthly, I defined themes as per the requirements of this step. I had to think more profound about the theme and the data available to support it. This was where I further refined the themes to the point that I decided to include sub-themes. Lastly, I did the write-up of the analysis.

4.10 TRUSTWORTHINESS

In an attempt to understand what trustworthiness is, I read what different authors have written about this concept and I learnt that trustworthiness is established when the findings of the study are able to capture the perspectives and meanings described in this instance by the [co-researchers] (Lincoln & Guba, 1985). This means that in order to establish the trustworthiness the researcher must ensure that he/she captures the co-researchers' views as accurately as possible. I also learnt that many critiques of qualitative research refuse to accept the trustworthiness of qualitative research (Shenton, 2004). However, there is a general consensus that it is important for every qualitative study to display the steps that the researcher followed to ensure the trustworthiness of the findings of his/her study. In order to ensure the trustworthiness of this study, I used the four constructs of trustworthiness; credibility, transferability, dependability and confirmability (Forero et al., 2018; Houghton, Casey, Shaw, & Murphy, 2013; Lincoln &

Guba, 1985). In the section below, I discuss what each of the latter concepts mean and how I applied them in this study.

Credibility

Credibility refers to the authenticity of the research findings (Lincoln & Guba, 1985). In other words, do the findings reflect the [co-researchers'] reality (Guba & Lincoln, 1994). This implies that the researcher has to ensure that the co-researchers' perspectives and meanings (findings) have to be interpreted and represented accurately. In order to maintain credibility in this study, I firstly, made use of member checking (Creswell, 2014), whereby after transcribing, I took the themes that emerged back to the co-researchers in order to establish if the themes captured their perspectives and meanings regarding the teaching and learning of GIS in a rural learning ecology accurately or not. This was done via a follow-up conversation with the co-researchers where they were given a platform to comment on the presentation of findings. Lincoln and Guba (1985, p. 314) state that member checking is "the most crucial technique for establishing credibility." Therefore, member checking was in line with the PAR methodology that was used in this study as it advocates for the involvement of the co-researchers throughout the research process. Member checking involves the co-researchers in the study as they review the findings presented by the researcher. Member checking also prolongs the time that the researcher spends in the field.

The second strategy that I used to maintain the credibility of the study was to spend a pro-longed period of time in the field (Creswell, 2014). When the ethical clearance application was approved, I visited the co-researchers at different sites where they were located with the aim of spending some time with them, getting to know them and building relationships and trust before the data generation process began. This was done because researchers are encouraged to spend a prolonged time in the field to increase the credibility of their findings (Creswell & Creswell, 2018; Creswell & Miller, 2000). The authors further state that "in practice, prolonged engagement in the field has no set duration" (Creswell & Miller, 2000, p. 128). But, in this study this was done in order to establish a close, harmonious and reciprocal relationship (rapport) with the co-

researchers in order for us to carry out an action (the teaching of GIS using the IBL framework) which included observation and reflection. This is because the PAR methodology prioritises action. I spent seven months in the field and this resulted in developing a greater understanding of the co-researchers' context. By the time I left we were able to communicate well with the co-researchers and an on-going relationship had been established. The triangulation of the data generation methods that I used enabled the prolonged engagement with the co-researchers.

Triangulation is understood as "a validity procedure where researchers search for convergence amongst multiple and different sources of information to form themes or categories in a study" (Creswell & Miller, 2000, p. 126). In this study, I made use of three methods of generating data; conversations, participant observation and reflective journals, in order to triangulate data (Creswell, 2014) with an aim of generation common themes during the data analysis process. Also, triangulation was used in this study with an aim of compensating for the individual limits of each data generation method and to maximise each method's benefits (Holtzhausen, 2001) as well as to provide corroboration that was generated from different co-researchers as they all had an interest in the teaching and learning of GIS in a rural learning ecology. Hever, it is important to state once more that this was done with aim of developing themes during data analysis and not for the purposes of reducing bias and cross-examining what the co-researchers had said with an aim of disapproving their perspectives and meanings as some authors (Anney, 2014; Oliver-Hoyo & Allen, 2006) have put forward as some of the aims of triangulation.

Transferability

Transferability is defined as "the degree to which the findings of this research can apply or be transferred beyond the boundaries of the thesis" (Guba & Lincoln, 1994, p. 57). In other words, can the findings of this study be applied or transferred to other settings or groups. This is not applicable to this study as it does not intend to generalise findings. Lincoln and Guba (1985) maintain that in qualitative research it is not possible to predict how data generated from one study is applicable to other contexts since collective knowing is unique to a certain context in which the problem exists. Sandelowski (1986)

asserts that the context in which qualitative data is generated and analysed is specific to the purpose of study, as a result, the generalisation of the data generated is limited. Barnes et al., (2012, p. 25) caution that the generated data from a qualitative study cannot always be transferred since what is prominent in one context will not necessarily occur in a similar situation. I concur with the latter because people are different and there are various paradigms that influence their actions thus data generated from this study should not be generalised.

Dependability

Dependability refers to making the research design of the study explicit in order to enable the reader to understand the research procedures that were followed but not necessarily to enable them to produce the same results (Shenton, 2004) because, as stated previously in the transferability section, the study did not aim to generalise findings. In order to ensure the dependability of the study, the research design including the data analysis procedures was explained thoroughly in order to enable the reader to understand the research processes that were followed when the study was conducted. In other words, the thick description (Lincoln & Guba, 1985) of the research design was provided to provide an outline of the research procedures. An audit trail was conducted where the purpose of the study was discussed, the procedure for the selection co-researchers was explained and a description of how data was generated and analysed was provided (See sections 4.7, 4.8 and 4.9 of this chapter).

According to Bergold and Thomas (2012), these are the steps that one should follow in order to ensure dependability when conducting research. Moreover, Shenton (2004) states that in order to improve the dependability of the study, researchers must provide operational documents that provide details of what was done in the field during the data generation process. This study was conducted using the PAR methodology, which prioritises action to change the situation. As a result, data were generated through conversations, observation and reflective journals. When the analysis of data was done, we arranged a session with the co-researchers in order to check whether the analysis

captured their perspectives and meanings correctly, this was done to maintain the dependability of the study.

Confirmability

Confirmability is defined as the ability of the researcher to demonstrate that the analysed data represents the co-researchers' perspectives and meanings, not the researcher's perspectives (Lincoln & Guba, 1985; Polit & Beck, 2008). To ensure confirmability, focus group discussions and conversations were recorded using a tape recorder and then transcribed verbatim. Thereafter, a data audit was conducted whereby we cross-checked the transcriptions listening to the recording to ensure that the responses had been documented correctly. Thereafter, I had a conversation with the co-researchers where I asked them if their perspectives and meanings had been captured correctly (Creswell, 2014). During these conversations the co-researchers were expected to comment on the accuracy of the verbatim quotations and the co-researchers confirmed that their perspectives and meanings were captured accurately. Some researchers have highlighted the issue of researcher biases affecting the research study and caution against it.

Thomas and Magilvy (2011) state that to minimise biases the researcher has to write field notes immediately after each observation session and also audiotape the sessions so that his/her pre-conceptions do not affect research. Even though biases and subjectivity are unavoidable in qualitative research, during the data generation process we wrote field notes and all the conversations were tape recorded and transcribed verbatim to ensure that the co-researchers' perspectives and meanings were captured properly. Hennink, Hutter and Bailey (2020) state that to better describe people's lives, the researcher has to become immersed in their context as this allows him or her to observe and understand their everyday activities. Spending plenty of time in the field allowed me to understand the co-researchers better. As a result, I was in a better position to report on their perspectives and meanings. Moreover, some of the co-researchers were involved in lesson observations, as a result, they formed part of the data generation process. Thus, the findings of the study can be said to be confirmable. Also, generating data through

Journals allowed for the provision of thick descriptions of what the co-researchers wrote as evidence. This also helped to maintain confirmability of the study.

4.11 ETHICAL CONSIDERATIONS

This research study involved working collaboratively with people. As a result, I was concerned about doing good and preventing harm throughout the research process to bring about change in the teaching of GIS in a rural learning ecology. Gove et al., (2017, p. 724) argue that "researchers have a legal and moral obligation to protect not only participants, but everyone involved in the research process from harm." During this study, we developed a rapport with the co-researchers and as a result, there was a free flow of communication between the various stakeholders and this was done in order to avoid harm and to bring about change as this was a PAR study. Moreover, Bergold and Thomas (2012) believe that participatory researchers should address ethical questions mostly because of the close relationship with the research partners. Therefore, ethical rules and norms should apply throughout the research process. The rules and the norms that were applied in this study are the ones that are prescribed by the University of KwaZulu-Natal's Humanities and Social Sciences Research Ethics Committee (HSSREC). I was made aware of this committee during the proposal development stage. The proposal form had questions on ethical considerations and when I presented the proposal to a panel of academics and ethical issues formed part of the presentation. As a result, we engaged on ethical issues.

The HSSREC committee prescribes that before the research is conducted, one needs to obtain gatekeeper permission to gain entry to the field. In the case of this research which consisted of various stakeholders, I had to obtain permission from the Department of Basic Education (DBE) as they govern the school as well as the district office where some of the co-researchers for the study are based. The DBE has a prescribed form that I had to fill out to request permission to conduct the study at the school and to seek permission to engage with the Geography subject advisor. The form was then signed by my supervisor and myself and submitted to the DBE offices in Pietermaritzburg. After a couple of weeks permission was granted by them via e-mail (see Appendix B).

While waiting for the DBE to respond, I filled out another form to request the Registrar of the University of KwaZulu-Natal for permission to conduct the study at the University because some of the co-researchers (lectures and students) were based here. I then emailed the form. Once more, the Registrar granted permission after a few weeks via e-mail. Upon the receipt of the approval letters, I filled in another form to the University's ethics committee to obtain ethics approval for the study to be conducted. The approval was granted after a couple of months. Both the DBE and HSSREC requested me to clarify how I would protect the co-researchers in this study. In these applications I stated that I would obtain informed consent from the participants and ensure their confidentiality by using pseudonyms when writing up findings.

Sotuku and Duku (2017) state that one of the major ethical values and principles that researchers have to follow is obtaining informed consent. This involves negotiating with the identified participants in order to establish whether they wish to participate in the study or not and also informing them that they have a right to withdraw from the study at any time. Thus, when the ethical clearance was granted by the HSSREC (Appendix A), I had meetings with all the stakeholders explaining the purpose of the study and how the study was going to be conducted. Thereafter, I requested permission from the co-researchers for them to take part in the study. When they agreed, I issued an informed consent form for them to sign. Their signatures confirmed the discussions that we had pertaining to the study, especially the clause which speaks of their right to freely withdraw from the study at any time should a need arise and they would not be required to state a reason for doing so.

Upon acquiring informed consent from the co-researchers, I explained to them that they could not be anonymous to myself and the other co-researchers because we were expected to interact throughout the research process given the nature of PAR but that they would be anonymous in the reporting of findings in the thesis through the usage of pseudonyms. Furthermore, I pursued ongoing consent as a norm throughout the duration of the research project. I asked continuously before classroom observations if they were comfortable with their lessons being observed and during conversations, I asked if I could audiotape the conversation. When data was transcribed member checking took place,

where the co-researchers were given copies of the transcriptions to check whether their ideas and recommendations had been interpreted correctly (Gordon, 2019). In conclusion, throughout the research process, I was aware of the need to treat the co-researchers with respect and not to assume the role of being an expert in the study.

4.12 LIMITATIONS OF THE STUDY

Regarding the limitations of this study, firstly, I observed that in the initial phase of the study, the co-researchers were sometimes consumed by other commitments, resulting in difficulties honouring the demand for follow-up meetings and workshops as this study adopted the PAR methodology. We mitigated this limitation by negotiating meeting dates timeously, sending reminders closer to the meeting dates. Furthermore, we ensured that during meetings we would summarise critical points, identify action items, and assign tasks in each session. As a result, the co-researchers' inputs were heard and they managed to follow through on the action items.

Finally, the group of 17 co-researchers that participated in this study may represent only a relatively small subgroup of the Geography community in KwaZulu-Natal. However, it should be noted that given the nature of this study's design (PAR), it allows for a small sample as it requires prolonged engagement and the development of trust and rapport amongst the co-researchers. Therefore, the findings and conclusions of this study are localised which implies that a replication of this study with different co-researchers may yield different findings.

4.13 SYNTHESIS

In this chapter, I first reminded the reader about the objectives of the study and the main research question. This was necessary as the aim of any research study is to address

the questions that have been posed in the study. Thereafter, I presented the classical discourse on research paradigms. Where I learnt that in the history of research there have been dominant paradigms that were used to conduct research and they were from the natural sciences. Researchers from the dominant paradigms often took the objective approach when conducting research and their intention was to generalise findings because they believed in a single truth. Over the years, the dominant paradigms were met with criticism from social sciences researchers who showed that the dominant paradigms were not adequate to study humans as human activities are driven by different psychological, sociological, cultural and economic factors. Given the philosophical assumptions and the methodologies that are followed in the natural sciences, it became apparent that their tools fell short of addressing social problems. From there onwards there was a rise of paradigms that are concerned about studying humans specifically. Different scholars came up with various paradigms that they deemed suitable for education research and amongst them was the transformative paradigm, which frames this study.

While reviewing literature on research paradigms, I learnt that the transformative paradigm is unique in the sense that it transforms the relationship between the researcher and the co-researchers. It has a social justice agenda, in the sense that it allows the co-researchers to be actively involved in the study. As they understand themselves and their context better than anyone else, they are in a better position to address whichever problem that they might be experiencing. This is in line with Critical Emancipatory Research, the theory which frames this study as it advocates for the emancipation of the co-researchers. The focus of this of this study was exploring the use of an IBL framework for teaching GIS in a rural learning ecology, therefore, the co-researchers participated in this study because they were all affected by the teaching of GIS.

After the discussion on paradigms, I presented the research design and the methodology that was utilised in this study. Which is qualitative research and Participatory Action Research. I learnt that qualitative research allows the researcher to gain an understanding of the co-researchers lived experiences and that is why it was suitable for this study. I then presented the origins of PAR as a methodology and it was suitable for

this study because it is concerned with participation, action and reflection. This is in alignment with the Critical emancipatory Research theory and the transformative paradigm because they are all concerned with taking action that is aimed at bringing about social change. I learnt that PAR consisted of various stages such as planning, acting, observing and reflecting and it is more about the process as it is empowering rather than the destination and that it is also time-consuming as implementing the stages and working collaboratively takes time.

After presenting the methodology, I explained the process of selecting the participants that participated as co-researchers in this study. They were selected on the basis that they were all affected by the teaching of GIS. Afterward, I presented the data generation procedures which are aligned with the PAR cycle and how the data generation methods were used in different phases of the research. I also highlighted CDA as a data analysis method, the issues of trustworthiness, ethical considerations that were observed in this study and the limitations of this study. I ended this chapter by presenting a synthesis of this chapter. In the following chapter, I present data that were generated in this study and I Interpreted this in relation to the secondary research questions and the literature that I have reviewed to achieve the aim of this study.

CHAPTER FIVE
DATA PRESENTATION, ANALYSIS AND INTERPRETATION

5.1 INTRODUCTION

In the previous chapter, I presented the research methodology that I adopted in this study. The study aimed to explore the use of an Inquiry-based framework for teaching GIS in a rural learning ecology. In this chapter, I present, analyse and interpret data to address the research questions of this study chronologically.

5.2 THE CURRENT SITUATION IN TEACHING GIS IN A RURAL LEARNING ECOLOGY

In the rural learning ecology where the study was conducted, there are severe challenges that negatively impact on the teaching of GIS in this context. The current situation in teaching GIS in the rural learning ecology is presented in this section under the following categories (1) formal GIS training, (2) adoption of traditional teaching approaches, (3) resources and (4) teacher attitude towards GIS.

5.2.1 Formal GIS training

The co-researchers revealed that GIS was an addition to the existing Geography curriculum. It also emerged from the conversations that the introduction of GIS required extensive formal training to ensure that teachers had a good grasp of GIS content and pedagogical knowledge. When the subject advisor was reflecting on his GIS training, he stated that GIS was introduced when he was already employed by the Department of Education as a Geography teacher. The training that he was exposed to took place in the form of a professional development workshop that he feels was not adequate. This can be deduced from the following comment:

> *GIS is tough to me. My perception is that it was wrongly introduced at the workshop that we had back in 2006 when I was still a secondary school teacher. The workshop created the impression that we had to have computers in order to teach GIS, while at my school there were no computers. This was the only training that I attended on GIS* (Andile)

Like the subject advisor, the teacher co-researchers that participated in this study were not exposed to formal GIS training. This can be seen in the following extracts:

> *I do not remember being taught GIS during my postgraduate certificate in education training* (Amahle)

> *I was not taught GIS at secondary school because back then it did not form part of the curriculum. I was also not taught GIS at higher education. What I can recall is GIS being mentioned in passing as a concept in a Geography lecture. I then consulted my cousin about GIS when I started teaching and he seemed confused while he was taught GIS at secondary school. What I know about GIS is what I have taught myself and I derive an understanding of GIS from a textbook* (Esethu)

This view of not being taught GIS during initial teacher training was further confirmed by the student teacher co-researcher who stated:

> *I am not very comfortable teaching GIS because I have insufficient knowledge of it. At university, we have never learnt about GIS before making it a topic which one still needs to familiarise themselves with. I am hoping to learn more about GIS during teaching practice* (Nkululeko)

The excerpts above reveal that there was a lack of formal GIS training for all parties. For instance, the teachers and student teachers indicated that they have come across GIS during their initial teacher training. As a result, when the teacher co-researchers graduated from university, they expected that they would receive GIS training during professional development workshops that are hosted by the subject advisor. However, this has not been the case. Amahle said:

> *We do have workshops, but I don't remember GIS being a part of the workshops. It is just mentioned that we must educate learners on the topic because they are tested in matric on the topic.*

On the other hand, Esethu made the following contribution:

> *There is a grey area between the subject advisor and the teachers. The subject advisor assumes that we as a young generation understand GIS. Because all the time when he conducts workshops answers are expected from the younger generation.*

As the conversation progressed, the subject advisor confirmed that he believes that the younger generation of teachers are more knowledgeable about GIS and this can be seen in the following excerpt:

> *The new generation like yourself should have been taught GIS at university. I have seen that young educators like [Esethu] are bright, I assumed that they were taught at universities that is why they know GIS* (Andile)

In terms of teacher training, the extracts above show that the subject advisor, teachers and student teacher co-researchers that participated in this study were not formally trained to teach GIS. Instead, the subject advisor attended a workshop where he was not taught about alternatives to teaching GIS when a school does not have computers. As a result, he expressed the view that GIS is tough. Moreover, the subject advisor expects geography teachers to be well-versed with the teaching of GIS. The opposite is true. Teachers indicated that they have not been trained in GIS. This may be true for teachers who either qualified before GIS was introduced into schools or were not taught GIS in their initial teacher training as it was not part of their curriculum. Therefore, there is a general lack of GIS training for teachers. The section below is dedicated to the teaching approaches that are used for teaching GIS in a rural learning ecology.

5.2.2 Use of traditional teaching approaches

Given the lack of formal GIS training and lack of professional development in GIS that I have alluded to in previous sections (for instance, see sections 1.2, 1.4 and 5.2.1). One of the teacher co-researchers expressed the following as we were discussing the approaches that he uses to teach GIS:

> *It is strenuous for a teacher not to understand content, this is counterproductive to the learning experience and sometimes causes teachers not to attend classes and GIS is one of the problematic contents* (Esethu)

The above account made by Esethu shows that at times, the teacher co-researchers resort to not going to class because of their lack of understanding of GIS content. In this regard, none of the teaching approaches are used because the teacher skips class.

As the conversation progressed, the teacher co-researchers explained that if they decide to go to class to teach GIS, they use traditional teaching approaches to teach because they do not have a thorough understanding of GIS and as a result, they do not teach GIS thoroughly. This can be seen in the following extracts:

> *When teaching GIS, eish [laughing], when teaching GIS, I do a rush job [laughing]. I just read from the textbook. I don't teach it thoroughly at all because it is tricky sometimes where I do not understand it, but at least I was teaching grade 10 so there was no application of GIS. At times during a GIS lesson, learners ask difficult questions that I cannot answer. I use storytelling to teach GIS* (Amahle)

> *I just teach the basic GIS concepts from previous question papers, using the lecture-based approach. That is how quick I move. I do not teach GIS for understanding; I teach for assessment. I just want learners to master concepts so that they may pass the examination. When teaching GIS, I do not feel like I'm teaching because I do not understand the content fully* (Esethu)

Surprisingly, some of the learner co-researchers have been observing the actions of Amahle and Esethu when teaching GIS. The learner co-searchers reflected on their experiences of being taught GIS in their journal entries:

> *We do not always have GIS lessons. What we do not like about GIS lessons is that we do not get to enjoy the lesson because we do not get enough lessons on GIS, but we always find it in the exams and that confuses us and make us panic in such a way that in the [examination] paper we do not know what to write since we have two to four GIS lessons in a year* (Lethu)

> *When the examinations are near the teachers rush us and we don't even get the chance to understand GIS fully even when we try to teach by ourselves. Nothing gets on the mind because the lessons were rushed* (Samkelo)

The journal entries show that GIS lessons are scarce in the rural learning ecology where the study was conducted. The teacher co-researchers have alluded to this earlier on. Unfortunately, the buck stops will the learner co-researchers as they are expected to respond to GIS questions during an examination. Thereafter, the learner scripts are taken to the subject advisor for moderation. The following excerpt provides the subject advisor's account of the current situation in teaching GIS in a rural learning ecology:

> *Learners are just defining concepts without applying them. For example, learners can define what is a raster and a vector model, but when you say go to block E7 identify anything that you think is a raster, I think this is where the problem is. They*

are unable to respond to such questions, although they can see what the features on the map are. This makes me say that grade 10 teachers do not teach layering thoroughly. Learners are not coping; the rural districts perform very poorly (Andile)

In the above extracts, the teacher co-researchers point out that they use storytelling and lecture-based teaching approaches to teach GIS concepts. These strategies have been effective to enable learners to understand concepts. However, the needs of the policy are not addressed adequately because the learner co-researchers indicated that they struggle to respond to all the GIS examination questions. The subject advisor co-researcher confirmed this by saying that learners are unable to apply concepts, and this negatively affects their performance in GIS. This suggests a need of adopting a different approach to teaching GIS. Lack of resources is a further challenge in teaching GIS in the rural learning ecology where this study was conducted.

5.2.3 Resources

While engaging the teacher co-researchers on the teaching approaches they use to teach GIS, they cited a lack of resources as one of the reasons for adopting the traditional teaching resources. For instance, Amahle stated: *I use storytelling to teach GIS to learners because we have no computers in the school to demonstrate what I am teaching about*. The unavailability of computers in the school was a general concern amongst the co-researchers. This is evident in the following excerpts:

It would have been better if we had laptops to learn GIS using them. Otherwise, we will not pass Geography as we wish to (Sipho)

This an under-resourced school because the school does not have electronic learning resources like computers. Geography teachers literally have no resources for teaching. Justice has not been done in providing schools with the necessary resources for teaching GIS (Bheki)

When it comes to resources, this school is under-resourced because the only teaching resources that were ever used was the basic textbook and the chalkboard. The school has no overhead projectors, data projector, no computers etc (Lwandle)

The excerpts above show that the co-researchers that participated in this study consider computers, overhead projectors and data projectors as essential resources for teaching

GIS. The learner co-researchers further highlighted that had the school provided laptops for learning GIS their performance would have improved. In addition to the unavailability of computers in the school, Esethu in the excerpt below reveals that there is also a shortage of maps in his school. This explains why Andile is saying that learners can define GIS concepts, but they are unable to apply them to maps:

> *Maps are a problem for our learners, they do not practice mapwork as much as we would like them to because we have very few maps. The school does supply enough maps for all the learners. Then when the school term comes to an end, we have no choice but to borrow maps from other schools that offer Geography and adjust the prescribed exam times so that learners could write the end the term tests and examinations. This is a common issue in many schools that offer Geography because the Department of Basic Education does not provide an adequate budget for schools to purchase enough resources for teaching Geography* (Esethu)

Whilst still on the issue of the shortage of maps and its impact on the application of GIS concepts, one of the student teacher co-researchers, Nkululeko added:

> *the school does not have enough maps to allow learners to experiment with the application of GIS concepts onto maps*

The above excerpts show that the shortage of maps impacts the teaching of GIS in the rural areas negatively because learners do not apply GIS onto maps just like Andile pointed out. Esethu also claimed that learners fail to apply GIS concepts onto the map because he does not allow them to do so during teaching time. After all, they do not have enough maps in his school. Nkululeko also confirmed that there is a shortage of maps at Esethu's school as he spent quite plenty of time at the school during teaching practice.

5.2.4 Teacher attitude towards GIS

The teacher co-researchers that participated in this study confessed that they have a negative attitude towards GIS due to several reasons such as limited marks assigned to GIS content in the examinations as well as not having adequate GIS content knowledge and the fact that it was added later onto an existing Geography curriculum. This can be seen in the extracts below:

> *I have a negative attitude towards GIS because it has limited marks assigned to it in the examinations. I believe that the majority of us as educators do not worry so much about GIS so we focus on the mapwork content and ignore GIS as learners can pass without it* (Esethu)

> *I do not have confidence when I am teaching GIS because I do not have sufficient knowledge of GIS. Confidence is boosted by sufficient knowledge that I do not have* (Amahle)

Andile agrees with the teacher co-researchers with regard to them having a negative attitude towards GIS. Because as he was carrying out his moderation duties for the KwaZulu-Natal province, he observed that the teaching of GIS was a serious challenge in secondary schools. He indicated that he believes that the reason for GIS being a challenge is teacher attitude. This can be observed in the excerpts below:

> *On the side of marking, results show that the teaching of GIS is a serious challenge in KwaZulu-Natal high schools. Fortunately, I moderate the whole province. That is where I realise that GIS is a serious challenge for teachers. I think that the main problem is the teachers' attitude, GIS is not that difficult, it's just that it was introduced at a later stage and I think I must assist teachers more. Teacher attitude is a problem, if we change the teachers' attitude GIS is not so bad* (Andile)

Andile further added that:

> *GIS was introduced to us when we were older, it is better for you because you are younger, we were older and had a negative attitude, so we did not want to change.*

The above extracts reveal that the co-researchers have diverse views on the teaching of GIS which has given rise to the negative attitude that they have adopted towards teaching GIS. The negative teacher attitude towards GIS was influenced by the marks allocated to GIS in the examinations – which gives rise to teachers having low expectations about their learners mastering GIS as well as not having sufficient GIS content knowledge and resisting curriculum change. In addition to these circumstances, the co-researchers reported that the rural learning ecology experienced frequent water cuts.

Concerning these water cuts, Bheki and Esethu also raised this issue when they reflected on the teaching of GIS in a rural learning ecology during a focus group discussion. This clearly showed that the co-researchers were concerned about the teaching time that was lost because of the water cuts. Bheki remarked:

> *There were also frequent water cuts during my time there which affected teaching and learning time because everyone would be sent home when there was no water. I did not like this because it delayed me to finish the content that I was told to teach during the time I was there for teaching practice*

And Esethu added:

> *Mostly I come in during weekends to teach some of the content because we lose a great deal of time when we are sent home because of the water cuts. That is very common in this area. On the weekends that I come in to teach I mainly focus on the content that has more marks in the examination.*

The water cuts resulted in limited teaching and learning time. This occurrence is a typical example of what causes disturbances in the process of teaching GIS in a rural learning ecology that is outside the teachers' control – and as it is a health hazard both learners and teachers are asked to leave the school. This results in a delay in the teaching plan as Bheki and Esethu have indicated above. To make up for some of the lost teaching time Esethu comes in on weekends and focuses on the Geography content that is assigned more marks in the examination.

To sum up, the above section on the current situation of teaching GIS in a rural learning ecology where the study was conducted revealed that the teaching of GIS in this context is not optimal. This is due to the lack of formal GIS training, the persistent use of traditional teaching approaches, the lack of resources as well as teacher attitude towards GIS. The latter shows that the challenges of teaching GIS in this context are multifaceted in the sense they are both school-based and external to the school.

5.3 THE NEED FOR THE INQUIRY-BASED LEARNING FRAMEWORK FOR TEACHING GEOGRAPHIC INFORMATION SYSTEMS IN A RURAL LEARNING ECOLOGY

This section unpacks the need for an Inquiry-Based learning framework for teaching Geographic Information Systems in a rural learning ecology. Establishing the need for the IBL framework for teaching GIS in a rural learning ecology called for an information-sharing session with all the co-researchers. This information sharing session took the form of a workshop, whereby all the co-researchers engaged in an extensive discussion

on understanding Geography as a discipline and viewing GIS as a sub-field of Geography. GIS in the secondary school curriculum was also discussed, as well as the teaching approaches used to teach GIS in this context. We ended the discussion by zooming onto the IBL approach and its elements to explore its applicability for teaching GIS in this context.

Unpacking the concept 'Geography' and its aim was key to enable the discussion on the appropriate teaching approach that would develop skills that are a prerequisite for Geography learners according to the Department of Basic Education's CAPS policy. Khulekani stated the following with regard to Geography and the envisioned GIS skills:

> *Understanding Geography is more than knowing facts. This means that learners should be taught for understanding. This understanding would help them to apply previously learnt knowledge to different situations, which enables them to solve problems. Geography explores human and environmental relationships. Meaning that as learners are taught GIS, they should be made aware that GIS is a system that can be used to represent space that surrounds them. Consequently, the teaching approaches that are used to teach GIS should promote inquisitiveness so that they can be concerned about analysing the space that surrounds them*

Khulekani believes then that Geography should be taught for understanding. This can develop learners' problem-solving skills. Additionally, GIS should be taught using approaches that promote inquisitiveness to engage learners. On the other hand, it was noted that the above view of the teaching of Geography and of envisioning GIS skills was opposed to how GIS was taught in the rural learning ecology. Esethu made the following comment after Khulekani made his contribution:

> *All this time I was teaching learning to memorise GIS concepts. I was teaching GIS from an imaginative perspective. This was hard to do because I was asking learners to imagine GIS and I was not able to provide the right guidance on how to do so as I was imagining how GIS works too. What I was dealing with my learners was a matter of imagination and this was the wrong approach as I had no clue on how GIS works in real life. In short, I was asking learners to imagine what I had imagined GIS to be*

Esethu's reacted to Khulekani's contribution by engaging in a deep reflection about teaching GIS. From the extract above we learn that Esethu was teaching learners to memorise concepts because he was not aware of how the GIS software operates in real

life as he has never used it before. So, in his teaching, the focus had been on learners defining concepts while the application of these concepts onto a map was neglected.

The learner-co-researchers concurred with Esethu by stating that:

> *What is happening right now is that the teachers just read from the textbook for the whole duration of the lesson, then we get bored. They then ask a few questions after reading stuff about GIS and we often do not respond to those questions because we would have stopped listening to the teachers a long time ago. We cannot imagine the uses of GIS because we have not seen it before* (Feziwe)

The above comment made by Feziwe clearly shows that some of the learner co-researchers are not satisfied with the teaching of GIS in this context. This is because they feel that they are not engaged during the lesson as teachers just read from the textbook and they are expected to listen. Feziwe also points out that it is difficult for them to try and make sense of how GIS works because they have never used and witnessed the usage of GIS before.

Sanele added:

> *It is necessary to have visuals for learners and something tangible for them to work with. It helps them to understand better. I now have a better understanding of some of the reasons why learners have not been performing well in GIS. They are unable to apply GIS concepts onto maps because it is presented in an abstract manner, thus, they are unable to picture how GIS works.*

From the excerpt above, Sanele states that one of the reasons why learners are not performing well in GIS is because of the way that it is taught. Whereby there are no visual stimuli to show learners the various components of GIS. He is suggesting that the use of visual stimuli when teaching GIS could enhance learners' understanding of GIS.

From the above deliberations with the various co-researchers, there is an acknowledgment that the teaching approaches used to teach GIS in the rural learning ecology were not producing the intended outcomes of developing learners' understanding of GIS. As a result, the co-researchers unanimously agreed that there had to be a change in the way that GIS was taught in the specific rural learning ecology where the study was

conducted. For instance, the subject advisor out of concern about the low performance in GIS in matric examinations expressed the view that:

> *For this project, I recommend we should offer GIS practicals, as learners cannot apply the concepts onto a map. They need to move from just defining concepts to application and analysis level in order to respond to the examination questions adequately* (Andile)

The above extract shows that Andile has been observing learners' inability to apply GIS concepts onto maps. He thus suggests that there is a need for a practical approach to teaching GIS so that learners can acquire application and analysis skills that are assessed during examinations. The proposal above made by the subject advisor expressed the need for an alternative teaching approach that would be used to help address some of the challenges that were mentioned by the co-researchers. The IBL approach was deemed appropriate by the co-researchers given its tenets; the teacher being a facilitator and learners participating in their learning. This can be seen in the commentary below:

> *Teaching using IBL means that teachers and learners become partners in the teaching and learning process. For an example when teaching GIS, it must not be the duty of the teacher only who is supposed to be an expert in terms of explaining the content which is covered during that lesson. As a learner you have to learn to improvise, search for materials and additional resources that might help you understand the content better. If you find that there is lack of resources, try to utilise other facilities in the school as well as out of the school. There are libraries within your reach. As well as charts that can help you understand the content better. So, let us not only put it to be the teacher's duty to provide all the information, but learners must also be active in seeking information that might help them* (Bheki)

In the above extract Bheki portrays his understanding of teaching from an IBL perspective. Bheki stresses that both teachers and learners should be actively involved in the process of learning. Bheki further supports his view by stating that it is not solely the teachers' responsibility to motivate learners to learn. However, learners must also play an active role in motivating themselves and taking responsibility for their learning.

They should seek additional resources that would enhance their understanding in and outside the school.

To conclude, in the information-sharing session, the co-researchers highlighted that the nature of Geography as a subject requires learners to understand the content and to apply it in different situations. This was not happening in the rural learning ecology where the study was conducted because learners were bored because they were only taught to memorise GIS concepts and to imagine how GIS works in a real-life situation. This teaching approach was not developing application skills in learners as envisioned by the policy, as a result, learners were unable to respond to application questions during examinations. This situation demonstrated a need for an alternative teaching approach for teaching GIS. The IBL approach was deemed suitable for teaching because it allows teachers and learners to be actively involved in knowledge creation. The section below explores the circumstances under which the IBL approach may be used to teach GIS in a rural learning ecology.

5.4 CIRCUMSTANCES UNDER WHICH AN INQUIRY-BASED LEARNING FRAMEWORK MAY BE USED TO TEACH GIS IN A RURAL LEARNING ECOLOGY

The GIS and IBL workshop that was hosted by the co-researchers and myself in the rural learning ecology was instrumental in driving change in the teaching of GIS in this context. This was because it brought together people with different knowledge, skills and experiences under one roof to deliberate on exploring the use of an IBL approach to teach GIS in this context. Given the various levels of expertise and skills that the co-researchers and I had, there were opportunities for learning for all the co-researchers that attended the workshop. The following section presents the circumstances under an IBL framework. The key circumstance is information-sharing and it provides opportunities for learning for all those that are involved.

5.4.1 Sharing expertise and lived experiences

One of the facilitators of the workshop was a GIS specialist. He demonstrated the use of the computer and the GIS app (ArcGIS) to all the co-researchers that were present on

that day. This enabled the co-researchers and myself to witness how the GIS software operates. While Khulekani was facilitating the discussion and demonstration of GIS, he covered some of the grade 10 and 11 GIS content prescribed by the CAPS policy. A transcription of what he presented reads as follows:

> *So, there are four components of GIS. Software, I will show you how the software we use works. A software is an application that you install on a device and you employ to do an analysis. For example, Facebook, WhatsApp, Microsoft office and windows are all software. Hardware would be the computer and other stuff such as your mouse and keyboard. Then we have people, people is me right now as I am teaching you/showing how GIS works. So, people might refer to any person who has GIS skills. When it comes to data, we have two types of data: spatial and attribute data* (Khulekani)

During the demonstration the co-researchers and I were free to stop the facilitator anytime to engage with what was happening as he stated:

> *As I proceed with the presentation please note that you can ask me questions at any time, please feel free to stop me. We have three ways of representing data on a map, we use lines, points and polygons. Points usually represent small features such as a town. Polygons represent features such as school and lines can represent features such as a river.*

The GIS specialist's presentation and demonstration were useful in the sense that they closed the gap between GIS theory and practice. As it covered GIS concepts that were taught in the rural learning ecology using textbooks and traditional teaching approaches. The demonstration was useful as it displayed how the concepts are put into practice and this made the GIS concepts tangible to the co-researchers and to me. We saw GIS come alive during the GIS specialist's presentation and demonstration. One of the learner co-researchers Sipho stated the following he reflected on the GIS specialist's presentation and demonstration:

> *All I can say is that thank you for bringing such a wonderful teacher [Khulekani]. As he was able to show us how the software works. In the past, we did not have such exposure and there is no way we could have understood what he showed us today had we not seen it. He also explained many things and answered if we had questions. I also felt free to ask him questions because he seems like he understands GIS fully. It was interesting to discover that GIS can provide data about the fertility of the soil, which enables a person to make informed decisions about what to plant and where* (Sipho)

One of the teacher co-researchers added:

> *Today I have learnt that there is so much in GIS, as we saw from [Khulekani's] demonstration today. He exposed us to a whole new world of GIS. We saw that the software has many functions and one must have computer skills to operate it* (Esethu)

The above quotations clearly show that the co-researchers were provided with some form of informal training in terms of developing the co-researchers' knowledge of GIS as the facilitator defined GIS, the components of GIS and demonstrated how the software works. He provided a practical experience of how the software functions. Feedback from the co-researchers was positive in this regard as they reported that they learnt many things during the presentation and demonstration as it spoke directly to the CAPS policy.

5.4.2 Exploring an alternative teaching approach

With regard to the persistent use of traditional teaching approaches to teach GIS in a rural learning ecology the co-researchers and I deliberated on this and the student teacher co-researchers proposed that the IBL approach would be suitable to teach GIS in this context as the traditional teaching approaches that were used were leading to poor learner performance in GIS. The student teacher co-researchers' advocacy for IBL can be seen in the following abstracts:

> *I am building on what [Andile] the subject advisor said. If you may recall he said, we need to 'practicalise' the way that GIS is taught and we supported this idea. I believe that one of the teaching approaches that can help us is Inquiry-Based Learning. The Inquiry-based learning approach has to do with providing room for learners to participate during a lesson. What are we saying? Let us break down the concept of Inquiry-Based learning – it is a teaching approach that provides room for active participation of learners. So, we are saying that in our teaching we must open up room for learners to share their experiences. Let us involve them more in learning because they experience Geography on a daily basis. Geography is not an isolated subject. It has to do with what is happening in learners' surroundings* (Bheki)

Andiswa made the following contribution to the IBL proposal:

> *I will not say much because [Bheki] has said everything, but I will just add on what he had said. So, I will focus on the role of a teacher and a learner in an IBL environment. Teaching using the IBL approach views the teacher as is a facilitator.*

> *A facilitator is someone who guides you as you perform a task. He or she is not just there to answer your questions. This means that the teacher is not the primary source of information, you as learners must display an interest in your education by researching the content that is prescribed by the CAPS policy*

While two of the learner co-researchers remarked:

> *From listening to what you have just said [Bheki and Nkululeko], I think that we can benefit from the Inquiry based learning approach. Because as learners we lack motivation. We do not like school because we are taught difficult things that we cannot understand. But if teachers can ask about our experiences it would be easy for us to answer questions during lessons* (Feziwe)

> *From what you have said about IBL, it seems like the IBL approach requires us as learners to be alert and focused. As you spoke of doing research. This means that we would be required to spend more time doing schoolwork* (Amanda)

And one of the teacher co-researchers said:

> *About the IBL approach, [Bheki and Andiswa] reminded us that we need to involve learners during the lessons. I must not just preach and preach all the time. But I must encourage learners to be active in the lesson and give them research activities* (Amahle)

The excerpts above show that the various co-researchers agreed that the IBL approach is suitable for teaching GIS in a rural learning ecology as it allows both teachers and learners to be involved in the learning process. Rather than the traditional approaches where the teacher is the primary source of information. The student co-researchers provided an outline of what teaching from an IBL approach entails and they alluded to the role of the teacher and learner in an IBL environment.

Both teacher and learner co-researchers welcomed the student teachers' interpretation of teaching and learning using the IBL approach and they were open to exploring with IBL given its potential benefits. IBL is an interactive approach as it advocates for learners to be actively involved in the learning process. Structured Inquiry seemed like a viable option for teaching GIS in this context as learners have not yet developed the skills of working independently and collaboratively with peers. The traditional teaching approaches that were used to teach GIS were not cultivating such a necessary skill of working independently and collaboratively with peers.

5.4.3 Seeking alternative resources

Many rural learning ecologies in South Africa face several challenges that are unique to their context. These challenges include the lack of resources. In the discussion about the teaching of GIS in this context, the co-researchers indicated that they do not have computers and software to demonstrate the use of GIS to learners. Moreover, the co-researchers suggested that the number of topographical and orthophoto maps that were available were fewer than were needed for the learners who specialise in Geography. This meant that the co-researchers and I had to come up with creative solutions to address the lack of resources.

One of the student teacher co-researchers, Andiswa recommended the following:

> *Learners have to go to libraries outside the school. There is free WI-FI in municipal libraries, which would enable one to research on their own. As much as teachers deliver content, learners have to hear other peoples' perspectives on that topic to broaden their understanding.*

The above recommendation meant that to address the lack of resources in the school the co-researchers and I had to look beyond what the school had to offer in terms of resources to enhance the teaching of GIS in this context. This was in line with the IBL approach as it encourages learners to take responsibility for their learning such as consulting different sources to get information. However, since IBL approach was newly introduced in this context, the role of the teacher included adopting structured inquiry as it is one of the variants of IBL. In this case, a structured inquiry was understood as providing learners with questions and examples of methods that they could use to answer these questions. Thereafter, learners were expected to use library resources and to work independently or collaboratively to answer such questions depending on the teachers' directive. Learners were also expected to analyse and evaluate what they found during their searches for information in the local library.

With regard to the shortage of maps, the subject advisor, Andile said:

> *I will make contact with the Department of Education's examination unit to find out if they will be able to provide a sufficient number of maps to the school*

And one of the student teacher co-researchers remarked:

> *While we wait for the Department of Education's examination unit, can we give learners a mapping task? In which they can draw a map from their homes to school. I think that this will give learners some form of mapping practical experience. Since GIS specialists are involved in designing maps as part of their job description* (Amanda)

This idea was welcomed by the other co-researchers as it was in line with the elements of IBL that include learners being active in learning. Drawing is a practical task and it allows learners to experience what it is like to combine different layers of information so that the map makes sense to the user. Drawing the map also develops spatial analysis skills in learners as they will be exploring their immediate environment since they would be required to show the different features that they pass on their way to school from home. From the contributions made by the different co-researchers, it became clear that there were creative ways of overcoming the lack of resources barrier to teaching GIS such as visiting local libraries, consulting the DBE for help as well as getting learners to create maps for themselves. This shows that deliberations are necessary as they allow the meeting of minds which results in positive outcomes.

5.4.4 A change in attitude

With regard to the teacher attitude, it was interesting to note that it shifted from negative to positive during the course of the study as we had open discussions about the teaching of GIS in the rural learning ecology. What emerged from our discussions was that teachers lacked support in the teaching of GIS, Andile the subject advisor alluded to this:

> *I think that the main problem is the teachers' attitude, GIS is not that difficult, it just that it was introduced at a later stage and I think I must assist teachers more.*

In the comment above, Andile indicates that he thinks that he has to assist teachers more. Meaning that he is aware that the GIS support that he has been offering to teachers is not enough given the low performance of learners in this section. To sum up this section, it was evident that combining different expertise of the co-researchers that participated in this study provided the necessary support to teachers to enable them to teach this section

confidently. Thus, their attitude towards the teaching of GIS using the IBL approach became positive.

The co-researchers and I had planning meetings in which we discussed creative ways that could be employed to overcome the resource barrier. We then planned and taught the lessons. Thereafter, we reflected on the process. The reflections were done to identify what was working and what was not working to promote learning as the IBL approach was new to many of the co-researchers. These were the circumstances under which IBL may be used to teach GIS in a rural learning ecology. The following section discusses the benefits and challenges of using the IBL approach to teach GIS in a rural learning ecology.

5.5 BENEFITS AND CHALLENGES OF USING THE IBL FRAMEWORK TO TEACH GIS IN A RURAL LEARNING ECOLOGY

In the following section, I discuss the benefits and challenges of using the IBL approach to teach GIS. First, I presented some benefits of using the IBL approach to teach GIS that the co-researchers acknowledged. These include its flexibility and the promotion of self-directed learning and collaboration skills. Second, I discussed some challenges of using the latter approach in teaching GIS that were highlighted by the co-researchers such as reluctance of teachers and learners to explore the IBL approach and time constraints.

5.5.1 The IBL approach is flexible

The discussions about teaching using the IBL approach led by the student teacher co-researchers. It became apparent that the co-researchers were of the view that the IBL approach enhances the teaching of GIS. This is because the IBL approach is flexible in the sense that it is a learner-centred approach. It inspires learners to participate during the lesson. As teachers interact with learners, they can use learners' prior knowledge to introduce new GIS content. This can be seen in the following account made by Amanda:

> *A teacher who makes use of the IBL approach to teach GIS must try to create a link between the content of the lesson and the knowledge that learners bring to class*

The traditional teaching approaches on the other hand do not encourage teacher-learner interaction. This is because the teacher is seen as the primary source of information and learners are on the receiving end. Teaching using the IBL approach flips the relationship in the sense that learners are invited to participate in the lesson. In the following except, Bheki agreed with Amanda with regard to teachers tapping into learners' prior knowledge to introduce new content:

> *Let us not treat the subject of Geography [GIS] as an animal that learners do not know. Meaning that as teachers when we tap into what learners already know it becomes easier for them to process new information*

Both the accounts made by the co-researchers show that they are in favour of using the IBL approach to teach GIS because it is flexible by inspiring learners to participate in the lesson.

5.5.2 IBL promotes self-directed learning and collaboration skills

The IBL approach allows for teachers to design individual and group activities. As a result, it opens opportunities for learning to take place inside and outside the confines of the classroom. Learner co-researchers said the following in an information-sharing session about the Inquiry-based learning approach:

> *We can even learn Geography with our classmates after school or on weekends because IBL teaches us that we do not have to always wait for the teacher to tell us what to do instead we should take responsibility for our learning* (Melokuhle)

> *I think by using the Inquiry-based approach that we can actively participate in learning and connect with classmates* (Feziwe)

The excerpts above show that the learner co-researchers recognise some of the benefits of applying the IBL approach such as working collaboratively with their peers even outside school hours. Which may in turn develop communication skills, as such skills are regarded as a highly important skill in the workforce in the 21st century. The learner-co researchers also realise that they had to play an active role in their learning by learning with and from each other. Despite what the co-researchers saw as benefits of using the IBL approach to teach GIS, they also identified challenges that impede the use of the approach. These are mentioned in the following section.

5.5.3 Reluctance of teachers and learners to explore the IBL approach

The co-researchers' acceptance of the IBL approach was key to exploring its use to teach GIS in the rural learning ecology. While engaging with the co-researchers on the challenges that they foresee with the application of the latter approach in their context. Bheki remarked:

> *Some teachers possess a negative attitude towards the IBL approach because they lack sufficient knowledge of it*

Esethu added:

> *The IBL approach requires a positive attitude towards teaching and learning from learners and teachers because it requires learners to talk. Getting learners to talk might be a problem because their behaviour tends to be problematic. When it comes to learner attitude we struggle from time to time. Because of drugs and alcoholism, so it becomes difficult for us to teach learners that are not focused*

The co-researchers' contribution above shows that some teachers are reluctant to make use of the IBL approach because they were not trained to use this teaching approach whilst others are open to exploring the IBL approach. Furthermore, Esethu maintained that one of the fundamental core elements that would make the use of the IBL flourish is learner attitude. Esethu highlighted that since the IBL approach requires learners to be active, in their context this is problematic because of behavioural problems in that some learners are aggravated by using alcohol and drugs. However, he further stated that

> *we first need to attend to both teacher and learner attitudes, by guiding them on what is to be done and what is expected from them*

This means that teachers and learners are willing to explore the use of the IBL approach to teach GIS if they understand the concept of IBL and their roles when the latter approach is applied.

5.5.4 Time constraints

The co-researchers expressed different views when it came to time constraints being a challenge when exploring the use of IBL in teaching GIS. The learner co-researchers said that their home environments are not very accommodating when it comes to putting extra

hours towards schoolwork because of chores that they need to perform after school. This can be seen in the following excerpts:

> *When we get home there are plenty of chores that we are expected to do. For example, fetching water, washing dishes and cooking. Our parents tell us that schoolwork should be done at school and housework should be done at home* (Melokuhle)

> *I agree with what [Melokuhle] has said. At home, they do not give us enough time to do our schoolwork. We are not given permission to go to the library. There is this belief that we go to the library to meet boys, so there is no learning that takes place there. Our parents just expect us to remain at home. Help with the chores such as cleaning and looking after our siblings* (Feziwe)

The above was different from how the teacher co-researchers viewed the issue of time constraints when exploring the use of the IBL approach to teach GIS. For instance, Amahle said:

> *I would say that the major problem that we have with exploring the use of the IBL approach is that as teachers we are guided by the CAPS policy which specifies the amount of time that should be spent teaching a certain topic. Unfortunately, these time limits are set by people who are not involved in teaching learners and who are unaware of charming teaching approaches such as the IBL. We are then given limited time to teach because they focus more on teaching rather than learning. So, we end up focusing more on completing the prescribed curriculum rather than focusing on whether learners are learning or not. The curriculum deadlines leave us with unlimited time to explore with IBL*

Esethu added:

> *Our School Management Team (SMT) is also a problem because they are also more focused on reinforcing the time limits that are prescribed by the curriculum. As a result, they do not acknowledge the value of field trips. I see them as a good tool to develop inquiry skills in learners. But we are limited when the SMT sees field trips as play or a waste of time*

From the two teacher co-researchers it is clear that they are positive about exploring the use of the IBL approach for teaching. However, they have experienced that the CAPS policy does not give them enough time to do so because it comes with predefined time limits that are set for a particular topic. Moreover, the teacher co-researchers stated that they feel that the curriculum developers focus more on teaching rather than learning. This

contradicts one of the core elements of IBL that is the active involvement of learners in the teaching process.

Teachers also experience challenges when they organise field trips that would engage learners because the SMT views them as play and a waste of time. Meaning that the SMT is still advocating for the traditional teaching approaches that confine learning to a physical classroom. In this section, I have shown that some of the benefits of the IBL approach are that it is flexible as it promotes the active participation of learners in education. IBL also encourages self-directed learning and collaboration skills, which are necessary for the 21st century. However, there are challenges with the adoption of the IBL approach such as the reluctance of teachers and learners to explore it. As well as time limitations but the potential benefits of using IBL far outweigh the challenges if the teachers and learners are supported when adopting this approach. In the following section, I discuss the implications for the use of an Inquiry-Based Learning approach to teach GIS in a rural learning ecology.

5.6 THE IMPLICATIONS FOR THE USE OF AN INQUIRY-BASED LEARNING FRAMEWORK TO TEACH GIS IN A RURAL LEARNING ECOLOGY

In this section, I discuss the implications for the use of an IBL approach to teach GIS in a rural learning ecology. The implications were drawn from the current situation in the teaching of GIS in a rural learning ecology (Section 5.2). Section 5.2 of this chapter revealed the challenges that the co-researchers faced in the teaching and learning of GIS. Moreover, the implications also come from the challenges that were described by the co-researchers when we deliberated upon the challenges of using the IBL approach in teaching GIS. The first implication responds to the issue of lack of training. While the second speaks to the lack of resources and the third implication responds to learner attitude.

5.6.1 Addressing negative teacher attitude through the provision of training

For a Geography teacher to be able to teach GIS using the IBL approach effectively, they need to be trained in both GIS content and IBL. Teachers need to understand and embrace the concept of IBL. They also need guidance, ongoing support and practical

examples of how to teach from an IBL perspective. This would prepare them to engage learners on a deeper level. Teachers need to be aware that when they make use of the IBL approach, their role changes to being a facilitator of the inquiry process whereby they ask questions, allow learners to ask questions and provide feedback. This would alert them of learners' progress as they cultivate higher-order thinking skills such as creative and critical thinking. The following extract is an example of the content featured in the IBL and GIS training workshop that took place in the rural learning ecology where this study was conducted:

> *When teaching using the IBL approach, the teacher needs to ask questions that enables learners to express their understanding. For example, if learners are expected to map major infrastructural developments that are new in their community. A teacher might ask learners to mention recent infrastructural development initiatives in their communities. By so doing, they would be opening a platform for any learner to answer the question from their experience or perspective because the question is relevant to them. For example, they could answer last year there was no clinic in the community but now we have it. This would show that they are aware of recent major development initiatives that are visible in their community. Therefore, they would be able to map them* (Amanda)

The import of the above extract was useful for teacher co-researchers that participated in this study because they were transitioning from teaching of GIS using traditional approaches to IBL. This meant that they had to reconceptualise their definition of teaching as when the study began the teacher co-researchers expressed that they did a rush job in teaching GIS content and their main focus was getting learners to pass examinations as they were not confident to teach this section. Thus, such training opportunities were necessary for the co-researchers as helped them to question their world views about teaching and being prepared to change them through engaging with the various support channels that were at their disposal. Through participating in this study, we also had the opportunity to explore with guided and structured IBL to teacher GIS. The fact that co-researchers and I combined our different expertise created an opportunity for us to learn with and from each other.

5.6.2 Overcoming the lack of resources barrier

In the previous sections in this study, the co-researchers indicated that teaching GIS in a rural learning ecology was curtailed by lack of resources. For effective teaching to take place adequate preparation time and resources are required. It is widely acknowledged that many schools located in rural learning ecologies lack sufficient resources for teaching and learning GIS. This was also the case in the rural learning ecologies where the study was conducted. To mitigate this deficiency the co-researchers and I decided to focus on the available resources at our disposal rather than being limited by what we did not have. This was revealed by Esethu where he said:

> a*t the end of the day, we are expected to teach GIS regardless of our understanding and the unavailability of resources. We must find creative ways to make GIS practical.*

Finding creative ways to make GIS practical meant that the co-researchers and I had to be open to exploring a different teaching approach such as the IBL approach because it enables learners to engage in research activities. This was driven by how the teachers phrased the questions as we made use of the structured and guided approach. For instance, a teacher would phrase inquiry tasks that require learners to work collaboratively as groups capturing different types of data from existing maps and photographs and where they would be required to go to the local libraries to find information and report back the findings to the class through presentations.

Another strategy of mitigating lack of resources includes reconceptualising how one sees education and resources and by moving beyond the mentality that everything that is needed to teach GIS practically will be provided by the DBE and that education is limited to the confines of the classroom. Rather teachers and learners can study their immediate environment (spatial analysis) carefully to see what it has to offer in terms of learning GIS. This is the kind of teaching that appreciates the importance of context. For instance, in the rural learning ecology where the study was conducted, there were two rivers and a couple of mountains a relatively short distance from the school. This enables teachers to organise local field trips when they view the latter as teaching resources.

In preparation for the field trip, the teacher could plan activities (guided inquiry) that would require learners to identify and map the features that they observe during the outing. In this way, learning occurs outside of the classroom that lacks resources that are required to teach GIS. Also, because the features are near the school the teacher can make use of the assigned Geography period to accompany learners to the site. Thereafter, they can come back to school before the subsequent period commences. If learners require additional time, they can always explore the site further after school or during the weekend since it is within their community. Hence, using the IBL approach allows for teaching and learning to occur beyond the confines of a classroom.

5.6.3 Addressing negative learner attitude

Teaching GIS using the IBL approach requires learner engagement and active participation. This means that the teacher should ask students to speak up and contribute to the inquiry activities. However, the teacher might experience challenges in this regard if many learners are reluctant to speak in front of the whole class. This can be seen in the extract below:

> *IBL seems like a good approach. But learners and teachers must work together so that everyone benefits. One of the difficulties is that our learners are so used to a teacher talking alone for the whole lesson because this is how we have always taught them. So, now when we start asking questions they do not participate that much* (Esethu)

One way of mitigating the above-mentioned challenge is reviewing the kinds of questions that a teacher asks throughout the inquiry. Such questions should be open-ended and initially, they should address learners' interests such as sports, weather, soapies and taking selfies. These open-ended questions would serve as an entry point for all the learners to take part in the conversation. Thereafter, the teacher could gradually include GIS content such as spatial and spectral resolution to form part of the conversation.

Another strategy to involve reluctant speakers in a guided inquiry task would involve dividing learners into small groups. The idea behind this is that they might be more comfortable speaking on such a platform as they would be exchanging ideas with their peers. Also, the teacher can ask learners to note down the questions that they might have

and make a submission as a group so that they may be attended to. This would ensure that the learners feel supported along the way as they engage in self-directed learning while the teacher facilitates the process. Self-directed learning allows learners to take charge of their learning process by seeking information and developing skills that they require for a particular task on their own.

The teacher may also ask learners to state what type of support they require from him/her. Meaning that the responsibility to learn shift from the teacher to the learner. This can take place in a form of a reflection at the end of every inquiry lesson. This might also improve the relationship between teachers and learners especially in the rural learning ecology where this study was conducted. For a long time, teaching was based on the idea that the teacher was the focal point. Where the teacher's role was to transmit information. In summary, teacher training, seeking alternative resources and learner-centered teaching are necessary to enable the use of IBL to teach GIS in a rural learning ecology.

5.7 SYNTHESIS

In this chapter, I began by presenting the current situation in teaching GIS in the rural learning ecology where the study was conducted. The generated data revealed that there were challenges in teaching GIS such as the teachers lacking formal GIS training, the persistence of traditional teaching approaches and there was a lack of resources to teach GIS. As a result, the teachers had a negative attitude towards teaching GIS content. This suggested that there was a need for an alternative teaching approach that would enable effective teaching of GIS in this context. The student teacher co-researchers thus introduced the IBL approach to the other co-researchers. In which upon hearing about IBL, the co-researchers unanimously agreed that there is value in using this approach given that it advocates for learners to be actively involved in their education.

The co-researchers and I then deliberated upon the circumstances under which the IBL approach may be used to teach GIS in the rural learning ecology. We concluded that sharing of expertise was necessary as well as exploring the IBL approach. In addition, due to the lack of resources, we had to seek alternative resources to enable the teaching of GIS. This was necessary to achieve the benefits of using IBL given that it is flexible

and it promotes self-directed learning and collaboration skills. However, we discovered that there were challenges that hindered the use of this approach. To overcome these challenges, we concluded that teachers had to be trained to enhance their knowledge of GIS and the IBL approach. Learners also needed to be engaged during the lesson by partaking in structured and guided inquiry tasks as individuals or small groups. One of the teachers' roles as a facilitator is to encourage learners to express themselves.

CHAPTER SIX
DISCUSSION OF FINDINGS

6.1 INTRODUCTION

In the previous chapter I presented, interpreted and analysed data using thematic analysis and I was guided by this study's research objectives. In this chapter, I used the research objectives to discuss the findings of the study, with reference to literature, PAR methodology and the CER theory. Bearing in mind the aim of this study, which was to explore the use of the IBL framework to teach GIS in a rural learning ecology.

6.2 DISCUSSION OF FINDINGS ON THE CURRENT SITUATION OF TEACHING GIS IN A RURAL LEARNING ECOLOGY

6.2.1 GIS training for the Geography subject advisors and teachers in rural learning ecologies is neglected

The findings from this study indicate that the subject advisor and the teacher co-researchers were not formally trained to teach GIS in their initial teacher education programmes (see section 5.2.1). The issue of lack of formal GIS training amongst secondary school teachers is widely acknowledged in GIS education literature globally (Kerski et al., 2013; Riihela & Maki, 2015) and in South Africa (Eksteen et al., 2012; Fleischmann et al., 2015). On the contrary, Mkhongi and Musakwa (2020) found that the majority of teachers from the uMgungundlovu district that participated in their study had modules such as GIS in their qualifications. However, the latter study did not provide enough information to ascertain whether or not the scope of the said GIS modules covers GIS content knowledge that is prescribed by the CAPS policy (Department of Basic Education, 2011). The overall conclusion of the Mkhongi and Muskwa's study was that many teachers that participated in the study were only teaching GIS concepts

theoretically. Similarly, this was also the case for this study since learners from the rural learning ecology were only taught GIS concepts theoretically.

The data (see section 5.2.1) from this study revealed that due to lack of training the subject advisor could not impart GIS knowledge and skills to the teachers that he supervises because the DBE provided him with limited GIS training when GIS was launched back in 2006. This implies that it has been more than 10 years now since the subject advisor attended the last GIS training workshop. Yet, he is expected to provide ongoing professional development to Geography teachers that he supervises. The lack of training contradicts the PAR methodology adopted in this study because it subscribes to the notion that people should be empowered with knowledge so that they may engage in informed decision-making (see 4.5.2.3). In this case, the findings of this study imply that the subject advisor was unable to make informed decisions regarding how teachers can teach GIS because he lacked GIS content knowledge and pedagogy.

Given the subject advisor's lack of expertise in GIS, teachers have to seek alternative ways to develop in GIS content knowledge and pedagogy. Self-directed GIS professional development opportunities are available for teachers throughout the country. However, access to GIS training institutions was limited by the rural context in which the teachers live and work (see 4.6). In addition, Breetzke et al., (2011) revealed that GIS teacher training is often concentrated in large cities, as a result, access becomes problematic for teachers from rural learning ecologies as many of them have to travel long distances to get to the training centers and they need to have an additional budget for accommodation.

Given the lack of GIS training amongst the Geography subject advisor and teachers that participated in this study, one can conclude that the subject advisor is disempowered to impart GIS knowledge and skills to teachers that he supervises. Consequently, teachers are also disempowered to teach GIS due to the lack of support from the subject advisor. Mudambi and Navarra (2015) state that knowledge is power. So, the subject advisor and the teacher are disempowered by the DBE to teach GIS as they do not have adequate GIS knowledge and skills. The disempowerment of the subject advisor and the teachers

supports the Critical Emancipatory Research (CER) theory since it advocates for the empowerment of oppressed people (Tshelane & Mahlomaholo, 2015b). The subject advisor and teachers were oppressed by the DBE by not providing them with adequate GIS training to enable them to impart GIS knowledge and skills. As a result, it was necessary for the co-researchers and I to adopt the PAR methodology as it promotes the self-empowerment ideology (see sections 4.5.2.3, 4.5.2.4).

6.2.2 Traditional teaching approaches are persistent

The findings of this research study demonstrate a correlation between the lack of GIS training (see 5.2.1) and the adoption of traditional teaching approaches. The findings of this study show that there is the persistent use of traditional teaching approaches in the rural learning ecology where the study was conducted because only GIS concepts were taught to Geography learners theoretically (see 5.2.2). This is in alignment with GIS research in education because Chen and Wang (2015) claim that teacher-center approaches are commonly used to introduce GIS concepts to learners. Teacher-centred approaches limit discussions between teachers and learners. Thus, findings from this study imply that teachers do not want to be engaged by learners when teaching GIS because they fear that it will become obvious that they do not understand the content that they are expected to teach. So, as a coping mechanism, the teachers quickly read GIS concept definitions from a textbook or previous examination question papers to learners (see 5.2.2). Previous examination question papers provide GIS concepts that have been tested in the previous years. One of the teachers that participated in this study stated that he reads quickly for learners so that they might be able to reiterate the definitions of GIS concepts during the examination and obtain full marks.

Preparing learners to reiterate the definitions of GIS concepts for the examination is a traditional approach to teaching as it promotes rote learning rather than the understanding of the concepts. Findings from this study reveal that the teaching of GIS is often done just before the exam period commences. Similarly, Larangeira and Van der Merwe (2016) reported a similar finding regarding the timing of when mapwork was taught to some of

the student teachers that participated in their study, as they reflected on their experiences of being taught mapwork as secondary school learners. This implies that there is a similar trend of teaching mapwork and GIS in secondary schools just before the examination period commences. The strategy of teaching GIS right before the examinations has proven to be unsuccessful as the learner co-researchers that participated in this study revealed that they find it difficult to memorise the definitions due to being rushed to memorise them over a short space of time (see 5.2.2). Thus, they perform poorly in the GIS section of the Geography examination. Also, one of the teachers that was a co-researcher in this study indicated that his sole focus during GIS lessons was to get learners to master GIS concepts. Moreover, he stated that often he feels that he is not teaching when he teaches GIS as he emphasises learners' definition of GIS concepts rather than their understanding, as he cannot impart an understanding of GIS that he does not have. This necessitated the sharing of expertise as per one of the elements of PAR (see 4.5.2.2)

Teaching GIS concepts right before the commencement of the examination or two to four times a year in the rural learning ecology where the study was conducted contradicts the policy requirements. As the CAPS policy states that GIS content should be taught from the first term in grades 10 – 12 with specified time limits (Department of Basic Education, 2011, pp. 19, 29, 40). A similar finding has been reported by Mkhongi and Musakwa (2020) who found that in most of the schools that they sampled, Geography was taught below the prescribed minimum time of four hours a week. Meaning that the teaching of GIS was not allocated the prescribed time frames and this implies that learners were not taught the content and skills as per the CAPS policy timeously. Moreover, the traditional teaching approaches used in the rural learning ecology were not yielding positive outcomes as learners could not move beyond defining GIS concepts in an examination setting (see 5.2.2). The subject advisor being a moderator of learners' examination scripts for the KwaZulu-Natal province indicated that it was through the moderation process that he saw that the traditional teaching approaches were not adequately cultivating the GIS content and skills that are tested during examinations which indicated a need for alternative teaching approaches to supplement the traditional ones which were used.

6.2.3 Resources for the teaching GIS need to be attended to in various ways

The resources for teaching GIS need to be attended to in various ways in rural learning ecologies. This study found that there were no computers for teaching and learning in the rural learning ecology where this study was conducted (see 5.2.3). The absence of computers had a negative impact on how GIS was taught to learners in this context. Madida et al., (2019) argued that many schools in rural learning ecologies are under-resourced due to the apartheid legacy. There was an unequal distribution of funding during apartheid. Furthermore, there is a consensus in research focused on the teaching of GIS in secondary schools that lack of resources is a hindrance to proper GIS implementation (Fleischmann & van der Westhuizen, 2017; Kerski et al., 2013; Mkhongi & Musakwa, 2020). In the sense that due to the unavailability of resources learners were taught about GIS rather than being taught with GIS (see sub-section 3.6.2.1). Wilmot and Dube (2016) reached a similar conclusion in their research where they found that due to lack of resources amongst other reasons many teachers in South African secondary schools end up teaching about GIS instead of teaching with GIS.

Some of the significant contributions made by scholars to mitigate the lack of resources in schools was the introduction of paper-based GIS Breetzke et al., (2011) and in the subsequent year Fleischmann (2012) launched the Interactive Geographic Information System Tutor (see 3.6.2.1). Despite this, Fleischmann et al., (2015) argue that computers are necessary for the teaching of GIS. However, the paper-based GIS option is a viable option in this context. But the findings of this study indicate that there is a shortage of maps in the rural learning ecology where this study was conducted because DBE does not provide an adequate budget for purchasing topographic and orthophoto maps (see 5.4.3) since the DBE provides a smaller number of maps than the enrolled learners. This implies that if the school cannot purchase maps for teaching and learning due to the lack of funding from the DBE it would be impossible for them to purchase the paper GIS package for teaching and learning. Once more, the lack of resources disempowered the co-researchers to teach GIS in the rural learning ecology where this study was conducted,

opposing one of the principles of the CER theory which is empowerment (2.2.2.3). Consequently, creative solutions were needed in this context to empower the co-researchers and myself to teach GIS despite the lack of resources in this context.

6.2.4 Teachers showed a negative attitude towards GIS

The data from this study revealed that the teacher co-researchers that participated in this study had a negative attitude towards GIS due to the following reasons (see section 5.2.4). Firstly, it is because GIS is allocated limited marks in examination compared to other Geography topics (see section 5.2.4). To be precise it is allocated fifteen marks in FET examinations as per CAPS policy (Department of Basic Education, 2011). Collett, Winearls and Olivier (2012) caution that although Geography topics are weighted differently in the CAPS policy and allocated uneven time limits, this should not be viewed as privileging certain topics over others since all topics are equally important. Nonetheless, the allocation of limited marks to GIS content in the CAPS policy and the examination has resulted in a negative attitude amongst Geography teachers in the rural learning ecology where this study was conducted. The type of questions of the Geography examination in paper two under GIS range from concept definitions to identifying and Interpreting GIS concepts using both orthophoto and topographic maps, statistics shown in tables and graphs, pictures, satellite images and aerial photographs (Department of Basic Education, 2017). The findings from this study show that the teacher co-researchers only teach GIS concept definitions due to a lack of computers to enable them to demonstrate to learners how GIS works.

Secondly, the reason for teachers adopting a negative attitude towards GIS is because the findings of this study indicate that teachers did not have formal GIS training and they have not been offered GIS professional development as previously outlined above (see section 6.3.1). Findings from this study reveal that what the teachers know about GIS is self-taught through reading from the Geography textbooks and past examination papers. Thus, it becomes a daunting task when the teachers must teach GIS because they lack confidence in teaching GIS topics due to having limited GIS content knowledge and skills.

Akinyemi (2016) argues that peoples' attitudes are shaped by their beliefs, which in turn shapes their response to certain situations. Findings from this study concur with the latter view regarding people's attitudes, beliefs and their responses to situations. Due to lack of GIS training the teacher co-researchers developed a negative attitude toward GIS and ended up assigning less and less time to the teaching of GIS and they decided to teach only concepts such as remote sensing, raster and vector data from textbooks and previous examination papers as they held a view that these were the only resources available at their disposal for teaching GIS. This implies that a shift in the teachers' attitude was necessary so that they would see GIS differently and perhaps teach it differently.

GIS is technology after all. As a result, it requires a teacher that possesses sufficient knowledge of pedagogy, the curriculum and technical skills to teach it well (Akinyemi, 2015). Several GIS studies which explored the teaching of GIS in a South African context found that many teachers are not keen to use or teach GIS technology in their classrooms because they lack training on both computers and GIS (Fleischmann & van der Westhuizen, 2017; Sefara, 2017; Mzuza & van der Westhuizen, 2019). Also, many teachers have not been trained on which pedagogy is suitable for the teaching of GIS. Consequently, due to lack of training on the GIS curriculum, technical skills and lack of suitable pedagogy the teachers that participated in this study had a negative attitude towards GIS. In brief, the current situation regarding the teaching of GIS in rural learning ecologies continues to encounter challenges including lack of resources, inadequate GIS training for subject advisors and in-service teachers. These result in a negative attitude towards GIS and the persistent use of traditional teaching approaches.

6.3 DISCUSSION OF FINDINGS ON ESTABLISHING THE NEED FOR THE INQUIRY-BASED LEARNING FRAMEWORK FOR TEACHING GEOGRAPHIC INFORMATION SYSTEMS IN A RURAL LEARNING ECOLOGY

The need for an IBL framework for the teaching of GIS in the rural learning ecology is justified on the grounds discussed in the subsequent sessions. Findings from this study

(see section 5.3) show that since Geography studies human and environmental relationships, it should be taught in a way that promotes understanding rather than to recall knowledge. Teaching for understanding would enable learners to apply previously learnt knowledge to explore the complex relationship between humans and the environment. This is termed Geographic Inquiry (ESRI, 2003; Merja, 2018). Moreover, Tambassi (2019) unpacks the latter view of Geography further by stating that Geography includes writing and drawing about the Earth, this is what led to the development of GIS in the first place. One of the reasons for the development of GIS was to enable practitioners to map, analyse and interpret their surroundings efficiently.

In section 1.3 GIS is defined as a technology that is used in different sectors that are interested in spatial data (Chaudhuri & Ray, 2015; Coetzee et al., 2014). These sectors require GIS specialists to operate the software. As a result, the DBE had to include GIS in the secondary school Geography curriculum so that learners can be introduced to GIS knowledge and application skills to prepare them for their possible future roles as GIS specialists (Innes, 2012). On the other hand, the Department of Basic Education (2018) and Innes (2012) found that GIS application skills were not developed adequately in Geography secondary school lessons. This study found that the usage of traditional teaching approaches was one of the reasons why learners' GIS application skills were not developed in the rural learning ecology. Learners were passive during GIS lessons.

Through our deliberations with the co-researchers that participated in this study, there was consensus that the way learners are taught has a bearing on how they learn (see section 5.3). Findings from this study showed that traditional teaching approaches used to teach GIS were not adequate because they promote surface learning rather than deep learning (see sub-sections 5.2.2, 6.2.2). The result of using traditional teaching approaches to teach GIS was that learners could not move beyond defining GIS concepts, this is similar to what Freire (1970) termed as a banking concept of education in which learners were not engaged. Hence, there was a call from the subject advisor to teach GIS practically (see section 5.3*).* The call from the subject advisor provides evidence that the elements of PAR were applied in this study. Specifically, the sharing of

power (see 4.5.2.1) as the subject advisor's suggestion about making GIS practical was taken into consideration and it justified the need for an alternative approach to teaching GIS that would move learners from merely defining GIS concepts. Also, findings from this research study reveal that GIS application skills can be nurtured using teaching approaches that promote inquisitiveness so that learners can be engaged during the learning process (see section 5.3).

This study found that there is a need for IBL for the teaching of GIS in a rural learning ecology because it allows learners to be engaged in their learning. Haq (2017) and Hwang et al., (2015) agree that IBL is one of the teaching approaches that can promote active learning, collaboration and problem-solving. Furthermore, findings from this study suggest that one of the ways of engaging learners in their learning is to give them research projects so that can develop skills of sourcing information and resources on their own rather than depending on the teacher as the sole source of information and resources. Giving learners research projects to complete can be regarded as guided inquiry (see section 2.3.1). The CAPS policy prescribes research projects as one of the formal assessments for secondary school Geography learners (Department of Basic Education, 2011). Therefore, if a teacher adopts the IBL approach it would enable them to fulfil the requirements of the policy. Furthermore, a teacher that is willing to experiment with the IBL approach must re-negotiate their role as a teacher because one of the elements of IBL is that the teacher becomes a facilitator of learning rather than an expert (see section 3.9).

To sum up, there was a need for the Inquiry-based learning framework for teaching geographic information systems in a rural learning ecology. This was justified by the nature of Geography as a discipline, it requires learners to engage in Geographic Inquiry. Moreover, there was a consensus amongst the co-researchers that the traditional teaching approaches that were used were only encouraging learners to recall knowledge. As a result, learners could not respond to GIS application questions. The IBL was deemed appropriate for teaching GIS because it advocates for learner-centred teaching in which learners can engage in a guided inquiry by seeking information and resources on their

own. Teaching from the Inquiry-based perspective means that a teacher's role shifts to being a facilitator of learning rather than being an expert.

6.4 DISCUSSION OF FINDINGS REGARDING THE CIRCUMSTANCES UNDER WHICH AN INQUIRY-BASED LEARNING FRAMEWORK MAY BE USED TO TEACH GIS IN A RURAL LEARNING ECOLOGY

This study found that there were some circumstances under which an Inquiry-based learning framework could be used to teach GIS in a rural learning ecology. These include sharing expertise and lived experiences, exploring an alternative approach, seeking alternative resources and a change in attitude. The latter are discussed in detail in the sections below.

6.4.1 Sharing expertise and lived experiences

Given that this study adopted the PAR methodology it allowed for the sharing of expertise and lived experiences by the different co-researchers that participated in this study. More details of sharing expertise and lived experiences can be accessed from section 4.5.2.2. Equally important, the PAR cycle was followed to generate data (see 4.8). Findings from this study confirm that it was helpful when different stakeholders engaged with the challenges of teaching GIS in the rural learning ecology because it resulted in the sharing of expertise and lived experiences since the co-researchers had different knowledge, skills and experiences that they could share during information sharing and reflection sessions. For instance, one of the facilitators who had the experience of operating the GIS software was able to demonstrate its use to the rest of the co-researchers and the co-researchers were free to ask questions. Fleming (2015) reported on a summary of GIS interventions that were studied over two years, in which none of them were initiated by the people who are affected by the teaching of GIS. This makes this research study unique as it has involved different stakeholders who are affected by the teaching of GIS to bring about change in the teaching of GIS in a rural learning ecology.

During the demonstration of how the GIS software works, grade 10 and 11 content knowledge was taught as per the CAPS policy (see 3.6). This bridged the gap between theory and practice because prior to this session learners were taught GIS concepts using the textbook and the traditional teaching approaches. So, during the demonstration, the co-researchers and I were able to see how the ArcGIS software works and we learnt that one needs to have computer skills to operate the software. Over and above this the facilitator was able to enhance our understanding of the GIS software by using examples of apps that we use on a daily basis such as Facebook and WhatsApp. This made GIS more relevant to us as learners and we were even able to grasp that GIS may provide soil fertility data, of which they deduced that the usage of GIS is also applicable in their context because they engage in subsistence farming with their families and neighbours.

The CAPS policy prescribed farming content under settlement Geography in grade 12 (Department of Basic Education, 2011). So, this made us realise that there is a link between GIS content and other Geography topics rather than mapwork only. In short, sharing of expertise and lived experiences was effective because all along the co-researchers and I were unable to make a link between theory and practice which was in line with the PAR methodology (see 4.5.2.2). Over the years the co-researchers and I were exposed to GIS theory from the textbooks and previous exam papers. What was unique about the demonstration of how the GIS software works was that we could understand the practical side of GIS. In turn our understanding of GIS was broadened because we realised that the software could store data about the fertility of the soil and this spoke directly to the rural learning ecology where the study was conducted because many learners had experience with subsistence farming.

6.4.2 Exploring an alternative teaching approach

Data from this study revealed that there was a need to explore an alternative approach for teaching GIS in the rural learning ecology. In one of the information-sharing sessions, the student teachers facilitated the conversation on exploring an alternative approach to teaching GIS. This is where they shared their understanding of teaching from an IBL

perspective (see section 5.4.2). From the deliberations, the different co-researchers expressed the view that the IBL approach would be suitable for their context as it cultivates curiosity in learners about spatially referenced data amongst other things. Also, it would give learners opportunities to gain access to knowledge and resources from different sources when they carry out research activities. Since the use of the IBL approach was being introduced in this context, structured Inquiry was deemed appropriate where the teacher provides guidelines to learners so that they can complete the task (Banchi & Bell, 2008). This would be done to supplement the traditional teaching approaches used gradually because they were contributing to learners' low performance in the GIS section (Department of Basic Education, 2013, 2018).

Research carried out by Dube (2012) and Wilmot and Dube (2016) revealed that many Geography teachers were not making use of the IBL approach in their teaching. As a result, they were missing out on harnessing the benefits of using the IBL approach as it is regarded as one of the most effective strategies to impart geographic knowledge, skills and values. Similarly, this research study found that the IBL approach was not used to teach GIS in the rural learning ecology. This finding implied that there was a need to explore the use of the IBL approach for teaching GIS in that context. Through our deliberations with the co-researchers, the IBL approach was deemed suitable for teaching GIS because of its advocacy of student-centredness (Fitzgerald, Danaia, & McKinnon, 2019; Newman, 2014). Hence, it was explored as an alternative approach to teaching GIS in the rural learning ecology where this research was carried out. Additionally, the IBL approach can be viewed as consistent with the CER. Through cultivating curiosity and thus producing learners that are autonomous the IBL empowers the learners who are often disempowered when other teaching approaches are used. Essentially, the IBL approach as an alternative teaching approach provides an opportunity deemed vital by the CER theory.

6.4.3 Seeking alternative resources

Many schools lack resources for teaching and learning GIS (Breetzke et al., 2011; Fleischmann & van der Westhuizen, 2017; Mzuza & van der Westhuizen, 2019b). The rural learning ecology where this study was conducted was not an exception to the norm. For instance, findings from this study revealed that the school did not have computers and software to demonstrate the use of GIS (see section 5.4.3). Also, the school had a shortage of maps (topographic and orthophoto) for integrating GIS and the basic mapwork content as per CAPS policy (Department of Basic Education, 2011). This shortage of resources in the rural learning ecology confirms the marginalisation of certain areas by the dominant political, social and economic structures as espoused by the CER theory. The legacy of apartheid marginalised rural learning ecologies while providing resources for schools located where the privileged lived. Hence, seeking alternative resources becomes an essential endeavour for the empowerment of the marginalised. This highlighted a need for creative solutions to mitigate the lack of resources for teaching GIS such as looking beyond what the school had to offer and understanding what resources are available in the community.

Through our deliberations with the co-researchers, they indicated there was a municipal library not very far from the rural learning ecology where the study was conducted. Therefore, learners were encouraged to make use of the library available in their neighbouring community. However, it would have been better if the library was in the rural learning ecology for learners to access it easily. Nonetheless, teachers had to be instrumental in ensuring that learners visited the library by providing them with structured Inquiry activities (see section 2.3.1). Banchi and Bell (2008) revealed that in a structured Inquiry a teacher provides learners with questions and guidance on how to go about answering those questions – this means that it is prescriptive in nature as the learners are provided with questions and guidance on how to answer questions. This was fitting in the rural learning ecology where this study was carried out because learners were not used to being taught with IBL, so they required scaffolding to get used to it. We saw this

teaching approach as fitting in an environment with resource constraints because it would enable teachers and learners to work collaboratively to mitigate this predicament.

The shortage of maps was a major impediment in the teaching of GIS in this rural learning ecology given the fact that one of the many reasons GIS was introduced in secondary school was to enhance maps skills (Goldstein, 2010; Mzuza & van der Westhuizen, 2019b). This makes it even more difficult for learners to understand the functions of GIS if they have not been taught the foundational map interpretation and skills. To mitigate this challenge during this study, the subject advisor indicated that he would send a request to the DBE's examinations office for extra maps so that learners can be taught mapwork adequately and to explore the relationship between mapwork and GIS content. The student teachers then suggested that as we wait for the DBE examinations office, learners should be given a task to draw their own maps. This suggestion was welcomed by the co-researchers as it would expose learners to one of the many roles of GIS specialists which is map-making (see section 2.3.2).

In conclusion, the above section has demonstrated that when different stakeholders come together, they can discuss ideas that lead to positive change. This is because initially the teaching of GIS was negatively impacted by resource constraints as the school did not have computers. However, when the co-researchers and I deliberated we were able to come up with creative solutions to ensure that learners are taught GIS regardless of the shortage of computers and maps. Although much more GIS content and pedagogy discussions and resources are needed to facilitate the teaching of GIS in this rural learning ecology due to this research study there was a change in this regard as the co-researchers and I were empowered to teach GIS. This is in line with CER because it advocates for change brought about by the people who are affected by the problem (Dube & Hlalele, 2018; Mahlomaholo & Nkoane, 2002).

6.4.4 A change in attitude

The findings of this study reveal that there was a change in attitude in terms of the way that the teachers perceived GIS content and pedagogy (see section 5.4.4). The change in attitude by teachers during this study confirms the view by CER that people need to be conscious of the societal challenges and need to engage in reflective practice. The reflective practice by the co-researchers facilitated their identification of teacher negative attitudes as a hinderance in the teaching of GIS. Thus, the findings from this study can be argued to be consistent with the CER theory on the key aspect of emancipatory knowledge.

Initially, the teachers' attitude towards GIS was negative because of a lack of support from the DBE. During the course of this study, the subject advisor revealed that according to him GIS content is not complicated. He supported this view by stating that the only hurdle that contributes to teachers having a negative attitude toward GIS content and pedagogy is because they were not trained in the latter as it was a newly introduced topic in the secondary school Geography curriculum. Thereafter, the subject advisor revealed that he had to capacitate teachers more in terms of GIS content and pedagogy.

Several research studies (Akinyemi, 2016; Fleischmann, 2012; Singh et al., 2012) concur with the findings from this study by revealing that teachers usually have a negative attitude towards GIS content and pedagogy because they lack training in this regard. While Demirci (2009, p. 43) found that teachers' attitudes were positive towards GIS, although, "more than half of the teachers (66%) had no precise understanding of what GIS is and 82 per cent of the teachers did not know how it could be used in geography lessons". This shows that for most teachers, the lack of GIS training results in a negative attitude towards teaching this section, while some teachers might have a positive attitude towards GIS even though they lack an understanding of what GIS is, as the findings of Demirci (2009) suggest. This discrepancy in findings regarding the relationship between teacher attitude and lack of training requires further research so that the teaching of GIS can be improved.

Because teacher attitude towards GIS content knowledge has an impact on learner attitude.

6.5 DISCUSSION OF FINDINGS ON THE BENEFITS AND CHALLENGES OF USING THE IBL FRAMEWORK TO TEACH GIS IN A RURAL LEARNING ECOLOGY

Some benefits of using the IBL approach to teach GIS are presented in the next section.

6.5.1 The IBL approach is flexible

This study found that one of the benefits of using the IBL approach is that it is flexible in the sense that learners are engaged during the lesson (see section 5.5.1). This finding is in line with previous research that has been conducted on the benefits of the IBL approach. For instance, Aditomo, Goodyear, Bliuc and Ellis (2013) and Krämer, Nessler, and Schlüter (2015) claim that many teachers use the IBL approach to explore the knowledge, skills and values that learners bring to their classrooms. By having this baseline information, teachers can plan their lessons effectively to move with the learners from the known (previously learnt knowledge, skills and values) to the unknown (newly introduced knowledge, skills and values). In the case of this study, this is particularly important when introducing new GIS content knowledge and skills as the IBL approach would enable the teacher to ask questions about what learners already know about mapwork and GIS so that he/she may introduce new content knowledge and skills (Wang, Wang, Tai, & Chen, 2010). Thus, the latter benefit of using the IBL approach makes it a suitable approach for teaching GIS as it allows learners to be involved actively in the lesson.

6.5.2 The IBL approach promotes self-directed learning and collaboration skills

Findings from this study also suggest that one other benefit of using the IBL approach is that it promotes self-directed learning and collaboration skills (see section 5.5.2) meaning that a teacher that employs the IBL approach may design activities that require learners

to work individually or as a group to complete tasks (Hmelo-Silver, Duncan, & Chinn, 2007; Jakab et al., 2016). The latter activities can be completed in the classroom as well as outside the confines of the classroom. Giving learners access to knowledge and resources that their classroom might not have. For instance, the rural learning ecology where this study was conducted did not have adequate resources for teaching GIS. Thus, when the teacher designs structured-Inquiry activities learners can make use of the resources that are found in external places such as libraries to develop their GIS content knowledge and skills.

According to Botha (2017, p. 39) teaching using the IBL approach includes the "creation of a classroom where learners are engaged in (essentially) open-ended and learner-centered hands-on activities." One advantage of working as a group to complete open-ended and hands-on activities is that learners can develop communication skills as they engage with group members to capture data for a fieldwork task. This helps to prepare learners for their future as many companies in the 21st century regard communication and data capturing skills as essential in the workforce. Meaning that as the teacher makes use of the IBL approach, he/she is not only teaching learners to fulfill the needs of the present, however, he/she is developing skills that are necessary for the learners' future roles, for instance, a GIS specialist needs to have good communication skills to communicate and interpret their research. In the subsequent section, I discuss two challenges of using the IBL approach to teach GIS.

6.5.3 Reluctance of teachers and learners to explore the IBL approach

One of the challenges to the use of IBL for teaching GIS in the rural learning ecology that this study found is that teachers may be reluctant to use the IBL approach in their teaching because they lack knowledge of IBL (see 5.5.3). Furthermore, the study found that learner behaviour may be a hindrance to the use of IBL in the rural learning ecology because many of them are demotivated to learn because of alcohol and drugs (see section 5.5.3). This means that to experiment with the IBL approach, the co-researchers and I needed to be trained in what it means to teach from an IBL perspective. This was covered in the

workshop that was discussed in sections 4.8 and 5.4. Also, both teacher and learner roles in an IBL environment had to be outlined so that everyone knew what was expected of them more especially because the teacher co-researchers were used to using traditional teaching approaches to get learners to memorise GIS concepts. Similar findings regarding the teaching of GIS using traditional teaching approaches have been reported (Fleischmann et al., 2015; Mkhongi & Musakwa, 2020).

During the IBL workshop, the teacher co-researchers, through reflecting on their teaching, realised that they now see that their role when making use of the IBL approach must be one of being a facilitator of learning and that they needed to plan for their lessons timeously so that they may have all the required resources (Fitzgerald et al., 2019). Poon and Lim (2014) caution that teachers making use of IBL must be aware that there might be a rise in behavioural challenges given learners having autonomy in the learning. Therefore, teachers must develop unique classroom management skills so that learners do not make excessive noise when they ask questions and when they work collaboratively in groups. So, we found that the teacher and learner attitudes toward the IBL approach became positive when they were made aware of what it is and the different roles that each stakeholder had to play. Interestingly, the teacher and learner co-researchers were excited about being partners in the teaching and learning of GIS. Unfortunately, the drug and alcohol problems that have been reported as hindrances to using the IBL approach were beyond the scope of this study. However, the teacher co-researchers were advised to report this issue to the school management team and to the parents of the affected learners as it disturbed them from carrying out their duties. Also, more research is needed on the behavioural challenges that prevent teachers from carrying out their duties and on mitigation strategies.

6.5.4 Time constraints

Findings of this study reveal that the learner co-researchers experience challenges when they wish to put in extra hours towards their schoolwork at home. This is because they spend enormous time doing chores. This finding is in alignment with research that has

been conducted on poverty and its impact on education, where Van der Berg (2008, p. 12) found that “home circumstances are often not conducive to learning in many poor communities. These include factors such as a lack of lighting, spending much time on domestic chores”. Similar findings have been reported by Strassburg, Meny-Gibert and Russell (2010), who researched barriers to participation in schooling. One way of overcoming such barriers is by involving parents more in education issues where the teachers negotiate with parents regarding schoolwork that must be completed outside of school hours. This way parents will become aware of the kind of support that their children require to meet the educational outcomes.

This study also found that teacher co-researchers experience time limitations when they wish to explore student-centred teaching approaches. According to the teacher co-researchers, they are of the view that the policy developers and the school management team place more emphasis on teaching rather than learning since their focus is on the completion of the curriculum. After all, the CAPS policy prescribes time limits that should be spent on teaching Geographic knowledge, skills, and values (Department of Basic Education, 2011; Mkhongi & Musakwa, 2020). The argument that the teacher co-researchers presented was that there is limited time assigned for teaching GIS. As a result, this makes traditional teaching approaches more attractive as they save time because there is no student engagement.

Traditional teaching approaches are problematic in the teaching of GIS because they did not cultivate application and analytic skills in the rural learning ecology where this study was conducted. Moreover, such teaching approaches are in contradiction with the IBL since it views teachers and learners as partners in education (Pappas, 2014; Pedaste et al., 2015). This finding indicated that there was a need for teachers to engage with policy developers and with the SMT regarding the allocated time for teaching content such as GIS being insufficient as well as to highlight the need for field trips in the teaching of GIS. However, this was beyond the scope of this study, therefore, more research is needed in this area to understand how policy decisions are made and the need to involve teachers in those decisions as the teacher co-researchers indicated that they are just meant to

implement the prescribed policy. From the challenges mentioned above, it becomes apparent that different stakeholders that are involved in educational matters should communicate regularly to overcome the challenges experienced by teachers and learners so that the teaching of GIS using the IBL approach may flourish in the rural learning ecology.

6.6 DISCUSSION OF FINDINGS ON THE IMPLICATIONS OF THE USE OF AN INQUIRY-BASED LEARNING FRAMEWORK TO TEACH GIS IN A RURAL LEARNING ECOLOGY

The implications discussed in the following section emanate from the data on the initial challenges of teaching GIS in the rural learning ecology (see section 5.2).

6.6.1 Addressing negative teacher attitude through training

The findings of this study reveal that the teacher co-researchers had a negative attitude towards the teaching of GIS because they were not trained to teach this in their initial teacher training programmes (5.6.1). Also, when they started working as Geography teachers, they were not offered professional development opportunities to train them in GIS content knowledge and pedagogy. Lack of GIS teacher training and the usage of educational training has been widely reported in the literature (Fleischmann & van der Westhuizen, 2017; Jantijies, 2019; Mzuza & van der Westhuizen, 2019a; Rienties, Brouwer, & Lygo-Baker, 2013). This finding necessitated having open conversations with the teacher co-researchers about their strengths and areas of development regarding GIS content knowledge and pedagogy.

During the open conversations, this was where the teacher co-researchers opened up about the coping mechanisms that they used to teach GIS and the shortfalls of the latter. This highlighted a need for training the teacher co-researchers as well as the rest of the co-researchers. The training took place in the form of a workshop (see sections 5.6.1, 5.4.1 and 4.8). After training teachers on GIS and the IBL approach, there was a shift in

the attitude of teachers from being negative to being positive. This clearly showed that the teacher co-researchers were willing to teach GIS, however, they lacked GIS content knowledge, skills and a suitable pedagogy for teaching the latter such as the IBL approach.

6.6.2 Mitigating the lack of resources barrier

The findings of this study show that the rural learning ecology where the study was conducted was no exception to the norm in terms of the shortage of resources for teaching GIS (see section 5.2.3 and 5.6.2). It is widely reported in the literature that many schools lack resources such as computers and software for teaching GIS (Breetzke et al., 2011; Fleischmann & van der Westhuizen, 2017; Kerski et al., 2013). Furthermore, schools within rural learning ecologies are mainly affected by a lack of resources due to the apartheid legacy as more funding went to urban schools rather than rural schools (Allsop, 2006; Gina, 2015). Although, the government has taken significant steps to close the resource gaps between rural and urban schools, much more needs to be done to bring about equity in terms of resources.

In terms of this study, the lack of resources barrier was mitigated by exploring an alternative approach for teaching GIS. More specifically, the IBL approach, where structured and guided Inquiry were utilised because it enabled learning to occur outside the confines of the classroom. For instance, learners were given research activities to carry out in groups. To respond to the research questions, they had to consult the library for information and resources. This approach worked because learners were able to source information and resources that was not available in the rural learning ecology. These research activities can be argued to be in line with the problem-posing approach espoused by emancipatory pedagogy.

During the study, the co-researchers and I discovered that the physical resources such as rivers and mountains that are found within the rural learning ecology can be used to teach GIS because the teachers can organise local field trips to these sites where learners

can engage in activities like data generation and analysis as GIS specialists engage in such tasks. Furthermore, learners were required to create a map of the physical features that they pass from home to school. This was a good practical exercise because it provided a link between the learners' immediate home environment and the theory that they learn from Geography textbooks. This contributed to mitigating the challenge of resource shortages in the teaching of GIS in the rural learning ecology.

6.6.3 Addressing the negative learner attitude

Finding from this study reveal that using the Inquiry-Based Learning approach to teach GIS in a rural learning ecology was problematic at first given the fact that there was limited learner participation during lessons (see section 5.5.3). This can be attributed to the fact that learners were accustomed to the traditional approaches used to teach GIS previously. Thus, they were unwilling to answer questions during the initial GIS lessons that made use of the IBL approach. Lotter, Yow, and Peters (2014) and Voet and De Wever (2016) concur with the findings of this study because when they researched the adoption of the IBL approach, they found that generally transitioning from traditional teaching to IBL approach was difficult. Therefore, teaching using the IBL approach is not common in many classrooms.

In the rural learning ecology, we found that one of the effective ways to encourage learner participation during the GIS lessons was to first ask learners general questions about sports, weather, and the soapies that they like. This strategy worked very well because it sparked conversation. Learners started to open up about what was happening in the TV shows. Thereafter, we gradually shifted the conversation to GIS content by asking open-ended questions and the learners participated in the lesson. Another strategy that we experimented with to encourage learner participation was dividing learners into small groups to engage in GIS content with their peers. We found this strategy to be effective too because it gave the learners who were shy to speak in front of the whole class the freedom to express themselves. Also, learners were encouraged to ask questions as a group rather than as individuals – we found that the latter encouraged more learner

participation. Thereafter, there were reflections at the end of the lesson to ascertain whether or not the learners felt supported to learn GIS using IBL. The response was positive in general and negative feedback was used to improve subsequent lessons. The co-researchers and I learnt that without attending to the negative learner attitude it would have been impossible to teach GIS using the IBL approach because learners would have not participated during the lessons as they were used to teacher-centred lessons.

6.7 SYNTHESIS

In this chapter, I discussed the findings according to the research objectives and the CER theory. First, I began by discussing findings on the current situation of teaching GIS in the rural learning ecology. There were many challenges in this regard caused by the lack of training for the subject advisor as well as the teachers and the lack of resources for teaching GIS. Second, I discussed findings on establishing the need for the IBL framework to teach GIS in the rural learning ecology. This need was justified on the basis that Geography studies human and environmental relationships, therefore, learners should cultivate understanding rather than knowledge recall, because future careers in Geography will require them to solve problems. Third, I discussed findings on the circumstances under which the IBL may be used to teach GIS in the rural learning ecology such as the sharing of expertise and lived experiences and the exploring of an alternative teaching approach.

After a discussion of the above findings, I went on to discuss findings related to the benefits of teaching from an IBL perspective such as the fact that it promotes self-directed learning and collaboration skills. I also discussed the challenges of using IBL such as the reluctance of teachers and learners to explore with the IBL approach and time constraints. Lastly, I discussed the implications for the use of the IBL approach such as its role in addressing the negative teacher and learner attitude towards the subject and mitigating the resources barrier. What I learnt from the transcriptions was that I had to contextualise the findings within the literature covered in the literature review as well as the theoretical framework. I did this to show how the findings relate to what other scholars have written

about teaching GIS in secondary schools globally and locally as well as the research that has been conducted on teaching from the IBL perspective.

CHAPTER SEVEN
TOWARDS AN INQUIRY-BASED LEARNING FRAMEWORK FOR TEACHING GIS IN A RURAL LEARNING ECOLOGY: CONTRIBUTIONS, CONCLUSIONS AND IMPLICATIONS

7.1 INTRODUCTION

In the previous chapter, I discussed the findings according to the research objectives, using the literature review, the Critical Emancipatory Research theory and Participatory Action Research. In this chapter, firstly, I present a brief overview of the conditions that led to the proposed Inquiry-Based Learning (IBL) framework for teaching Geographic Information Systems (GIS) in a rural learning ecology. Secondly, I outlined the key players in exploring the framework. Thirdly, I discussed the circumstances that allow the use of the framework. Fourthly, I examined the contributions of the study and its conclusions. After that, I suggested implications for further research. Lastly, I reflected on my doctoral journey before providing a synthesis of the chapter.

7.2 ABOUT INQUIRY-BASED LEARNING

Inquiry-based learning (IBL) is an approach to learning that encourage students to ask questions and to share their ideas about a topic (see section 2.3.1). IBL is deeply rooted in the constructivist theory. The latter theory advocates for active learning, which means learning by doing (Ratinen & Keinonen, 2011). It promotes student-centredness, in which learners are actively involved in their learning through engaging in hands-on experiences and through asking questions. Moreover, in IBL settings, learning occurs in a social context, meaning that learners learn together and from one another.

In an IBL classroom, the teacher's role is one of being a facilitator (see section 3.9). Whereby he/she is expected to ask questions to ascertain what learners already know and to build upon this by sparking curiosity in learners. Additionally, the teacher places equal emphasis on the subject content, communication, reflecting, analysing, and

collaboration to cultivate learners' inquiry skills. The teacher is also expected to organise the resources that learners will need during an inquiry activity. Also, the teacher is likely to reflect throughout the process to establish if the learning outcomes are being met and to engage with learners consistently to gain a deeper understanding of how they learn.

This IBL framework for teaching GIS in a rural learning ecology proposed in this study emanated from findings of a collaborative Inquiry in which different stakeholders that had an interest in the teaching of GIS in a rural learning ecology worked together to bring about change in the way that GIS was taught to grade 10 and 11 secondary school learners. The stakeholders were teachers, learners, a subject advisor, student teachers and lecturers. As it can be observed from the latter the stakeholders were from different settings within basic and higher education. This meant that there were different knowledges, skills and lived experiences the co-researchers possessed, which facilitated learning with and from each other. The findings of this study provided the foundation for this framework as well as studies that I reviewed during the course of this study.

The IBL framework for teaching GIS was responsive to the challenges of teaching GIS in a rural learning ecology where the study was conducted. The challenges included the lack of resources for teaching GIS. The lack of resources is widely acknowledged in the reviewed literature of this study and it is prevalent in many rural learning ecologies in South Africa. However, findings from this study reveal that the impact of lack of resources on the teaching of GIS can be mitigated through collaboration. Collaboration has so much power according to this study. Therefore, it came to be concluded that the most fundamental resource that is required for the framework to function is human resourcefulness.

Human resources in this context includes teachers, learners, the subject advisor, student teachers and lecturers who are committed to bringing about change. Such people are expected to volunteer their time, skills and expertise to see the project through, and this was the case with the co-researchers who participated in this study. Planning and reflection sessions were an essential part of this study and they were mandatory as the

PAR methodology was employed and its cycles include planning, acting and observing, and reflecting. Engaging in the PAR cycles was taxing in terms of time. Despite this, the co-researchers kept attending the different meetings that led to the proposed framework for teaching GIS in a rural learning ecology.

7.3 THE KEY PARTNERS IN EXPLORING THE USE OF THE INQUIRY BASED LEARNING FRAMEWORK FOR TEACHING GIS IN A RURAL LEARNING ECOLOGY

The key partners in exploring the use of the IBL framework for teaching GIS in a rural learning ecology were the Geography subject advisor, two Geography teachers (one taught grades 10 and 11 and the other one taught grades 11 and 12), learners from grades 10 and 11, final year student teachers and two lecturers (Geography education and GIS). All these co-researchers made valuable contributions to the IBL framework for teaching GIS. Their contributions are outlined in Figure 7.3 below:

Key Partners	Objectives	Actions
Geography Teachers	To plan, teach and reflect on all lessons	Designing lesson plans, teaching and reflecting, liaising with the SMT and the municipal library staff to organise resources
Subject Advisor	To plan, teach and reflect on all lessons	Facilitating professional development workshops, designing lesson plans and liaising with the DBE to provide the necessary resources such as maps
Learners	To participate during lessons and to reflect on all the lessons	Reflecting on the taught lessons. The feedback provided was used to shape subsequent lessons.
Lecturers	To plan, teach and reflect on all lessons	Facilitating professional development workshops, designing lesson plans, observing lessons and reflecting.
Student teachers	To plan, teach and reflect on all lessons	Facilitating professional workshops, designing lessons, teaching/observing lessons and reflecting

Figure 7.3 Key players in exploring the use of the IBL framework for teaching GIS

7.4 THE CIRCUMSTANCES UNDER WHICH AN INQUIRY-BASED LEARNING FRAMEWORK MAY BE USED TO TEACH GIS IN A RURAL ECOLOGY

The circumstances that should be considered for using the IBL learning framework to teach GIS involve building relationships and sharing of expertise, professional development to equip stakeholders to explore the IBL approach to teach GIS, seeking alternative resources and a change of attitude.

7.4.1 Building relationships and sharing of expertise

Before sharing expertise, it is crucial for the co-researchers to build trust and rapport. This is because the PAR methodology requires prolonged engagement and calls for the co-researchers to be honest with one another about their strengths and weaknesses as they embark on a journey of learning with and from each other. Considering the latter, it can be concluded that building relationships amongst the co-researchers is necessary for the IBL framework to teach GIS in a rural learning ecology.

Opportunities to network amongst the co-researchers is imperative to enable the use of the IBL framework to teach GIS because as the co-researchers interact it becomes possible to tap into the knowledge, skills and lived experiences that each co-researcher brings to the table allowing for the sharing of expertise to occur, empowering the co-researchers as they learn with and from each other. Sharing expertise and lived experiences is useful for planning the intervention, implementing it and reflecting on the process as the co-researchers engage in a collective co-learning journey.

7.4.2 Professional development to equip stakeholders to explore the IBL approach to teach GIS

One of the findings of this study was that the teachers and the subject advisor were not trained to teach using the IBL approach in their initial teacher training. As a result, there was a need for capacity building in this regard as they were experimenting with an alternative teaching approach. Therefore, for the IBL framework to work, professional development is necessary to empower teachers and the subject advisor to move from a position of delivering content (traditional teaching approach) to where they can focus on

helping learners learn (IBL). Professional development was instrumental in addressing the training gap in IBL. Teaching from an IBL perspective means that teachers must concern themselves with how learners learn. Teachers must first be familiar with conceptual frameworks that structure Geography as a school subject, the habits of the mind that are important to the latter discipline. Notably, the development of spatial thinking and teaching with maps as the focus of this study was GIS.

Teachers must understand how learners construct new knowledge. In so doing, they can scaffold effectively and develop strategies and skills of teaching GIS using IBL. Appropriate scaffolding on the teacher's side is helpful in an IBL classroom to meet the needs of the learners. Learners should be provided with more guidance especially when IBL is introduced to learn GIS theory and for practicals. Given the expected roles that a teacher must perform in an IBL classroom and beyond, professional development is fundamental upon introducing IBL and ongoing support until the various stakeholders understand the newly introduced teaching and learning approach. Teachers who lack experience with the inquiry process can start with a more structured, guided inquiry method before extending toward more open forms of Inquiry. This means that the elementary stages of professional development in IBL should be focused on supporting teachers to implement structured and guided Inquiry.

When teachers are confident with the more structured and guided Inquiry, open forms of Inquiry can be introduced gradually. In addition, classroom management skills are essential in an inquiry classroom, specifically, dealing with learners going off topic and losing focus. Therefore, the professional development sessions should include conversations regarding classroom management skills. The professional development opportunities can be offered in the form of ongoing workshops. Furthermore, the training provided at the professional development opportunities must be relevant to the curriculum. This is important because teachers' responsibilities include fulfilling the needs of the curriculum and the CAPS policy outlines the GIS content to be taught to grades 10-12 secondary school learners. Hence this study's focus was to explore the use of IBL to teach GIS in a rural learning ecology. To conclude, reflection is a crucial element in the

professional development endeavours because it would help to assess whether or not the training provided is adequate to support the teachers to experiment with IBL and to meet the needs of the curriculum. Equally important, the reflection sessions should inform planning for the upcoming training workshops.

7.4.3 Seeking alternative resources

The effort required to change teaching practices from being teacher-centred to student-centred such as in IBL requires the necessary resources for both learners and teachers. Resources such as enough topographic and orthophoto maps are necessary to have in an IBL environment so that learners can perform practical tasks using maps and applying some of the GIS concepts that they have been exposed too. Additionally, map drawing skills should be cultivated in learners and they need to be provided with the necessary resources such as textbooks, pencils, rulers, erasers, sharpeners, tracing paper etc. Equally important, GIS software and hardware is also required to teach GIS effectively as it would provide learners with the opportunity to interact with the actual GIS software rather than imagining how it operates.

Given that many schools in rural learning ecologies lack the resources for teaching GIS. This study suggests that teachers should partner up with local libraries by forming a working relationship with the librarians in order to enable learners to access resources that are not available in the schools such as computers and internet connection. These would be useful when teachers plan inquiry activities because they would alert the librarians about the project then when learners visit the library they can be supported adequately. Moreover, teachers must communicate their need for resources for teaching the school administrators as well as the subject advisor because the former controls the school's budget and the latter has a responsibility to ensure that the teachers are supported adequately to carry out their teaching duties.

7.4.4 A change in attitude

For the IBL framework to work there has to be a change in attitude in both teachers and learners. More particularly, in an environment where the teaching approaches have been predominantly traditional. Where learners view a teacher as the primary source of information in most cases, consequently, there is limited learner engagement because teachers view learners as passive receivers of knowledge. According to this study the general attitude adopted by the teacher co-researchers was that I will teach and learners will listen. Whereas in an IBL environment, a shift from teacher-centred to student-centred teaching is necessary. This is because in a student-centred environment, teachers take on the roles of facilitators and learners interchangeably. Hence, a change of attitude would contribute to seeing learners as bringing value to the lesson because they have rich experiences to share with the rest of the class. Thus, the teacher would ask questions and allow learners to tap into learners' experiences to move with them from the known to the unknown. Moreover, for the IBL framework to be effective in teaching GIS, the teacher would also be expected to design group work activities.

The change in teacher attitude might cause a change in learners' attitudes. In many cases, learners who are taught using the traditional approach would be so used to being on the receiving end of teaching and being passive during lessons. So, teaching from a student-centred approach requires a change in learners' attitudes because they assume an active role in their learning. Moreover, they may collaborate with their peers to complete group work activities. The change in attitude in both teachers and learners can be made possible through support resulting from relationship building and sharing of expertise (see section 7.4.1), professional development workshops to explore an alternative approach to teaching (see section 7.4.2) and consistent reflections throughout the process.

7.5 OUTLINING THE INQUIRY-BASED LEARNING FRAMEWORK

This section outlines the IBL framework for teaching GIS in a rural learning ecology. The IBL framework draws from the findings of this study, along with the Inquiry model of Alberta Learning (2004). The Alberta Learning Inquiry model (2004) reflects the cross-curricular and the transferable nature of IBL, thus making it suitable for teaching GIS as it may allow learners to engage in technological Inquiry. It consists of six phases that inquirers have to engage in; planning, retrieving, processing, creating, sharing, evaluating and reflecting on the process. The Inquiry model is a non-linear approach where teachers and learners engage in different stages such as planning, retrieving, processing, sharing and evaluating whilst consistently reflecting on the process throughout the Inquiry (Learning, 2004).

Through analysing several Inquiry models, the Alberta Learning Inquiry model (2004) stood out for the co-researchers and I for several reasons. Firstly, just like the PAR methodology used in this study, the Alberta Inquiry model places an emphasis on planning and reflecting amongst other things. Planning and reflecting are crucial elements in education, as they involve planning for lessons and reflecting on the taught lessons with an aim of improving future lessons. Secondly, the Alberta Inquiry model encourages sharing through communication which relates to some findings of this study as building relationships and sharing of expertise is necessary to enable the of teaching GIS using the IBL framework in a rural learning ecology. Lastly, the Alberta Inquiry model aligns with the Guided Inquiry proposed by Kuhlthau's et al., (2015) that states that inquiries follow unilinear general cognitive and affective patterns. As a result, learners need to be supported through a process of reflection for them to adjust to the nonlinear, flexible and recursive nature of inquiry (Learning, 2004, p. 9). This is why teachers assume the role of facilitators in an IBL environment.

The following figure presents the main objective of the study, which is teaching GIS using an IBL framework. Furthermore, based on the findings of this study, it shows the circumstances that are necessary for teaching GIS using an IBL framework as outlined in section 7.4 in conjunction with the Alberta Learning Inquiry model.

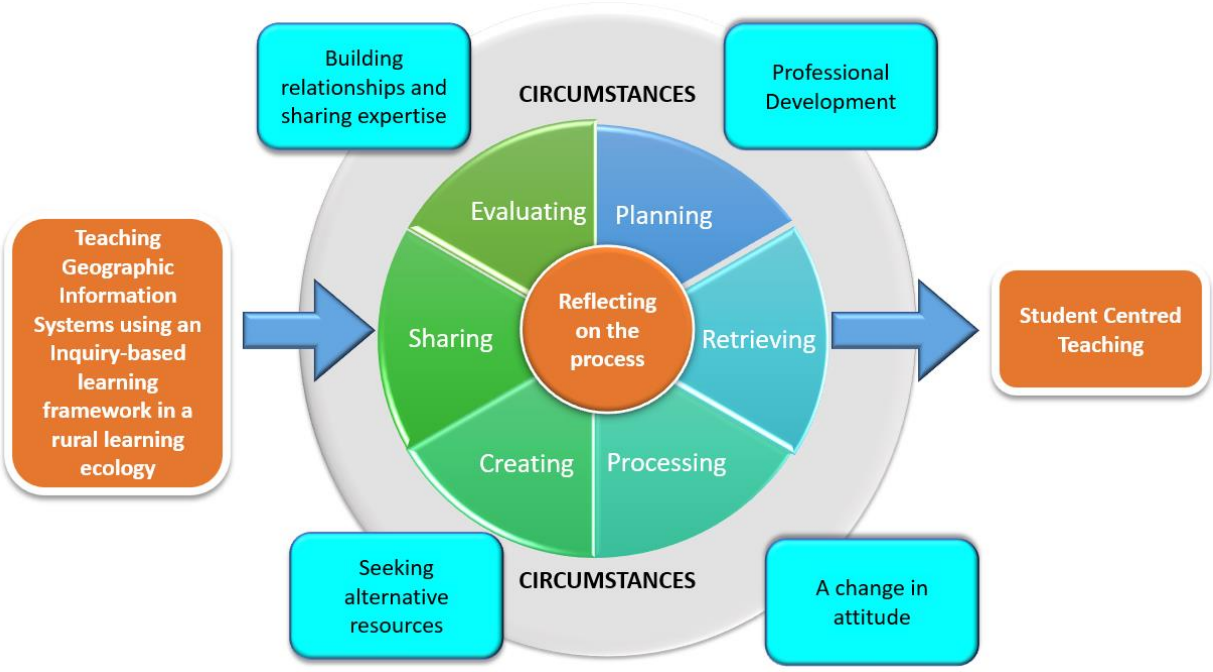


Figure 7.5 An Inquiry-Based learning framework for teaching Geographic Information Systems in a rural learning ecology

7.6 CONTRIBUTIONS OF THIS STUDY

7.6.1 Theoretical contribution

The teaching of GIS is a challenge to many South African secondary schools due to a number of reasons such as the unavailability of resources such as computer software and hardware as well as teachers that are skilled to teach it because it was introduced at a later stage in the Geography school curriculum compared to other content that is prescribed by the CAPS policy. Literature also cites lack of clear implementation guidelines as the hinderance to successful implementation of GIS in South African schools (Eksteen et al. 2012; Zuma, 2016). In light of the latter, this study adds value to the efforts that work to advance GIS pedagogy by advocating for the use of the IBL framework in teaching GIS thus, mitigating the gap of the lack of clear guidelines of implementing GIS in South African secondary schools that is often cited in GIS education literature. Teaching using the Inquiry-based learning

framework calls for teachers to see learners as active in knowledge construction and to create a space in their classrooms and beyond for intellectual curiosity that emerges from the lived experiences of learners as they teach GIS.

7.6.2 Methodological contribution

Within the field of education, this study asserts the profound value of PAR in studying educational challenges. This study has shown that PAR enables co-researchers to define a problem and find a solution collaboratively. Through the application of PAR cycles, the co-researchers are able to engage in the journey of self-empowerment as a result of learning with and from each other. This shows that PAR is emancipatory as it provides for people to solve their problems. None of the South African studies that I have reviewed have used the PAR methodology to study the teaching of GIS. Therefore, this study is unique because it used a different methodology to study the teaching of GIS. Thus, creating a platform for various stakeholders to come together and engage in communicative action to improve the teaching of GIS.

The use of the PAR research methodology in this study has demonstrated its potential value as a tool for training for all the co-researchers. Through engaging in this study, the co-researchers went beyond gaining practical research experience to gaining training on Inquiry-based learning as a teaching approach and on GIS content and practical knowledge that was covered during the workshops. This enhanced practice-related skills to mitigate some of the barriers that negatively impacted the teaching of GIS in the rural learning ecology where this study was conducted. Co-researchers acknowledged that they gained valuable experience through the use of the PAR methodology, which included planning, acting, observing and reflecting (Cumming & Norwood, 2012; Kemmis, McTaggart & Nixon, 2014), as they were expected to engage in such activities during the course of the study. Similar benefits have been identified by other scholars, such as feeling esteemed and empowered through the use of PAR (Dudgeon et al. 2017; Esienumoh, Allotey, & Waterman, 2018). Which implies that PAR is indeed an empowering methodology as it cultivates certain skills.

The co-researchers reported feeling heard and they valued the development of significant and supporting relationships during the course of the study. This would not have been possible with many other research methodologies. PAR is unique in the sense that it requires the pro-longed engagement of the co- researchers as they are expected to work collaboratively over a more extended period. Experience gained through the application of PAR, the transformative paradigm and the methods used for generating data proved that PAR might be useful for other studies focused on teaching GIS across different contexts.

7.7 CONCLUSIONS

This study addressed the following critical research question: *How can an Inquiry-based learning framework inform the teaching of Geographic Information Systems in a rural learning ecology*? To interrogate this critical research question, I developed five secondary questions that guided this study (see section 1.6). The co-researchers in this study revealed that they experienced several challenges regarding the teaching of GIS, such as lack of formal GIS training and inadequate resources. The latter is widely acknowledged in literature (Fleischmann & van der Westhuizen, 2017; Kerski, Demirci, & Milson, 2013; Mkhongi & Musakwa, 2020). According to the co-researchers, the latter circumstances resulted in them having a negative attitude towards teaching GIS to learners. The teacher co-researchers also recognised their limitations regarding GIS content knowledge and skills. As a result, they adopted traditional teaching approaches (teacher-centeredness) to teach GIS concepts only rather than exposing learners to applying the concepts in different scenarios. The traditional approaches used were not producing the desired outcomes of learners responding adequately to GIS application questions. Hence, there was poor learner performance in GIS application questions (Department of Basic Education, 2018). The shortcoming of the traditional approaches is one of the reasons why there was a need for an IBL framework to teach GIS in this context.

Given that the co-researchers and I were introducing the idea of teaching from an Inquiry-based learning perspective in this context for the first time, the co-researchers needed to organise and attend workshops to learn from and with one another. The workshops facilitated sharing expertise and lived experiences amongst the co-researchers as we explored the alternative approach to teaching GIS. GIS is technology after all, and as a result, teachers need to be supported to teach it, especially those who were not trained to teach it. Bingimlas (2009); Winter, Costello, O'Brien and Hickey (2021) state that effective professional development has to be provided to teachers for technology integration to flourish in schools. Moreover, the co-researchers made the point that a new teaching approach meant additional teaching resources were needed to facilitate IBL. Resources to complement textbooks, as textbooks are considered one of the most common resources found in South African classrooms (Ramnarain & Padayachee, 2015) particularly resources such as computers, GIS software and access to the internet.

The co-researchers alluded to the fact that both teacher and learner co-researchers required a change of attitude to accommodate the new approach to teaching GIS. In an IBL classroom, teachers and learners become partners in education, where the teachers recognise that the learners' experiences are of value in the classroom. This was achieved by the co-researchers interrogating the possible benefits and challenges of using IBL to teach GIS. In so doing, they realised that both teachers and learners have a role to play in an IBL environment. According to the co-researchers, the implications of using the IBL approach to teach GIS include addressing the negative teacher and learner attitude towards GIS, encouraging learner participation during lessons, and devising creative solutions to mitigate the shortage of resources.

At the conclusion of this study, the teacher co-researchers planned to continue experimenting with the IBL framework to teach GIS because they saw its value. Moreover, the student teacher co-researchers also shared the same sentiments and expressed the conviction that they would use this teaching approach when certified as Geography teachers. The co-researchers showed excitement with their newfound learner-centred teaching approach. The enthusiasm was observed during the planning and teaching of

and reflections on the taught lessons. Over time the teacher co-researchers exhibited a willingness to trust and empower learners more. They let go of total control of the GIS lessons by creating space for learner engagement during lessons.

7.8 IMPLICATIONS FOR FURTHER RESEARCH

This study was conducted in a rural learning ecology in KwaZulu-Natal. A replication of this study in more diverse settings such as urban areas and townships may provide further insight into how an IBL framework may be used to teach GIS in such settings. This is because the latter contexts represent a variety of geographic locations and population groups with different socio-economic statuses. After all GIS is taught in many secondary schools across different provinces. Therefore, studies conducted in different contexts may yield differing findings. Given that at the initial stage of this study, traditional teaching approaches were more dominant in the classroom it may be beneficial to conduct future research aimed at investigating teachers' ability to facilitate learner-centred teaching using IBL.

A follow up study involving the teacher co-researchers and student teacher co-researchers that participated in this study would be of value to determine if there is sustained change in their teaching practice as a result of this study. Findings from such a research study may in turn provide insights for other educational practitioners that may wish to experiment with the use of IBL to teach GIS. Moreover, the teacher co-researchers that participated in this study had at least five years of teaching experience. As a result, they were relatively homogenised in terms of mindset and experience. Thus, a more diverse group of teacher co-researchers might bring new opportunities and challenges to exploring the use of an IBL framework to teach GIS. A group of older and more experienced Geography teachers may yield different findings.

One of the findings of this study was that many of the learner co-researchers are not given time and space to focus on their homework at home. Therefore, a study which investigates the beliefs and attitudes of parents towards engaging in schoolwork after

hours is needed. Particularly, to gauge if parents recognise the value of homework and of visiting libraries after school and on weekends. Findings from such a study would help teachers and the SMT to devise strategies to communicate to parents regarding the need for learners to spend extra time doing homework and be supported in this regard. Because the IBL framework requires learners to be engaged and to assume an active role in their learning, this is why they must spend additional time doing schoolwork.

7.9 REFLECTIONS ON MY DOCTORAL LEARNING JOURNEY

As I reflect on my doctoral learning journey, I feel that I have become more enlightened as a lecturer. Working with the co-researchers in this study over time, exploring our challenges, victories and lived experiences of teaching GIS was an eye-opening experience for me. The power of collaboration inspired me to be a better lecturer. Throughout the research process, I could relate to the co-researchers' stories, and I was amazed by the ideas, skills, and creativity they brought to the study. It was beautiful to learn with and from each other as we strived to become better teachers and learners every day. To be honest, before engaging in this study, I had never engaged in meaningful and deep professional learning.

My doctoral learning journey alerted me to my thinking patterns of focusing on the deficits and of feeling disempowered to act rather than to celebrate the opportunity to play an active role in finding solutions. Through working with different stakeholders, I have developed a great deal of patience and understanding. I have also learnt that there is so much power in accepting that that I do not know everything and that it is okay not to know everything. As a result, I learnt more humility and the value of being vulnerable. In the past, I saw vulnerability as a weakness and now I see it as a strength. My doctoral learning journey has taught me to let go of wanting control over everything and to trust more in possibilities. Most importantly, I have grown in my journey as a constructivist lecturer and I have learnt to trust my students more to assume a more active role in their education.

7.10 SYNTHESIS OF THE CHAPTER

In this chapter, I presented the Inquiry- based learning framework. Thereafter, I discussed the contribution of this study, conclusions and implications for further research. As I conclude this thesis, I have come to understand that the systematic barriers of teaching GIS can be overcome if stakeholders with different expertise collaborate to bring about change. My interest in conducting this study was mainly professional. As discussed in Chapter One, I decided to embark on the doctoral learning journey because I was concerned about the teaching of GIS at both basic and higher education level. As a former rural secondary school teacher who experienced difficulties in teaching GIS and a lecturer responsible for training student teachers, I knew that I had to attend to my lack of GIS training to better prepare the student teachers for their future roles as GIS teachers. Furthermore, I was concerned about the low learner performance in GIS in the NSC grade 12 examination as it was a clear indication that there might be a problem with how GIS is taught. Through an informal conversation I had with a Geography teacher from a rural school, he confessed that he lacks confidence in teaching GIS because he was not trained to teach it. I could relate to his experiences so much because I was also not trained to teach GIS.

The conversation I had with the teacher mentioned above led to the birth of this study. On that day, we decided to embark on a journey to improve our situation. We decided to invite the subject advisor, the other Geography teacher at his school, learners, other lecturers and student teachers who all participated as co-researchers in this PAR study. The journey was difficult at first because I brought different stakeholders together, developing trust and rapport took a few encounters. However, it became easy over time because we shared a common purpose of wanting to change the way that GIS was taught. As CER, the theoretical framework underpinning this study advocates for communicative action, empowerment and emancipation. The co-researchers and I developed several skills along the way, such as communication skills and organising skills. Furthermore, we had to display values such as tolerance, respect, honesty and patience. Also, we learnt together and from each other through engaging in the workshops about GIS and IBL.

The workshops gave birth to the IBL framework for teaching GIS in a rural learning ecology (see section 7.5). The IBL framework was still in its infancy in the rural learning ecology at the time of the write up of this study. However, the teacher co-researchers and I will continue to apply it in our teaching and share it with our colleagues during Geography workshops to assess its efficacy in different contexts to develop it further. In short, given the methodology of this study, there is flexibility in applying more PAR cycles because professional development is an ongoing journey rather than a destination. I am glad that I came across PAR as a research methodology during my doctoral learning. I was happy to discover that it helped the co-researchers and myself to create a collaborative, communicative space where we shared the challenges of teaching GIS and engaged in action to mitigate them. The Inquiry-based learning framework promises a bright future for offering engaging GIS lessons in a rural learning ecology.

REFERENCES

Aditomo, A., Goodyear, P., Bliuc, A., & Ellis, R. (2013). Inquiry-based learning in higher education: principal forms, educational objectives, and disciplinary variations. *Studies in Higher Education, 38*(9), 1239-1258.

Akinyemi, F. (2015). An assessment of GIS use for teaching in Rwandan secondary schools. *The Geography Teacher, 12*(1), 27-40.

Akinyemi, F. (2016). Technology use in Rwandan secondary schools: an assessment of teachers' attitudes towards geographic information systems (GIS). *International Journal in Geographical and Environmental Education, 25*(1), 20-35.

Akinyemi, A. F., Rembe, S., Shumba, J., & Adewumi, T. M. (2019). Allocation of time in communities of practice: A strategy to enhance continuing professional teachers' development of high schools teachers'. *Cogent Social Sciences*, *5*(1), 1-16.

Alberta Learning (2004). *Focus on inquiry: a teacher's guide to implementing Inquiry-based Learning*. Retrieved February 3, 2018 from https://open.alberta.ca/publications/0778526666

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of educational psychology, 103*(1), 1.

Alfreds, D. (2015). Gauteng digital school initiative 'doomed to fail'. *Fin24.* Retrieved March 21, 2018, from https://www.news24.com/fin24/Tech/Opinion/Gauteng-digital-school-initiative-doomed-to-fail-20150120

Allsop, T. (2006). Emerging Voices: a report on education in South African rural communities. *International Journal of Educational Development, 26*, 561-567.

Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How learning works: Seven research-based principles for smart teaching*. San Francisco, CA: John Wiley & Sons.

Anđelković, S., & Pavlović, D. (2015). New media in teaching of Geography: Literature Review. *Bulletin of the Serbian geographical society, 95*(4), 173-194.

Anderson, J. (2000). The "Third Generation" of the Frankfurt School". *Intellectual History Newsletter, 0*(22), 48-61.

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., . . . Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives, abridged edition.* White Plains, NY: Longman.

Andrews, T. (2012). What is social constructionism? *Grounded theory review, 11*(1), 39-46.

Anney, V. N. (2014). Ensuring the quality of the findings of qualitative research: Looking at trustworthiness criteria. *Journal of Emerging Trends in Educational Research and Policy Studies (JETERAPS), 5*(2), 272-281.

Ansari, S., Panhwar, A. H., & Mahesar, G. A. (2016). Mixed Methods Research: Ontological, Epistemological and Methodological Underpinnings. *An International Research Journal of Language and Literature, 27*, 133-141.

Aparicio-Ting, F. E., Slater, D. M., & Kurz, E. U. (2019). Inquiry-based learning (IBL) as a driver of curriculum: A staged approach. *Papers on Postsecondary Learning and Teaching*, *3*, 44-51.

Arnaboldi, M., Azzone, G., & Palermo, T. (2010). Managerial innovations in central government: not wrong, but hard to explain. *International Journal of Public Sector Management, 23*(1), 78-93.

Arslan, O. (2011). Learning with Geographic Information Systems in Turkey. *Published under Creative Commons Attribution License*. Retrieved February 15, 2019, from http://gispoint.de/fileadmin/user_upload/paper_gis_open/GI_Forum_2011/537510003.pdf

Asghar, J. (2013). Critical Paradigm: A Preamble for Novice Researchers. *Life Science Journal 10*(4), 3121-3127.

Audet, R. H., & Paris, J. (1997). GIS implementation model for schools: Assessing the critical concerns. *Journal of Geography, 96*(6), 293-300.

Avelino, F., Wittmayer, J. M., Pel, B., Weaver, P., Dumitru, A., Haxeltine, A., . . . Ruijsink, S. (2017). Transformative social innovation and (dis) empowerment. *Technological Forecasting and Social Change*, 145, 195-206.

Ayaya, G., Makoelle, T. M., & van der Merwe, M. (2020). Participatory Action Research: A Tool for Enhancing Inclusive Teaching Practices Among Teachers in South African Full-Service Schools. *SAGE Open, 10*(4), 1-13.

Babbie, E. (2011). *Introduction to Social Research*. California: Wadworth Cengage Learning.

Baerwald, T. J. (2010). Prospects for geography as an interdisciplinary discipline. *Annals of the Association of American Geographers, 100*(3), 493-501.

Baker, T., & White, S. (2003). The Effects of G.I.S. on Students' Attitudes, Self-efficacy, and Achievement in Middle School Science Classrooms. *Jounal of Geography, 102*(6), 243-254.

Baker, T. R., Kerski, J. J., Huynh, N. T., Viehrig, K., & Bednarz, S. W. (2012). Call for an agenda and center for GIS education research. *Review of International Geographical Education Online, 2*(3), 254-288.

Bakhshi, F., Shojaeizadeh, D., Sadeghi, R., Taghdisi, M. H., & Nedjat, S. (2017). The Relationship between Individual Empowerment and Health-promoting Lifestyle among Women NGOs in Northern Iran. *Electronic physician, 9*(2), 3690.

Balfour, R., Mitchell, C., & Moletsane, L. (2008). Troubling contexts: Toward a generative theory of rurality as education research. *Journal of Rural and Community Development, 3*(3), 95-107.

Balram, S., & Dragicevic, S. (2006). Collaborative geographic information systems: origins, boundaries, and structures. In S. Balram & S. Dragicevic (Eds.), *Collaborative geographic information systems* (pp. 1-23). Hershey: Idea Group Publishing.

Banchi, H., & Bell, R. (2008). The many levels of inquiry. *Science and children, 46*(2), 26.

Barnes, J., Conrad, K., Demont-Heinrich, C., Graziano, M., Kowalski, D., Neufeld, J., Palmquist, M. (2012). Generalizability and Transferibility. Retrieved January 2, 2018, from https://writing.colostate.edu/guides/guide.cfm?guideid=65

Barron, B. (2006). Interest and self-sustained learning as catalysts of development: A learning ecology perspective. *Human Development, 49,* 193-224.

Barros, S., Tavares, V., & Martins, S. (2019). *The Participatory Action Research as a Support for Social Education and Intervention with Older Adults in Care facilities.* Paper presented at the The 4th World Conference on Qualitative Research, Porto, Portugal.

Baum, F., MacDougall, C., & Smith, D. (2006). Participatory action research. *Journal of Epidemiology & Community Health, 60*(10), 854-857.

Baum, F. E. (2016). Power and glory: applying participatory action research in public health. *Gaceta Sanitaria*, 30(6), 405-407.

Bednarz, S. W. (2004). Geographic information systems: A tool to support geography and environmental education? *GeoJournal, 60*(2), 191-199.

Bednarz, S. W., & Audet, R. H. (1999). The status of GIS technology in teacher preparation programs. *Journal of Geography, 98*(2), 60-67.

Bednarz, S. W., & Ludwig, G. (1997). Ten things higher education needs to know about GIS in primary and secondary education. *Transactions in GIS, 2*(2), 123-133.

Bednarz, S. W., & Schee, J. v. d. (2006). Europe and the United States: The implementation of geographic information systems in secondary education in two contexts. *Technology, Pedagogy and Education, 15*(2), 191-205.

Belotto, M. (2018). Data Analysis Methods for Qualitative Research: Managing the challenges of Coding, Interrater reliability, and Thematic analysis. *The Qualitative Report, 23*(11), 2622-2633.

Bergold, J., & Thomas, S. (2012). Participatory research methods: A methodological approach in motion. *Historical Social Research/Historische Sozialforschung*, 191-222.

Bertram, C., Mthiyane, N., & Mukeredzi, T. (2013). 'It will make me a real teacher': Learning experiences of part time PGCE students in South Africa. *International Journal of Educational Development*, *33*(5), 448-456.

Bingimlas, K. (2009). Barriers to the Successful Intergration of ICT in Teaching and Learning Environments: A review of the Literature. *Eurasia Journal of Mathematics, Science and Technology Education, 5*(3), 235-245.

Birjandi, P., & Hadidi Tamjid, N. (2012). The role of self-, peer and teacher assessment in promoting Iranian EFL learners' writing performance. *Assessment & evaluation in higher education*, *37*(5), 513-533.

Blanchard, K. H., Carlos, J. P., & Randolph, W. A. (1999). *The 3 keys to empowerment: Release the power within people for astonishing results*. Oakland, CA: Berrett-Koehler Publishers.

Bloom, B. S. (1956). *Taxonomy of educational objectives. Vol. 1: Cognitive domain*. *New York: McKay*, 20(24), 1.

Bonnett, A. (2008). *What is Geography?* London: SAGE.

Boog, B. W. (2003). The emancipatory character of action research, its history and the present state of the art. *Journal of Community & Applied Social Psychology, 13*(6), 426-438.

Botha, R. (2016). Inquiry-based Learning: Improving South African Schools. *Journal of Sociology and Social Anthropology, 7*(2), 76-83.

Botha, R. (2017). *The Key Attributes of Inquiry-based Learning: Towards Effectiveness in South African Schools.* Paper presented at the GAI International Academic Conference, Prague, Czechia.

Boukhobza, I. (2015). Is IBL (Inquiry based learning) Helping Zayed University Students Acquire Scientific Skills In A General Science Course? *TOJSAT, 5*(4), 57-63.

Bourdieu, P. (1986). The forms of capital. *Cultural theory: An anthology, 1*, 81-93.

Bourke, R., Loveridge, J., O'Neill, J., Erueti, B., & Jamieson, A. (2017). A sociocultural analysis of the ethics of involving children in educational research. *International Journal of Inclusive Education, 21*(3), 259-271.

Boyd, B., & Bargerhuff, M. E. (2009). Mathematics education and special education: Searching for common ground and the implications for teacher education. *Mathematics Teacher Education and Development, 11*, 54-67.

Bradbury, H. (2015). *The SAGE handbook of action research*. Washington DC: SAGE.

Braun, V., & Clarke, V. (2006). Using thematic analysis in Psychology. *Qualitative Research in Psychology*, 3, 77-101.

Braun, V., Clarke, V., (2019). Answers to frequently asked questions about thematic analysis. Retrieved June 2, 2020, from https://cdn.auckland.ac.nz/assets/psych/about/ourresearch/documents/Answers%20to%20frequently%20asked%20questions%20about%20thematic%20analysis%20April%202019.pdf

Breda, K. M. L. (2015). What is old is also new-participatory action research. *Texto & Contexto-Enfermagem, 24*(1), 9-10.

Breetzke, G. (2006). Geographical information systems (GIS) and policing in South Africa: a review. *Policing: An International Journal of Police Strategies & Management, 29*(4), 723-740.

Breetzke, G., Eksteen, S., & Pretorius, E. (2011). Paper Based GIS: A practical answer to the implementation of GIS education into Resource-Poor Schools in South Africa. *Journal of Geography, 110*(4), 148-157.

Breitbart, M. M. (2010). *Key Methods in Geography*. London: SAGE

Brighton, C. M. (2003). The effects of middle school teachers' beliefs on classroom practices. *Journal for the Education of the Gifted*, *27*(2), 177-206.

Broek, J. O. (1967). National Character in the Perspective of Cultural Geography. *The Annals of the American Academy of Political and Social Science, 370*(1), 8-15.

Bromley, E., Mikesell, L., Jones, F., & Khodyakov, D. (2015). From subject to participant: Ethics and the evolving role of community in health research. *American Journal of Public Health, 105*(5), 900-908.

Brown, A., & Chartrand, F. (1983). Stratiform copper deposits and interactions with co-existing atmospheres, hydrospheres, biospheres and lithospheres. *Precambrian Research, 20*(2-4), 533-542.

Brown, J. (2000). Growing up: Digital: How the web changes work, education, and the ways people learn. *Change: The Magazine of Higher Learning, 32*(2), 11-20.

Brown, S., & Leonard, P. (2004). Biosolids and Global Warming: Evaluating the Management Impacts. *Biocycle, 45*(8), 54.

Buchanan, S. M. C., Harlan, M. A., Bruce, C., & Edwards, S. (2016). Inquiry Based Learning Models, Information Literacy, and Student Engagement: A literature Review. *School Libraries Worldwide*, *22*(2), 23-39.

Bunterm, T., Lee, K., Ng Lan Kong, J., Srikoon, S., Vangpoomyai, P., Rattanavongsa, J., & Rachahoon, G. (2014). Do different levels of inquiry lead to different learning outcomes? A comparison between guided and structured inquiry. *International Journal of Science Education, 36*(12), 1937-1959.

Bush, T., & Heystek, J. (2003). School governance in the new South Africa. *Compare: A Journal of Comparative and International Education*, *33*(2), 127-138.

Cahill, C., Quijada Cerecer, D. A., & Bradley, M. (2010). ‘‘Dreaming of...’’: Reflections on Participatory Action Research as a Feminist Praxis of Critical Hope. *Affilia, 25*(4), 406-416.

Cammarota, J., & Fine, M. (2010). *Revolutionizing education: Youth participatory action research in motion*. New York, NY: Routledge.

Carl, A. (2005). The " voice of the teacher" in curriculum development: a voice crying in the wilderness? *South African Journal of Education, 25*(4), 223-228.

Carr, W., & Kemmis, S. (1986). Becoming Critical: Education. *Knowledge and Action Research.* London: Falmer.

Carstens, A. (2012). Using literacy narratives to scaffold academic literacy in the Bachelor of Education: a pedagogical framework. *Journal for Language Teaching= Ijenali Yekufundzisa Lulwimi= Tydskrif vir Taalonderrig*, *46*(2), 9-25.

Carr, W., & Kemmis, S. (2003). *Becoming critical: education knowledge and action research.* New York, NY: Routledge.

Cassell, E. J. (2000). The principles of the Belmont report revisited: how have respect for persons, beneficence, and justice been applied to clinical medicine? *Hastings center report, 30*(4), 12-21.

Castro-Gómez, S., & Johnson, A. (2000). Traditional and critical theories of culture. *Nepantla: Views from South, 1*(3), 503-518.

Chambre, H., & McLenna, D. (2018). Marxism. Retrieved November 30, 2018, from https://www.britannica.com/topic/Marxism

Chaudhuri, S., & Ray, N. (2015). Application of web-based Geographical Information System (GIS) in tourism development. In S. Chaudhuri & N. Ray (Eds.),

Encyclopedia of Information Science and Technology (pp. 7026-7036). Hershey: Idea Group Publishing.

Chen, C., & Wang, Y. (2015). Geospatial Education in High Schools: Curriculums, Methodologies, and Practices In O. Solari, A. Demirci, & J. van der Schee (Eds.), *Geospatial Technologies and Geography Education in a Changing world* (pp. 67-76). Tokyo: Springer.

Chidarikire, M. (2017). *A peer counselling strategy for alleviating drug abuse in Zimbabwean rural learning ecologies* (Unpublished doctoral thesis), University of the Free State, South Africa.

Chilisa, B., & Kawulich, B. (2012). Selecting a research approach: paradigm, methodology and methods. *Doing Social Research, A Global Context*. London: McGraw Hill.

Chu, S. K. W., Reynolds, R. B., Tavares, N. J., Notari, M., & Lee, C. W. Y. (2017). Twenty-first century skills and global education roadmaps. In *21st century skills development through inquiry-based learning* (pp. 17-32). Singapore: Springer.

Cilliers, D., Klerk, T., & Sandham, L. (2013). Reflecting on GIS-related Research in South Africa: 1980-2012. *South African Geographical Journal, 95*(1), 70-90.

Clarke, A. (2016). SA geomatics industry showcases technology and tackles skills concerns. *PositionIT*. Retrieved February 15, 2019, from https://www.ee.co.za/article/sa-geomatics-industry-showcases-technology-tackles-skills-concerns.html

Clifford, N., Cope, M., Gillespie, T., & French, S. (2016). *Key Methods in Geography*. New York, NY: SAGE.

Clifford, N., French, S., & Valentine, G. (Eds.). (2010). *Key Methods in Geography* (2nd Edition ed.). Los Angeles, CA : SAGE.

Coetzee, S., Eksteen, S., & Roos, A. (2014). Results from a survey of the South African GISc community show who they are and what they do. *South African Journal of Geomatics, 3*(2), 224-245.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education* (7th ed.). London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education* (8th ed.). New York, NY,: Routledge.

Cohen, N., & Arieli, T. (2011). Field research in conflict environments: Methodological challenges and snowball sampling. *Journal of Peace Research, 48*(4), 423-435.

Collett, H., Winearls, N., & Olivier, C. (2012). *Study and Master Grade 10 Geography Teacher's Guide*. Cape Town: Cambridge University Press.

Conroy, G. C., Anemone, R. L., Van Regenmorter, J., & Addison, A. (2008). Google Earth, GIS, and the Great Divide: a new and simple method for sharing paleontological data. *Journal of human evolution, 55*(4), 751.

Cook, T., Brandon, T., Zonouzi, M., & Thomson, L. (2019). Destabilising Equilibriums: Harnessing the Power of Disruption in Participatory Action Research. *Educational Action Research, 27*(3), 379-395.

Corbin, J., & Strauss, A. (2015). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (4th ed.). Los Angeles, CA: SAGE.

Corson, M., Doe, W., Thomas, M., & Thomas, G. (2018). What is Geography. Retrieved April 19, 2018, from https://www.e-education.psu.edu/geog882/l3_p4.html

Cottrell, S. (2017). *Critical thinking skills: Effective analysis, argument and reflection*. United Kingdom: Palgrave Macmillan Publishers Limited.

Council, N. R. (2006). *Learning to Think Spatially: GIS as a Support System in the K-12 Curriculum* (0309092086). Retrieved January 5, 2018, from https://www.doe.k12.de.us/cms/lib09/DE01922744/Centricity/Domain/141/Learning%20to%20Think%20Spatially.pdf

Cram, F., & Mertens, D. (2015). Transformative and Indigenous Frameworks for Multimethod and Mixed Methods Research In S. Hesse-Biber & B. Johnson (Eds.), *The Oxford Handbook of Multimethod and Mixed Methods Research Inquiry*. Jericho: Oxford University Press.

Crang, M. (2013). *Cultural Geography*. New York, NY: Routledge.

Cranton, P. (2011). A transformative perspective on the scholarship of teaching and learning. *Higher Education Research & Development, 30*(1), 75-86.

Creswell, J. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th ed.). Los Angeles, CA: SAGE.

Creswell, J., & Creswell, D. (2018). *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* (5th ed.). Thousand Oaks, CA: SAGE Publications.

Creswell, J., & Miller, D. (2000). Determining validity in qualitative inquiry. *Theory into practice, 39*(3), 124-130.

Creswell, J., & Poth, C. (2018). *Qualitative Inquiry and Research Design*. Thousand Oaks: SAGE publications.

Cumming, G., & Norwood, C. (2012). The Community Voice Method: Using participatory research and filmmaking to foster dialog about changing landscapes. *Landscape and Urban Planning, 105*(4), 434-444.

Cutchin, M. P. (2008). John Dewey's metaphysical ground-map and its implications for geographical inquiry. *Geoforum, 39*(4), 1555-1569.

Damen, M. M., & McCuistion, N. N. (2010). *Women, Wealth and Giving: The virtuous legacy of the boom generation*. New Jersey: John Wiley & Sons.

Darling-Hammond, L., Hyler, M. E., Gardner, M. & Espinoza, D. (2017). *Effective teacher professional development*. Palo Alto, CA: Learning Policy Institute.

De Jong, T., Sotiriou, S., & Gillet, D. (2014). Innovations in STEM education: the Go-Lab federation of online labs. *Smart Learning Environments, 1*(1), 3.

de Róiste, M. (2014). Filling the gap: The geospatial skills shortage in New Zealand. *New Zealand Geographer, 70*(3), 179-189.

Demirci, A. (2008). Evaluating the implementation and effectiveness of GIS-based application in secondary school geography lessons. *American Journal of Applied Sciences, 5*(3), 169-178.

Demirci, A. (2009). How do teachers approach new technologies: Geography teachers' attitudes towards Geographic Information Systems (GIS). *European Journal of Educational Studies, 1*(1), 43-53.

Demirci, A. (2011). Using Geographic Information Systems (GIS) at schools without a computer laboratory. *Journal of Geography, 110*(2), 49-59.

Demirci, A. (2012). Turkey: GIS for Teachers and the Advancement of GIS in Geography Education. In A. Milson, J. Kerski, & A. Demirci (Eds.), *International Perspectives on teaching and learning with GIS in Secondary Schools*. New York, NY: Springer.

Demirci, A. (2015). The Effectiveness of Geospatial Practices in Education. In O. Solari, A. Demirci, & J. van der Schee (Eds.), *Geospatial Technologies and Geography Education in a Changing World: Geospatial Practices and Lessons Learnt* Tokyo: Springer.

Denzin, N. K. (2010). Moments, mixed methods, and paradigm dialogs. *Qualitative inquiry, 16*(6), 419-427.

Denzin, N. K., & Lincoln, Y. S. (2011). *The SAGE handbook of qualitative research*. Thousand Oaks: SAGE.

Department of Basic Education, South Africa. (2011). *Curriculum and Assessment Policy Statement: Geography Further Education and Training Phase Grades 10-12*. Pretoria: Government Printers.

Department of Basic Education, South Africa. (2013). Report on the 2013 national senior certificate: Diagnostic report. Pretoria: Government Printers.

Department of Basic Education, South Africa. (2015). Report on the 2015 national senior certificate: Diagnostic report. Pretoria: Government Printers.

Department of Basic Education, South Africa (2016). Report on the 2016 national senior certificate: Diagnostic report. Pretoria: Government Printers.

Department of Basic Education, South Africa (2017). *Geography Examination Guidelines*. Pretoria: Government Printers.

Department of Basic Education, South Africa (2017). Head of department (Subject / Group of Subjects). Retrieved January 25, 2019 from https://education.gov.mt/en/education/quality-assurance/Documents/QAD-REVIEW-SCHOOL_IMP/qad-rev-HOD-ROLE.pdf

Department of Basic Education, South Africa (2018). Report on the 2018 national senior certificate: Diagnostic report. Pretoria: Government Printers.

Department of Basic Education, South Africa (2020). Funza Lushaka Bursary Scheme: About the Bursary. Retrieved June 2, 2021, from http://www.funzalushaka.doe.gov.za/background_info.jsp

Department of Basic Education, South Africa (2020). Report on the 2020 national senior certificate: Diagnostic report. Pretoria: Government Printers.

Dewey, J. (1916). *Education and Democracy: An Introduction to the Philosophy of Education*. New York, NY: Macmillan.

Dold, C. J., & Chapman, R. A. (2012). Hearing a voice: Results of a participatory action research study. *Journal of Child and Family Studies, 21*(3), 512-519.

du Plessis, H., & van Niekerk, A. (2012). A curriculum framework for Geographical Information Science (GISc) training at South African universities. *South African Journal of Higher Education, 26*(2), 329-345.

du Plessis, P., & Mestry, R. (2019). Teachers for rural schools - a challenge for South Africa. *South African Journal of Education, 19*(1), 1-9.

Dube, B., & Hlalele, D. (2018). Engaging critical emancipatory research as an alternative to mitigate school violence in South Africa. *Educational Research for Social Change, 7*(2), 74-86.

Dube, C. (2012). *Implementing education for sustainable development: The role of Geography in South African secondary schools* (Unpublished doctoral thesis), University of Stellenbosch, South Africa.

Dudgeon, P., Scrine, C., Cox, A., & Walker, R. (2017). Facilitating empowerment and self-determination through participatory action research: Findings from the National Empowerment Project. *International Journal of Qualitative Methods, 16*, 1-11.

Dwyer, S. C., Piquette, N., Buckle, J. L., & McCaslin, E. (2013). Women gamblers write a voice: Exploring journaling as an effective counseling and research tool. *Journal of Groups in Addiction & Recovery, 8*(1), 36-50.

Economist, T. (2017). South Africa has one of the world's worst education systems. *The Economist*. Retrieved May 15, 2019, from https://www.economist.com/middle-east-and-africa/2017/01/07/south-africa-has-one-of-the-worlds-worst-education-systems

Egerton, F. N. (2013). History of ecological sciences, part 47: Ernst Haeckel's ecology. *The Bulletin of the Ecological Society of America, 94*(3), 222-244.

Eksteen, S., Pretorius, E., & Breetzke, G. (2012). South Africa: Teaching Geography with GIS Across Diverse Technological Contexts. In A. Milson, A. Demirci, & J. Kerski (Eds.), *International Perspectives on Teaching and Learning with GIS in Secondary Schools* (pp. 225-232). Dordrecht: Springer.

Emile, N., Bosco, N. J., & Karine, B. (2013). Prevalence of intestinal parasitic infections and associated risk factors among Kigali Institute of Education students in Kigali, Rwanda. *Tropical biomedicine, 30*(4), 718-726.

Englund, C., Olofsson, A. D., & Price, L. (2017). Teaching with technology in higher education: understanding conceptual change and development in practice. *Higher Education Research & Development, 36*(1), 73-87.

Esienumoh, E. E., Allotey, J., & Waterman, H. (2018). Empowering members of a rural southern community in Nigeria to plan to take action to prevent maternal mortality: A participatory action research project. *Journal of clinical nursing, 27*, e1600-e1611.

ESRI. (2003). Geographic Inquiry: Thinking Geographically. Retrieved April 23, 2018, from https://www.esri.com/Industries/k-12/education/~/media/Files/Pdfs/industries/k-12/pdfs/geoginquiry.pdf

ESRI. (2016). FundLula Mapwork with GIS. Retrieved August 21, 2018, from https://www.esri-southafrica.com/wp-content/uploads/2018/07/fundalula-a-new-dimansion-to-teaching-and-learning-geography.pdf

ESRI. (2018). Helping Students Learn with GIS. Retrieved July 7, 2019, from https://www.esri.com/about/newsroom/wp-content/uploads/2018/11/helping-students-learn-with-gis.pdf

EThekwini Municipality (2011). About eThekwini municipality. Retrieved March 12, 2018, from http://www.durban.gov.za/Discover_Durban/Pages/AboutEM.aspx

Fassinger, R., & Morrow, S. L. (2013). Toward best practices in quantitative, qualitative, and mixed-method research: A social justice perspective. *Journal for Social Action in Counseling & Psychology, 5*(2), 69-83.

Faxier, T., & van der Schee, J. (2012). Exploring the characteristics of an optimal design for inquiry-based geography education with Geographic Information Systems. *Computer & Education, 58*(1), 666 - 677.

Fischer, M. M. (2019). *Spatial analytical*. London: Routledge.

Fiske, E. B., & Ladd, H. F. (2004). *Elusive equity: Education reform in post-apartheid South Africa*. Washington DC: Brookings Institution Press.

Fitzgerald, M., Danaia, L., & McKinnon, D. (2019). Barriers Inhibiting Inquiry-Based Science Teaching and Potential Solutions: Perceptions of Positively Inclined Early Adopters. *Research in Science Education, 49*, 543-566.

Fleischmann, E., & van der Westhuizen, C. (2017). The Interactive-GIS-Tutor (IGIST): An option for GIS teaching in resource-poor South African schools. *South African Geographical Journal, 99*(1), 68-85.

Fleischmann, E., van der Westhuizen, C., & Cilliers, D. (2015). Interactive-GIS-Tutor (IGIST) integration: Creating a digital space gateway within a textbook-bound South African Geography class. *International Journal of Education and Development using ICT, 11*(2), 23-37.

Fleischmann, E. M.-L. (2012). *The viability of an Interactive Geographic Information System Tutor (I–GIS–T) application within the FET phase.* (Masters Thesis), North-West University.

Fleming, B. (2015). *GIS interventions that work at secondary level education (High School) in South Africa –some recent success stories.* Paper presented at the Geomatics Indaba Proceedings Emperors Palace, Ekurhuleni.

Fleming, B. (2016). GIS interventions at Secondary Level Education in South Africa – some recent successes and shortfalls. *Journal of Geography Education for Southern Africa, 1*(1), 25-31.

Flicker, S. (2008). Who benefits from community-based participatory research? A case study of the Positive Youth Project. *Health education & behavior, 35*(1), 70-86.

Finnish National Board of Education. (2003). *National Core Curriculum for General Upper Secondary Education*. Helsinki: Vammalan kirjapaino Oy, Vammala.

Forero, R., Nahidi, S., De Costa, J., Mohsin, M., Fitzgerald, G., Gibson, N., Aboagye-Sarfo, P. (2018). Application of four-dimension criteria to assess rigour of qualitative research in emergency medicine. *BMC health services research, 18*(1), 1-11.

Foresman, T. (1998). GIS Early Years and the Threads of Evolution In T. Foresman (Ed.), *The History of Geographic Information Systems: Perspectives from the Pioneers* (pp. 3-18). Upper Saddle River, : Prentice Hall PTR

Forsey, M. (2010). Ethnography as Participant Listening. *Ethnography, 11*(4), 558-572.

Forster, M. (2008). Teaching GIS at Rwandan Secondary Schools. Retrieved February 12, 2018, from https://www.esri.com/news/arcnews/spring08articles/teaching-gis.html

Forster, M., Burikoko, T., & Nsengiyumva, A. (2012). Rwanda: Socioeconomic transformation to a knowledge-based economy through the integration of GIS in secondary schools. In A. Milson, J. Kerski, & A. Demirci (Eds.), *International perspectives on teaching and learning with GIS in secondary schools* (pp. 207-214). New York, NY: Springer.

Forster, M., Schilling, M., & McConnell, T. (2007). *Introducing GIS to K12 education in Rwanda.* Paper presented at the ESRI Education and User Conference, San Diego, California.

Fradelos, E. C., Papathanasiou, I. V., Mitsi, D., Tsaras, K., Kleisiaris, C. F., & Kourkouta, L. (2014). Health based geographic information systems (GIS) and their applications. *Acta Informatica Medica, 22*(6), 402.

Freire, P. (1970). The “banking” concept of education. New York, NY: Routledge

Freire, P. (1972). *Pedagogy of the oppressed*. Harmondsworth: Penguin.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. *Review of educational research, 82*(3), 300-329.

Geuss, R. (1981). *The idea of a critical theory: Habermas and the Frankfurt School*: Cambridge University Press.

Ghaye, T. (2010). *Teaching and Learning Through Reflective Practice: A practical g,uide for Positive Action*. Pennsylvania: Routledge.

Giarelli, J. (1992). Critical theory and educational research: An introduction. *International Journal of Qualitative Studies in Education, 5*(1), 3-5.

Gibbs, G. (1988). *Learning by Doing, A guide to Teaching and Learning Methods*. United Kingdom: Oxford Centre for Staff and Learning Development.

Gillis, A., & Jackson, W. (2002). Research for nurses: Methods and Interpretation. Philadelphia: FA Davis Hinshaw. *AS (1992). Nursing research: Weaving the past and the future. In L Aiken & F. Claire (Eds.), Changing nursing future: Agenda for the 1990s (pp485-503). Philadelphia: JP Lippincott*.

Gina, N. (2015). Rural schooling /multi-grade schools/farms schools/non-viable schools; Inclusive Education implementation; Special Needs schools: Department briefing. Retrieved March 30, 2018, from https://pmg.org.za/committee-meeting/21135/

Glesne, C. (2016). *Becoming Qualitative Researchers: An introduction*. Upper Sadle River, New Jersey: Pearson.

Goldstein, D. L. (2010). *Integration of geospatial technologies into K–12 curriculum: An investigation of teacher and student perceptions and student academic achievement*: Florida Atlantic University.

Gonzales, L. D., & Rincones, R. (2013). Using participatory action research and photo methods to explore higher education administration as an emotional endeavor. *The Qualitative Report, 18*(32), 1-17.

Gonzalez-Acevedo, N. (2019). Some Research Methods for Teacher Researchers. In D. Masats, M. Mont, & N. gonzalez-Acevedo (Eds.), *Joint Efforts for Innovation: Working Together to Improve Foreign Language Teaching in the 21st Century* (pp. 223-233). Trowbridge: Paragon Publishing

Goodchild, M. F. (2018). Reimagining the history of GIS. *Annals of GIS, 24*(1), 1-8.

Goodchild, M. F., & Kemp, K. K. (1990). *NCGIA Core Curriculum: Introduction to GIS*. Santa Barbara: National Center for Geographic Information and Analysis, Berkley: University of California.

Goodnough, K. (2016). Professional learning of K-6 teachers in science through collaborative action research: An activity theory analysis. *Journal of Science Teacher Education*, *27*(7), 747-767.

Gordon, P. (2019). Volunteer Organizations and Skill Development—Exploring the Qualitative Research Process. *SAGE Research Methods Cases Part 2.* Retrieved August 9, 2019, from https://methods-SAGEpub-com.ezproxy.cul.columbia.edu/case/volunteer-organizations-and-skill-development-qualitative-research-process

Gove, D., Diaz-Ponce, A., Georges, J., Moniz-Cook, E., Mountain, G., Chattat, R., . . . Dementia, T. E. W. G. o. P. w. (2017). Alzheimer Europe's position on involving people with dementia in research through PPI (patient and public involvement). *Aging & Mental Health, 22*(6), 723-729.

Gqirana, T. (2016). Without resources, rural schools will continue to underperform - NGO. Retrieved February 15, 2018, from https://www.news24.com/SouthAfrica/News/without-resources-rural-schools-will-continue-to-underperform-ngo-20160106

Grant, C., & Osanloo, A. (2016). Understanding, Selecting and Intergrating a Theoretical Framework in Disseration Research: Creating the Blueprint for your "House". *Administrative Issues Journal: Connecting Education, Practice and Research, 4*(2), 12-26.

Gribbins, M., & Cook, V. (2017). *Workshop: Emerging Technologies and Practices that Promote Student-Centered Learning.* Paper presented at the Proceedings of the Twelfth Midwest Association for Information Systems Conference (MWAIS), Springfield, Illinois.

Guba, E. G. (1990). *The paradigm dialog.* Paper presented at the Alternative Paradigms Conference, Mar, 1989, Indiana U, School of Education, San Francisco, CA, US.

Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105-117). Thousand Oaks, CA: SAGE

Häkkinen, P., Järvelä, S., Mäkitalo-Siegl, K., Ahonen, A., Näykki, P., & Valtonen, T. (2017). Preparing teacher-students for twenty-first-century learning practices (PREP 21): a framework for enhancing collaborative problem-solving and strategic learning skills. *Teachers and Teaching, 23*(1), 25-41.

Halfacree, K. H. (1993). Locality and social representation: space, discourse and alternative definitions of the rural. *Journal of rural studies, 9*(1), 23-37.

Hamati-Ataya, I. (2018). The Sociology of Knowledge as Postphilosophical Epistemology: Out of IR's "Socially Constructed" Idealism. *International Studies Review, 20*(1), 3-29.

Hammersley, L. (2017). Language matters: Reciprocity and its multiple meanings *Learning through community engagement* (pp. 115-131). Singapore: Springer.

Hanley, B. (2005). *Research as Empowerment?: Report of a Series of Seminars Organised by the Toronto Group*: Joseph Rowntree Foundation.

Haq, I. (2017). Inquiry-based Learning. In P. Cantillon (Ed.), *ABC of Learning and Teaching in Medicine*. New Jersey: Wiley Blackwell.

Hartshorne, R. (1959). *Perspective on the Nature of Geography*. Chicago, Ilin.: Rand McNally & Company.

Harvey, F., Kwan, M.P., & Pavlovskaya, M. (2005). Introduction: critical GIS. *Cartographica: The International Journal for Geographic Information and Geovisualization, 40*(4), 1-4.

Hayman, B., Wilkes, L., & Jackson, D. (2012). Journaling: Identification of Challenges and Reflection on Strategies *Nurse Researcher, 19*(3), 27-31.

Hayward, C. N., Kogan, M., & Laursen, S. L. (2016). Facilitating instructor adoption of inquiry-based learning in college mathematics. *International Journal of Research in Undergraduate Mathematics Education*, *2*(1), 59-82.

Heckathorn, D. D. (2011). Comment: Snowball versus respondent-driven sampling. *Sociological methodology, 41*(1), 355-366.

Held, D. (1980). *Introduction to critical theory: Horkheimer to Habermas*. Berkeley: University of California Press.

Hennink, M., Hutter, I., & Bailey, A. (2020). *Qualitative research methods*. Thousand Oaks: SAGE.

Higginbottom, G. M., Rivers, K., & Story, R. (2014). Health and social care needs of Somali refugees with visual impairment (VIP) living in the United Kingdom: A focused ethnography with Somali people with VIP, their caregivers, service providers, and members of the Horn of Africa Blind Society. *Journal of Transcultural Nursing, 25*(2), 192-201.

Hittie, M. M., & Peterson, J. (2003). *Inclusive teaching: Creating effective schools for all learners*. London: Pearson Education, Inc.

Hlalele, D. (2014). Creating sustainable rural learning ecologies in South Africa: Realities, lessons and prospects. *Journal of Human Ecology, 45*(2), 101-110.

Hmelo-Silver, C., Duncan, R., & Chinn, C. (2007). Scaffolding and Achievement in Problem-Based and Inquiry Learning: A Response to Kirschner, Sweller. *Educational Psychologist, 42*(2), 99-107.

Holland, B. (2018). Critical thinking about critical thinking. Retrieved July 26, 2018, from https://www.edweek.org/leadership/opinion-critically-thinking-about-critical-thinking/2018/06

Holtzhausen, S. (2001). Triangulation as a powerful tool to strengthen the qualitative research design: The Resource-based Learning Career Preparation Programme (RBLCPP) as a case study. Proceedings of the *Higher Education Close Up conference 2,* July 16-18, 2001, Lancaster University. Retrieved from http://www.leeds.ac.uk/educol/documents/00001759.htm

Hong, B. (2015). Qualitative Analysis of the Barriers College Students with Disabilities Experience in Higher Education. *Journal of College Student Development 56*(3), 209-226.

Hong, E. (2016). Designing GIS learning materials for K–12 teachers. *Technology, Pedagogy and Education, 26*(3), 323-345.

Hong, J. (2015). *Teaching GIS and Other Geospatial Technologies to In-Service Teachers*. Tokyo: Springer.

Hong, J., & Melville, A. (2018). Training Social Studies Teachers to Develop Inquiry-Based GIS Lessons, *Journal of Geography*, 117:6, 229-244.

Houghton, C., Casey, D., Shaw, D., & Murphy, K. (2013). Rigour in qualitative case-study research. *Nurse Researcher, 20*(4), 12-17.

Huang, H.-h., & Coker, A. D. (2010). Examining issues affecting African American participation in research studies. *Journal of Black Studies, 40*(4), 619-636.

Husni, H. (2020). The effectiveness of the social responsibility program for Islamic religious education through the participatory action research method. *The Social Studies: An International Journal*, *6*(1), 103-116.

Hwang, G.-J., Chiu, L.-Y., & Chen, C.-H. (2015). A contextual game-based learning approach to improving students' inquiry-based learning performance in social studies courses. *Computers & Education, 81*, 13-25.

Hyvönen, T. (2003). Management accounting and information systems: ERP versus BoB. *European Accounting Review, 12*(1), 155-173.

Innes, L. M. (2012). South African school geography: Underpinning the foundation of geospatial competence. *South African Journal of Geomatics, 1*(1), 77-91.

Irizarry, J. G., & Brown, T. M. (2013). Humanizing research in dehumanizing spaces: The challenges and opportunities of conducting participatory action research with youth in schools. In D. Paris & M. Winn (Eds.), *Humanizing research: Decolonizing qualitative inquiry with youth and communities* (pp. 62-80). London: SAGE.

Jahn, W. (2011). The Four Basic Ethical Principles that apply to Forensic Activities are Respect for autonomy, Beneficence,Nonmaleficence, and Justice. *Journal of Chiropractic Medicine, 10*, 225-226.

Jakab, I., Grezo, H., & Sevcík, M. (2016). Inquiry based and blended learning using geographical information system. In J. Novotna & A. Jancarik (Eds.) *Proceedings of the 15th European Conference on e-learning ECEL* (pp. 287-295). Prague, Czech Republic: Charles University.

Janesick, V. (1998). *Journal Writing as a Qualitative Research Technique: History, Issues, and Reflections*. Paper presented at the American Education Research Association, San Diego CA.

Jantijies, M. (2019). 5 things South Africa must get right for tech in schools to work. Retrieved May 5, 2019, from https://www.parent24.com/Learn/High-school/5-things-south-africa-must-get-right-for-tech-in-schools-to-work-20190619

Javadi, M., & Zarea, K., (2016). *Understanding thematic analysis and its pitfall*. Journal of Client Care, 1(1), 34-40.

Jay, M. (1973). *The Dialectical Imagination: A history of the Frankfurt School and the Institute of Social Research*. Boston: Little Brown.

Jimes, C., Weiss, S., & Keep, R. (2013). Addressing the Local in Localization: A Case Study of Open Textbook Adoption by Three South African Teachers. *Journal of Asynchronous Learning Networks*, *17*(2), 73-86.

Johansson, T. (2003). GIS in Teacher Education – Facilitating GIS applications in Secondary School Geography. Retrieved January 5, 2018, from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.124.3454&rep=rep1&type=pdf

Johansson, T. (2013). Finland: Diffusion of GIS in Schools from Local Innovations to the Implementation of a National Curriculum. In A. Milson, A. Demirci, & J. Kerski (Eds.), *International Perspectives on Teaching and Learning with GIS in Secondary Schools*. New York, NY: Springer.

Jull, J., Giles, A., & Graham, I. D. (2017). Community-based participatory research and integrated knowledge translation: advancing the co-creation of knowledge. *Implementation Science, 12*(1), 150.

Jung, J. K., & Elwood, S. (2019). *Qualitative GIS and Spatial Research*. Thousand Oaks: SAGE Publications

Kaymakamoglu, S. E. (2018). Teachers' Beliefs, Perceived Practice and Actual Classroom Practice in Relation to Traditional (Teacher-Centered) and Constructivist (Learner-Centered) Teaching (Note 1). *Journal of Education and Learning*, *7*(1), 29-37.

Karatepe, A., & Tuna, F. (2012). An analysis of the use of technology and GIS in secondary geography courses in Turkey: A case study of Sakarya province. *International Journal of Science and Advanced Technology, 2*(8), 32-38.

Keahey, J. (2016). Whose knowledge counts? Developing fair trade skills in South Africa. *Globalizations, 13*(4), 409-424.

Keiper, T. A. (1999). GIS for elementary students: An inquiry into a new approach to learning geography. *Journal of geography, 98*(2), 47-59.

Kemmis, S. (2006). Exploring the relevance of critical theory for action research: Emancipatory action research in the footsteps of Jurgen Habermas. *Handbook of action research, 4*, 94-105.

Kemmis, S. (2010). What is to be done? The place of action research. *Educational Action Research, 18*(4), 417-427.

Kemmis, S., & McTaggart, R. (1990). *The action research reader* (3rd ed.). Geelong, Victoria: Deakin University Press.

Kemmis, S., McTaggart, R., & Nixon, R. (2013). *The action research planner: Doing critical participatory action research*. London: Springer Science & Business Media.

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The action research planner: Doing critical participatory action research.* London: Springer Science & Business Media.

Kerski, J. (1999). *A nationwide analysis of the implementation of GIS in high school education.* Paper presented at the Proceedings of the 21st Annual ESRI User Conference, San Diego, California.

Kerski, J. (2003). The Implementation and Effectiveness of Geographic Information Systems Technology and Methods in Secondary Education. *Jounal of Geography, 102*(3), 128-137.

Kerski, J., & Demirci, A. M., A. (2013). The Global Landscape of GIS in Secondary Education. *Jounal of Geography, 112*(6), 232-247.

Kerski, J. J. (2001). A national assessment of GIS in American high schools. *International Research in Geographical and Environmental Education, 10*(1), 72-84.

Kerski, J. J., Demirci, A., & Milson, A. J. (2013). The global landscape of GIS in secondary education. *Journal of geography, 112*(6), 232-247.

Kidman, G., & Palmer, G. (2006). GIS: The technology is there but the teaching is yet to catch up. *International Research in Geographical and Environmental Education, 15*(3), 289-296.

Kincheloe, J. L., & McLaren, P. (2002). Rethinking critical theory and qualitative research. *Ethnography and schools: Qualitative approaches to the study of education*, 87-138.

Kinniburgh, J. (2010). A constructivist approach to using GIS in the New Zealand classroom. *New Zealand Geographer*, *66*(1), 74-84.

Kinniburgh, J. C. (2012). Australia: Inquiry learning with GIS to simulate coastal storm inundation. In *International perspectives on teaching and learning with GIS in secondary schools* (pp. 13-25). Dordrecht: Springer.

Kitawi, A. (2015). Community Capacity Development in Universities: Empowering Communities Through Education Management Programmes in Strathmore University (a pilot study). *Contemporary Issues in Education Research, 7*(2), 75-94.

Kivunja, C., & Kuyini, A. B. (2017). Understanding and Applying Research Paradigms in Educational Contexts. *International Journal of higher education, 6*(5), 26-41.

Knowles, M., Nieuwenhuis, J., & Smit, B. (2009). A narrative analysis of educators' lived experiences of motherhood and teaching. *South African Journal of Education, 29*(3), 1-10.

Knowles, R. T., Hawkman, A. M., & Nielsen, S. R. (2020). The social studies teacher-coach: A quantitative analysis comparing coaches and non-coaches across how/what they teach. *The Journal of Social Studies Research, 44*(1), 117-125.

Knox, P., Martson, S., & Imort, M. (2016). *Human Geography: Places and Regions in Global Context*. New York, NY: Pearson.

Kolawole, O. D. (2013). Soils, science and the politics of knowledge: How African smallholder farmers are framed and situated in the global debates on integrated soil fertility management. *Land Use Policy, 30*(1), 470-484.

Krajcik, J., & Blumenfeld, P. (2006). Project-based learning. In R. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 317-334). New York, NY: Cambridge.

Krämer, P., Nessler, S. H., & Schlüter, K. (2015). Teacher students' dilemmas when teaching science through inquiry. *Research in Science & Technological Education, 33*(3), 325-343.

Krauss, K., & Turnip, M. (2013). The Emancipation of the Researcher as part Information Communications Technology for Development in deep rural South Africa. *The Electronic Journal of Information Systems in Developing Countries, 59*(1), 1-21.

Kuhlthau, C. C., Maniotes, L. K., & Caspari, A. K. (2015). *Guided inquiry: Learning in the 21st century: Learning in the 21st century*. California: ABC-CLIO.

Kuhn, T. S. (1962). *The structure of scientific revolutions*. *The Uni: Chicago, London*.

Labaree, R. (2019). Organising your Social Science Researh Paper: The methodology. Retrieved September 12, 2020, from https://libguides.usc.edu/writingguide/methodology

Lambert, D., & Balderstone, D. (2012). *Learning to teach Geography in the Secondary School: A Companion to School Experience*. New York, NY: Routledge.

Larangeira, R., & van der Merwe, C. D. (2016). Map literacy and spatial cognition challenges for student geography teachers in South Africa. *Perspectives in Education, 34*(2), 120-138.

Leavy, P. (2017). *Research design: Quantitative, qualitative, mixed methods, arts-based, and community-based participatory research approaches*: Guilford Publications.

Levers, M. J. D. (2013). Philosophical paradigms, grounded theory, and perspectives on emergence. Thousand Oaks: *SAGE Open, 3*(4), 2158244013517243.

Lewin, K. (1946). Action research and minority problems. *Journal of Social Issues, 2*(4), 34-46.

Lin, N. (2017). Building a network theory of social capital. *Social capital* (pp. 3-28). New York, NY: Routledge.

Lincoln, Y., Lynham, S., & Guba, E. (2018). Paradigmatic Controversies, Contradictions, and Emerging Confluences, Revisited. In N. Denzin & Y. Lincoln (Eds.), *The SAGE Handbook of Qualitative Research*. Thousand Oaks CA: SAGE.

Lincoln, Y. S., & Guba, E. G. (1985). Establishing trustworthiness. *Naturalistic inquiry, 289*, 331.

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2018). Paradigmatic contro-versies, contradictions, and emerging confluences, revisited. In N. K. Denzin, & Y. S. Lincoln (Eds.), SAGE handbook of qualitative research, 5th ed. (pp. 108–150). Thousand Oaks, CA: SAGE.

Lincoln, Y. S., Lynham, S. A., & Guba, E. G. (2011). Paradigmatic controversies, contradictions, and emerging confluences, revisited. *The SAGE handbook of qualitative research, 4*, 97-128.

Liu, M., Navarrete, C. C., & Wivagg, J. (2014). Potentials of mobile technology for K-12 education: An investigation of iPod touch use for English language learners in the United States. *Journal of Educational Technology & Society, 17*(2), 115-126.

Liu, S., & Zhu, X. (2008). Designing a structured and interactive learning environment based on GIS for secondary geography education. *Journal of geography, 107*(1), 12-19.

Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2005). *Geographic information systems and science*. West Sussex: John Wiley & Sons.

Lotter, C., Yow, J. A., & Peters, T. T. (2014). Building a community of practice around inquiry instruction through a professional development program. *International Journal of Science and Mathematics Education, 12*(1), 1-23.

Louw, M. (2014). Solutions for all Map Skills. Retrieved February 10, 2018 from https://www.macmillan.co.za/news/macmillan-news/1/solutions-for-all-map-skills/12

Macaulay, A. C. (2016). *Participatory research: What is the history? Has the purpose changed?* : Oxford University Press UK.

MacDevette, D., Fincham, R., & Forsyth, G. (1999). The rebuilding of a country: the role of GIS in South Africa. In P. Longley, M.Goodchild, D. Maguire, and D. Rhind (Eds.), *Geographic Information Systems* (pp. 913-924), Vol. 2. New York: John Wiley and Sons, Inc.

MacDonald, C. (2012). Understanding participatory action research: A qualitative research methodology option. *The Canadian Journal of Action Research, 13*(2), 34-50.

MacEachren, A. M. (2000). Cartography and GIS: facilitating collaboration. *Progress in Human Geography, 24*(3), 445-456.

Madhuri, G. V., Kantamreddi, V. S. S. N., & Prakash Goteti, L. N. S. (2012). Promoting higher order thinking skills using inquiry-based learning. *European Journal of Engineering Education*, *37*(2), 117-123.

Madida, M., Naidoo, G., & Rugbeer, H. (2019). Barriers to Effective Digital Teaching in Rural Schools. *Gender & Behaviour, 17*(4), 14101-14115.

Mahlomaholo, S. (2009). Critical emancipatory research and academic identity. *Africa education review, 6*(2), 224-237.

Mahlomaholo, S., & Nkoane, M. (2002). The case for an emancipatory qualitative research: reflections on assessment of quality. *Education as Change, 6*(1), 69-84.

March, G., & Scarletto, E. (2017). The evolution of GIS services within North American academic libraries: Documenting change through the decades (1995–2016). *Journal of Map & Geography Libraries*, *13*(2), 222-245.

Martin, Y. E., & Johnson, E. A. (2012). Biogeosciences survey: Studying interactions of the biosphere with the lithosphere, hydrosphere and atmosphere. *Progress in Physical Geography, 36*(6), 833-852.

Marx, K., & Engels, F. (2009). *The economic and philosophic manuscripts of 1844 and the Communist manifesto*. New York, NY: Prometheus Books.

Matthews, M. E., & Hodge, A. M. (2016). Using IBL in a History of Mathematics course: A skeptic's success. *Journal of Humanistic Mathematics*, *6*(2), 23-37.

McClintock, D., Ison, R., & Armson, R. (2003). Metaphors for reflecting on research practice: researching with people. *Journal of Environmental Planning and Management, 46*(5), 715-731.

McDonald, K., Kidney, C., & Patka, M. (2012). 'You need to let your voice be heard': research participants' views on research. *Journal of Intellectual Disability Research*, *57*(3), 216-225.

McLenna, D. (2000). *Karl Marx selected readings*. New York, NY: Oxford University Press.

McTaggart, R. (1991). Principles for participatory action research. *Adult education quarterly, 41*(3), 168-187.

Merja, K. (2018). Narratives of Inquiry Learning in Middle-School Geographic Inquiry Class. *International Research in Geographical and Environmental Education, 27*(1), 85-98.

Mertens, D. (2007). Transformative paradigm: Mixed methods and social justice. *Journal of mixed methods research, 1*(3), 212-225.

Mertens, D. (2008). The transformative-emancipatory perspective as a philosophical foundation for mixed methods research. In V. L. P. Clark, and J. W Creswell*. The mixed methods reader* (pp. 66-104). Los Angeles, SAGE publications

Mertens, D. (2015). Philosophical Assumptions and Programme Evaluation. *Spazio Filosophic, 13*.

Mertens, D., & Wilson, A. (2012). *Program Evaluation Theory and Practice. A comprehensive Guide*. New York, NY: The Guilford Press.

Mertens, D. M. (2010). *Research and Evaluation in Education and Psychology* (3rd ed.). London: SAGE.

Mertens, D. M. (2012). Ethics in Qualitative Research in Education and the Social Sciences. In S. Laphan, M. Quartaroli, & F. Riemer (Eds.), *Qualitative research: An introduction to methods and designs* (pp. 19-39). San Francisco, CA: Jossey-Bass.

Mestry, R., & Ndhlovu, R. (2014). The implications of the National Norms and Standards for School Funding policy on equity in South African public schools. *South African Journal of Education*, *34*(3), 1-11.

Mezirow, J. (1981). A critical theory of adult learning and education. *Adult education, 32*(1), 3-24.

Mfutso-Bengo, J., Masiye, F., Molyneux, M., Ndebele, P., & Chilungo, A. (2008). Why do people refuse to take part in biomedical research studies? Evidence from a resource-poor area. *Malawi Medical Journal, 20*(2), 57-63.

Michael Connelly, F. (2013). Joseph Schwab, curriculum, curriculum studies and educational reform. *Journal of Curriculum Studies, 45*(5), 622-639.

Mihas, P. (2019). Qualitative Data Analysis. In G. Noblit (Ed.), *Oxford Research Encyclopedia of Education*. Oxford: Oxford University Press.

Milson, A. J., Demirci, A., & Kerski, J. J. (Eds.). (2012). *International perspectives on teaching and learning with GIS in secondary schools*. New York, NY: Springer.

Minkler, M., & Wallerstein, N. (2008). Introduction to community-based participatory research: new issues and emphases. In M. Minkler, and N. Wallerstein (Eds.), *Community-based participatory research for health: from process to outcomes* (pp. 47-66)*. San Francisco: Jossey-Bass*.

Minner, D. D., Levy, A. J., & Century, J. (2010). Inquiry-based science instruction—what is it and does it matter? Results from a research synthesis years 1984 to 2002. *Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, 47*(4), 474-496.

Mkhongi, F. A., & Musakwa, W. (2020). Perspectives of GIS Education in High Schools: An Evaluation of uMgungundlovu District, KwaZulu-Natal, South Africa. *Education Sciences, 10*(5), 131.

Mohajan, H. K. (2018). Qualitative research methodology in social sciences and related subjects. *Journal of Economic Development, Environment and People*, *7*(1), 23-48.

Mokotjo, L. G. (2017). *An active learning strategy for addressing dyscalculia in a mathematics classroom* (Unpublished Masters thesis), University of the Free State, South Africa.

Moletsane, R. (2015). Whose Knowledge is It? Towards Reordering Knowledge Production and Dissemination in the Global South. *Educational Research for Social Change, 4*(2), 35.

Mshelia, C., Le, G., Mirzoev, T., Amon, S., Kessy, A., Baine, S., & Huss, R. (2016). Developing learning diaries for action research on healthcare management in Ghana, Tanzania and Uganda. *Action Research, 14*(14), 412 - 420.

Msimanga, M. R. (2017). *Teach and assess: a strategy for effective teaching and learning in economic and management sciences* (Unpublished doctoral thesis), University of the Free State, South Africa.

Mudambi, R., & Navarra, P. (2015). Is knowledge power? Knowledge flows, subsidiary power and rent-seeking within MNCs *The Eclectic Paradigm* (pp. 157-191). New York: Springer.

Mukamusoni, D. (2006). Distance Learning Program of Teachers' at Kigali Institute of Education: An expository study. *International Review of Research in Open and Distance Learning, 7*(2), 1-10.

Murphy, M., & Fleming, T. (2010). *Habermas, critical theory and education*. London: Routledge.

Musakwa, W. (2017). Perspectives on geospatial information science education: an example of urban planners in Southern Africa. *Geo-Spatial Information Science, 20*(2), 201-208.

Myende, P., & Chikoko, V. (2014). School-University Partnership in a South African Rural Context: Possibilities for the Asset-Based Approach. *Journal of Human Ecology, 43*(6), 249-259.

Myers, M. D., & Klein, H. K. (2011). A set of principles for conducting critical research in information systems. *MIS quarterly*, 35(1), 17-36.

Mzuza, M., & van der Westhuizen, C. P. (2019). Review on the state of GIS application in secondary schools in the southern African region. *South African Geographical Journal*, 101(2), 175-191.

Mzuza, M., & van der Westhuizen, C. (2019a). Inclusion of GIS in student teacher training and its significance in higher education in southern African countries. *International Research in Geographical and Environmental Education*, 29(4), 332-346.

Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball Sampling: A purposeful method of sampling in qualitative research. *Strides in Development of Medical Education*, *14*(3), 1-4.

Narain, A. (2017). Which country has the most diverse geospatial industry presence? Retrieved January 9, 2018, from https://www.geospatialworld.net/blogs/country-geospatial-industry/

National Geographic (2019). Geographic Skill 1. Retrieved August 9, 2019, from https://www.nationalgeographic.org/geographic-skills/1/

Ndlovu-Gatsheni, S. J. (2015). Decoloniality as the Future of Africa. *History Compass, 13*(10), 485-496.

Neuman, W. L. (2005). Social research methods: Quantitative and qualitative approaches (Vol. 13). *Allyn and Bacon Boston. sectional acceptance study. International Journal of Medical Informatics, 81*(2), 88-97.

Neuman, W. L. (2013). *Social research methods: Qualitative and quantitative approaches*. New York: Pearson education.

Newman, M. (2014). *Vital Witnesses: Using Primary Sources in History and Social Studies*. New York, NY: Rowman & Littlefield.

New York State Education Department. (2004). *The Impact of High-Stakes Exams on Students and Teachers*. New York: New York State Education Department.

Ngulube, P. (2018). Overcoming the difficulties associated with using conceptual and theoretical frameworks in heritage studies *Handbook of research on heritage management and preservation* (pp. 1-23): IGI Global.

Nikkhah, H. A., Redzuan, M. r., & Abu-Samah, A. (2012). Development of'Power within'among the Women: A Road to Empowerment. *Asian Social Science, 8*(1), 39.

Nkabinde, Z. P. (1997). *An analysis of educational challenges in the new South Africa*. New York, NY: University Press of America.

Nkoane, M. M. (2012). Critical emancipatory research for social justice and democratic citizenship. *Perspectives in Education, 30*(4), 98-104.

Noel, L. (2016). *Promoting an emancipatory research paradigm in Design Education and Practice.* Paper presented at the Design Research Society 50th Anniversary Conference, Brighton, UK, June.

Noorollahi, Y., Arjenaki, H. G., & Ghasempour, R. (2017). Thermo-economic modeling and GIS-based spatial data analysis of ground source heat pump systems for regional shallow geothermal mapping. *Renewable and Sustainable Energy Reviews, 72*, 648-660.

Odum, E., & Barrett, G. (1971). *Fundamentals of ecoloy* (5th ed. Vol. 3). Philadephia, PENN: Saunders.

Ojo, O., & Adu, E. (2018). The effectiveness of Information and Communication Technologies (ICTs) in teaching and learning in high schools in Eastern Cape Province. *South African Journal of Education, 38*(2), 1-11.

Okeke, C. (2017). Achieving Qualitative Validity, Realibility and Generalisibility. In C. Okeke & M. van Wyk (Eds.), *Educational Research: An African approach* (pp. 207 - 222). Cape Town: Oxford University Press.

Oliver-Hoyo, M., & Allen, D. (2006). The Use of Triangulation Methods in Qualitative Educational Research. *Journal of College Science Teaching, 35*(4), 42-47.

Oliver, M. (1992). Changing the social relations of research production? *Disability, Handicap & Scociety, 7*(2), 101-114.

Oliver, M. (1997). Emancipatory Research : Realistic Goal or Impossible Dream? *Doing Disability Research, 2*, 15-31.

Pacheco, D., & Velez, V. (2009). Maps, Mapmaking, and Critical Pedagogy: Exploring GIS and Maps as a Teaching Tool for Social Change. *Seattle Journal for Social Justice, 8*(1), 272-302.

Padmanabhan, V. N., & Subramanian, L. (2001). An investigation of geographic mapping techniques for Internet hosts*. ACM SIGCOMM Computer Communication Review*, 31(4), 173-285.

Page, N., & Czuba, C. E. (1999). Empowerment: What is it. *Journal of extension, 37*(5), 1-5.

Pain, R., Kindon, S., & Kesby, M. (2007). Participatory Action Research: making a difference to theory, practice and action *Participatory Action Research Approaches and Methods* (pp. 52-58): United Kingdom: Routledge.

Panasan, M., & Nuangchalerm, P. (2010). Learning outcomes of project-based and inquiry-based learning activities. *Journal of Social Sciences*, *6*(2), 252-255.

Pappas, C. (2014). Instructional Design Models and Theories: Inquiry-based Learning Model. Retrieved April 16, 2018, from https://elearningindustry.com/inquiry-based-learning-model

Paris, D., & Winn, M. T. (2013). *Humanizing Research: Decolonizing Qualitative Inquiry with Youth and Communities*. London: SAGE.

Pathak, V., Jena, B., & Kalra, S. (2013). Qualitative Research. *Perspectives in Clinical Research, 4*(3), 192-102.

Pattison, W. D. (1990). The four traditions of geography. *Journal of geography, 89*(5), 202-206.

Pearson (2018). Platinum Interactive Skills Atlas. Retieved June 25, 2019, from https://vimeo.com/277622042

Pedaste, M., Mäeots, M., Siiman, L. A., De Jong, T., Van Riesen, S. A., Kamp, E. T., Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational research review, 14*, 47-61.

Perkins, D. (2010). Empowerment. In R. A. Couto (Ed.), *Political and Civic Leadership: A Reference Handbook* (pp. 207-218). Thousand Oaks, CA: SAGE Publications.

Phelps, J. L. (2021). The transformative paradigm: Equipping technical communication researchers for socially just work. *Technical Communication Quarterly*, *30*(2), 204-215.

Piaget, J. (1929). *The Child's Conception of the World.* New York, NY: Harcourt, Brace Jovanovich.

Piper, B., Zuilkowski, S. S., & Ong'ele, S. (2016). Implementing mother tongue instruction in the real world: Results from a medium-scale randomized controlled trial in Kenya. *Comparative Education Review, 60*(4), 776-807.

Pitsoe, V., & Maila, W. (2012). Towards constructivist teacher professional development. *Journal of Social Sciences, 8*(3), 318-324.

Plantin, J.-C. (2018). Google maps as Cartographic Infrastructure: From Participatory Mapmaking to Database Maintenance. *International journal of communication, 12*, 489-506.

Polit, D. F., & Beck, C. T. (2008). *Nursing research: Generating and assessing evidence for nursing practice*. Philadelphia: Lippincott Williams & Wilkins.

Poole, R. (2010). *Earthrise: How man first saw the Earth*. New Haven, Co: Yale University Press.

Poon, C.-L., & Lim, S. S. (2014). *Transiting into inquiry science practice: Tales from a primary school Inquiry into the Singapore Science Classroom* (pp. 139-164). Singapore: Springer.

Poon, C. L., Tan, D., & Tan, A. L. (2009). Classroom Management and Inquiry-Based Learning: Finding the Balance. *Science Scope*, *32*(9), 18-21.

Postholm, M. B., & Skrøvset, S. (2013). The researcher reflecting on her own role during action research. *Educational Action Research, 21*(4), 506-518.

Potts, K., & Brown, L. (2015). Becoming an Anti-oppresive Researcher. In S. Strega & L. Brown (Eds.), *Research as resistance: Critical, Indigenous and anti-oppresive approaches* (pp. 17-42). Toronto: Canadian Scholars' Press.

Powell, K. (2010). Making sense of place: Mapping as a multisensory research method. *Qualitative inquiry, 16*(7), 539-555.

Press, P. (2015). Areas of vibrant growth in the residential property market. Retrieved July 18, 2018, from https://www.privateproperty.co.za/advice/news/articles/areas-of-vibrant-growth-in-the-residential-property-market/3491

Přinosilová, J., Mechlová, E., & Kubicová, S. (2013). ICT on four levels of inquiry-based science education in environmental education. *International Journal of Information and Communication Technologies in Education, 2*(1), 17-32.

Promduangsri, P., & Crookall, D. (2018). *Global Warming Causes and Consequences: A Poster game + Debriefing.* Paper presented at the EGU General Assembly Conference Abstracts, Vienna, Austria.

Raja, F. & Najmonnisa, D. (2018). Comparing Traditional Teaching Method and Experiential Teaching Method using Experimental Research. *Journal of education and educational development*, (5)2. 276-288.

Rajgopaul, D. (2018). Durban's Tourism industry is booming. Retrieved May 6, 2019, from https://www.iol.co.za/business-report/durbans-tourism-industry-is-booming-12242059

Ramnarain, U. (2016). Understanding the influence of intrinsic and extrinsic factors on inquiry-based science education at township schools in South Africa. *Journal of Research in Science teaching*, *53*(4), 598-619.

Ramnarain, U., & Padayachee, K. (2015). A comparative analysis of South African Life Sciences and Biology textbooks for inclusion of the nature of science. *South African Journal of Education, 35*(1), 1-8.

Ranga, M., & Etzkowitz, H. (2015). Triple Helix systems: an analytical framework for innovation policy and practice in the Knowledge Society. In J. Mitra & J. Edmondson (Eds.), *Entrepreneurship and Knowledge Exchange* (pp. 117-158). London: Routledge.

Ratinen, I., & Johansson, T. (2005). Teachers' opinions of the incorporation of GIS in the upper secondary schools in Finland (pp. 1-9). *Proceedings of the International Cartographic Conference*, Corunä, Spain.

Ratinen, I., & Keinonen, T. (2011). Student-teachers's use of Google Earth in Problem-Based Learning. *International Research in Geographical and Environmental Education, 20*(4), 345-358.

Reason, P., & Bradbury, H. (2001). *Handbook of action research: Participative inquiry and practice*. Thousand Oaks: SAGE publucations.

Revell, S. M. H. (2013). Making meaning in qualitative research with conversational partnerships: A methodological discussion. *Advances in nursing science, 36*(2), E54-E65.

Ricker, B., & Thatcher, J. (2017). Evolving technology, shifting expectations: Cultivating pedagogy for a rapidly changing GIS landscape. *Journal of Geography in Higher Education*, *41*(3), 368-382.

Rickles, P., Ellul, C., & Haklay, M. (2017). A suggested framework and guidelines for learning GIS in interdisciplinary research. *Geo:Geography and Environment*, 4(2), 1-17.

Rienties, B., Brouwer, N., & Lygo-Baker, S. (2013). The effects of online professional development on higher education teachers' beliefs and intentions towards learning facilitation and technology. *Teaching and teacher education, 29*, 122-131.

Riihela, J., & Maki, S. (2015). Designing and implementing an online GIS tool for schools: The Finnish case of the PaikkaOppi project. *Journal of geography, 114*(1), 15-25.

Rind, I. A., & Mari, M. A. (2019). Analysing the impact of external examination on teaching and learning of English at the secondary level education. *Cogent Education*, *6*(1), 1-14.

Robinson, J. L. (1976). A new look at the four traditions of geography. *Journal of geography, 75*(9), 520-530.

Rodríguez, L. F., & Brown, T. M. (2009). From voice to agency: Guiding principles for participatory action research with youth. *New directions for youth development*(123), 19-34.

Roffey-Barentsen, J., & Malthouse, R. (2013). *Reflective Practice in Education and Training* (2nd ed.). London: SAGE.

Romm, N. (2014). Exploration of Transformative Paradigm with Pragmatist twist to contribute to educational change. *International Journal on New Trends in Education and Their Implications, 5*(2), 134-144.

Romm, N. (2018). *Responsible Research Practice: Revisiting Transformative Paradigm in Social Research*. Switzerland: Springer.

Rose, J., & Glass, N. (2008). The importance of emancipatory research to contemporary nursing practice. *Contemporary Nurse, 29*(1), 8-22.

Ross, K. (2017). Making empowering choices: How methodology matters for empoweringresearch participants. In *Forum Qualitative Sozialforschung/Forum: Qualitative Social Research,*18(3), 17.

Rundell, J. (2015). Agnes Heller: Critical theory, value reflexivity and horizons of modernity. *Thesis Eleven*, 0725513616654789.

Russell, W., Waters, S., & Turner, T. (2017). *Essentials of Elementary Social Studies*. New York, NY: Routledge.

Sadler, G. R., Lee, H. C., Lim, R. S. H., & Fullerton, J. (2010). Recruitment of hard-to-reach population subgroups via adaptations of the snowball sampling strategy. *Nursing & health sciences, 12*(3), 369-374.

Saldana, J. (2015). *The Coding Manual for Qualitative Researchers*. London: SAGE

Salerno, R. (2004). *Beyond The Enlightnment Lives and Thoughts of Social Theorists*. Westport: Praeger.

Sandelowski, M. (1986). The problem of rigor in qualitative research. *Advances in nursing science*, 8(3), 27-37.

Sandelowski, M. (1998). The call to experts in qualitative research. *Research in nursing & health, 21*(5), 467-471.

Šapkova, A. (2014). The relationships between the traditional beliefs and practice of mathematics teachers and their students' achievements in doing mathematics tasks. *Problems of Education in the 21st Century*, *58*, 127-143.

Scheepers, D. (2009). GIS in the geography curriculum. *Position IT*, 40-45.

Schmidt, C. (2013). Esri Summer Camps in Rwanda and the Democratic Republic of Congo. Retrieved June 30, 2018, from https://proceedings.esri.com/library/userconf/emea13/papers/emea_61.pdf

Schober, D. (2010). ESRI summer camps in Germany, Ruanda and Switzerland. Retrieved September 14, 2018, from https://proceedings.esri.com/library/userconf/educ10/educ/papers/pap_1351.pdf

Schratz, M. (2019). *Qualitative Voices in Educational Research*. London: Routledge.

Schwabe, C., O'Leary, B., & Sukai, S. (1997). *A model for the provision of spatial information to bring about reconstruction and development in South Africa.* Paper presented at the 3rd Africa GIS Conference, Gaborone.

Scotland, J. (2012). Exploring the Philosophical Underpinnings of Research: Relating Ontology and Epistemology to the Methodology and Methods of the Scientific, Interpretive, and Critical Research Paradigms. *English language teaching, 5*(9), 9-16.

Sefara, P. J. (2017). *Teaching and learning of Geographical Information Systems (GIS) In South African Secondary Schools: A case of Limpopo Province* (Unpublished doctoral thesis), University of Limpopo, South Africa.

Sheddy, M., & Brittian, C. (2018). Introduction to the special issue on the Frankfurt School and religion. *Critical Research on Religion, 6*(3), 221-225.

Shenton, A. K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for information, 22*(2), 63-75.

Siisiainen, M. (2003). Two concepts of social capital: Bourdieu vs. Putnam. *International Journal of Contemporary Sociology, 40*(2), 183-204.

Sikko, S. A., Lyngved, R., & Pepin, B. (2012). Working with Mathematics and Science teachers on Inquiry-based learning (IBL) approaches: Teacher beliefs. *Acta Didactica Norge, 6*(1), 1-18.

Silm, G., Tiitsaar, K., Pedaste, M., Zacharia, Z. C., & Papaevripidou, M. (2017). Teachers' Readiness to Use Inquiry-Based Learning: An Investigation of Teachers' Sense of

Efficacy and Attitudes toward Inquiry-Based Learning. *Science Education International*, *28*(4), 315-325.

Simth, L. (2012). *Decolonizing Methodologies: Research and Indigenous Peoples* (2nd ed.). New York, NY: Zed Books.

Singh, S. S. B., Kleeman, G., & Van Bergen, P. (2012). Opportunities to implement GIS in teaching and learning geography: a survey among smart schools in Sabah, Malaysia. *Procedia-Social and Behavioral Sciences, 69*, 884-889.

Smit, J., & Makanga, P. (2010). A review of the status of Spatial Data Infrastructure Implementation in Africa. *South African computer journal, 2010*(45), 18-25.

Smith, M., Carrivick, J., & Quincey, D. (2016). Structure from motion photogrammetry in physical geography. *Progress in Physical Geography, 40*(2), 247-275.

Solis, C. A. (2015). Beliefs about Teaching and Learning in University Teachers: Revision of Some Studies. *Journal of Educational Psychology-Propósitos y Representaciones*, *3*(2), 245-260.

Sotuku, N., & Duku, S. (2017). Ethics in Human Sciences Research. In C. Okeke & M. van Wyk (Eds.), *Educational Research: An African Approach* (pp. 112-130). Cape Town: Oxford University Press.

South African Council of Educators (2014). CPTD Management Systems. Retrieved February 1, 2018, from https://www.sace.org.za/pages/cptd-management-system

Sperka, L. (2018). Selecting, Understanding and Applying Theory as a Neophyte Researcher *Qualitative Research in Sport, Exercise and Health, 11*(3), 348-363.

Spring, J. (2017). *American Education*. New York, NY: Routledge.

Spronken-Smith, R., Bullard, J. O., Ray, W., Roberts, C., & Keiffer, A. (2008). Where might sand dunes be on Mars? Engaging students through inquiry-based learning in geography. *Journal of Geography in Higher Education*, *32*(1), 71-86.

Stelzenmüller, V., Lee, J., Garnacho, E., & Rogers, S. I. (2010). Assessment of a Bayesian Belief Network–GIS framework as a practical tool to support marine planning. *Marine pollution bulletin*, *60*(10), 1743-1754.

Strahler, A., & Strahler, A. (2007). *Physical geography*. New Jersey: John Wiley & Sons.

Strassburg, S., Meny-Gibert, S., & Russell, B. (2010). *More than getting through the school gates: Barriers to participation in schooling* (0620492260). Retrieved November 2, 2020, from https://www.wits.ac.za/media/wits-university/faculties-and-schools/commerce-law-and-management/researchentities/cals/documents/programmes/basicservices/resources/More%20than%20getting%20t

hrough%20the%20school%20gates%20Barriers%20to%20participation%20in%20schooling.pdf

Sutton, J., & Austin, Z. (2015). Qualitative research: data collection, analysis, and management. *The Canadian journal of hospital pharmacy, 68*(3), 226.

Swanson, R. A., & Chermack, T. J. (2013). *Theory building in applied disciplines*: San Francisco CA: Berrett-Koehler Publishers.

Tadajewski, M. (2016). Academic labour, journal ranking lists and the politics of knowledge production in marketing. *Journal of Marketing Management, 32*(1-2), 1-18.

Tambassi, T. (2019). What a Geographical Entity Could Be *The Philosophy of GIS* (pp. 177-205). New York, NY: Springer.

Tan, C. (2015). Beyond rote-memorisation: Confucius' concept of thinking. *Educational Philosophy and Theory, 47*(5), 428-439.

Tarisayi, K. S. (2018). Lessons for GIS Implementation in Zimbabwe from the South African Experiences. *Alternation Special Edition, 21*, 185-202.

Tarr, Z. (2017). *The Frankfurt School: The Critical Theories of Max Horkheimer and Theodor W. Adorno*. London: Routledge.

Taylor, C. (2013). Epistemelogical Issues in Educational Research. In A. Ainsworth (Ed.), *Sociology of Education: An A-to-Z Guide*. Los Angeles, CA: SAGE.

Thaiposri, P., & Wannapiroon, P. (2015). Enhancing students' critical thinking skills through teaching and learning by inquiry-based learning activities using social network and cloud computing. *Procedia-Social and Behavioral Sciences*, *174*, 2137-2144.

Thomas, E., & Magilvy, J. K. (2011). Qualitative rigor or research validity in qualitative research. *Journal for specialists in pediatric nursing*, 16(2), 151-155.

Thrower, N. J. (2008). *Maps and civilization: cartography in culture and society. Illinois*: University of Chicago Press.

Tomaszewski, B. M., Maurice, K. J., Vodacek, A., Vodacek, K., & Holt, N. (2015). *Spatial thinking for educational innovation: the Rwandan Iwacu project. Proceedings of the Seventh International Conference on Information and Communication Technologies and Development* (pp. 1-4). Nanyang Technological University, Singapore.

Tomlinson, R. (2012). Foreword. In A. J. Milson, A. Demirci, & J. Kerski (Eds.), *International Perspectives on Teaching and Learning with GIS in Secondary Schools*. New York, NY: Springer.

Tomlinson, R. F. (1967). An introduction to the geo-information system of the Canada Land Inventory. *Department of Forestry and Rural Development,* Ottawa, Canada.

Tomlinson, R. F. (1987). Current and potential uses of geographical information systems The North American experience. *International Journal of Geographical Information System, 1*(3), 203-218.

Tong, J. (2014). *Education Dilemma in Malaysia: Past, Present and Future*. Singapore: Partrige Publishing.

Toomey, A. H. (2011). Empowerment and disempowerment in community development practice: eight roles practitioners play. *Community Development Journal, 46*(2), 181-195.

Toros, K., & Medar, M. (2015). Social work students' thoughts on self-reflection: A qualitative study based on reflective journaling. *International Journal of Humanities and Social Science, 5*(3), 89-96.

Trainor, A., & Bouchard, K. A. (2013). Exploring and developing reciprocity in research design. *International Journal of Qualitative Studies in Education, 26*(8), 986-1003.

Trilling, B., & Fadel, C. (2009). *21st Century Skills.: Learning for Life in Our Times*. San Francisco, CA: John Wiley & Sons.

Tshelane, M. (2014). Participatory Action Research and the construction of Academic Identity among Postgraduate Research Students. *The Journal for Transdiciplinary Research in Southern Africa, 9*(3), 413-429.

Tshelane, M., & Mahlomaholo, S. (2015a). Creating Sustainable Learning Environments for Professional Curriculum Leadership through Information and Communication Technologies. *Journal of Higher Education in Africa, 13*, 193-212.

Tshelane, M., & Mahlomaholo, S. (2015b). Creating Sustainable Learning Environments for Professional Curriculum Leadership through Information and Communication Technologies. *Journal of Higher Education in Africa, 13*(1), 193-212.

Tuan, Y. F. (1991). A view of geography. *Geographical review, 81*(1), 99-107.

Tulloch, D. L. (2000). Data shaping the landscape: GIS and stewardship. *Landscape Journal, 19*(1-2), 211-219.

Tummons, J. (2013). Research Paradigms in Educational Studies. In A. Ainsworth (Ed.), *Sociology of Education: An A-to-Z Guide*. Los Angeles, CA: SAGE.

UNESCO. (2019). Building Knowledge Societies Retrieved August 30, 2020, from https://en.unesco.org/themes/building-knowledge-societies

Unlu, M. (2011). The Level of Realizing Geographical Skills in Geography Lessons. *Educational Sciences: Theory and Practice*, *11*(4), 2166-2172.

van Delene, J., & van der Graaf, R. (2017). Revised CIOMS International Ethical Guidelines for Health-related Research Involving Humans. *Jama, 317*(2), 135-136.

Vaismoradi, M., Turunen, H. & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, 15, 398-405.

Van der Berg, S. (2008). *Poverty and Education*. Retrieved March 3, 2018, from South Africa: https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.464.9607&rep=rep1&type=pdf

Vaughan, M., Boerum, C., & Whitehead, L. (2018). Action Research in Doctoral Coursework: Perceptions of Independent Research Experiences. *International Journal for the Scholarship of Teaching and Learning, 13*(1), 1-8.

Verbeek, C. (2014). Critical reflections on the PGCE (Foundation Phase) qualification in South Africa. *South African Journal of Childhood Education*, *4*(3), 37-51.

Voet, M., & De Wever, B. (2016). History teachers' conceptions of inquiry-based learning, beliefs about the nature of history, and their relation to the classroom context. *Teaching and teacher education, 55*, 57-67.

Voogt, J., Erstad, O., Dede, C., & Mishra, P. (2013). Challenges to learning and schooling in the digital networked world of the 21st century. *Journal of computer assisted learning, 29*(5), 403-413.

Wahyuningtyas, N., Laila, N., & Andini, F. (2021). *Forming spatial thinking skills of social studies students in phenomenon analysis geosphere through the Geographic Information System (GIS).* Paper presented at the IOP Conference Series: Earth and Environmental Science.

Walliman, N. (2011). *Research methods: The basics*. New York, NY: Routledge.

Wang, J. R., Wang, Y. C., Tai, H.-J., & Chen, W.-J. (2010). Investigating the effectiveness of inquiry-based instruction on students with different prior knowledge and reading abilities. *International Journal of Science and Mathematics Education, 8*(5), 801-820.

Wang, W.-X., & Rainbow, P. S. (2020). Physical Geography. In W.-X. Wang & P. S. Rainbow (Eds.), *Environmental Pollution of the Pearl River Estuary, China. Estuaries of the World* (pp. 5-11). Berlin: Springer.

Watkins, J. M. (1994). A Postmodern Critical Theory of Research Use. *Knowledge and Policy: The International Journal of Knowledge Transfer and Utilization, 7*(4), 55-77.

Weiner, D., & Harris, T. (2003). Community-integrated GIS for land reform in South Africa. *URISA journal, 15*(2), 61-73.

Weiner, R. R. (1978). Sociological Implications of the Habermas-Related Second Generation of the Frankfurt School: A Bibliographic Essay. *Mid-American Review of Sociology*, 3(2), 83-107.

Whitehead, J. (2000). How do I improve my practice? Creating and legitimating an epistemology of practice. *Reflective Practice, 1*(1), 91-104.

Wiegand, P. (2001). Geographical information systems (GIS) in education. *International Research in Geographical and Environmental Education, 10*(1), 68-71.

Williams, R. L., Willging, C. E., Quintero, G., Kalishman, S., Sussman, A. L., & Freeman, W. L. (2010). Ethics of health research in communities: perspectives from the southwestern United States. *The Annals of Family Medicine, 8*(5), 433-439.

Willig, C. (2019). Ontological and epistemological reflexivity: A core skill for therapists. *Counselling and Psychotherapy Research, 19*(3), 186-194.

Wilmot, P., & Dube, C. (2016). Opening a window onto school geography in selected public secondary schools in the Eastern Cape Province. *South African Geographical Journal, 98*(2), 337-350.

Wilmsen, C. (2012). Participation, reciprocity, and empowerment in the practice of Participatory Research. *University of California, Berkeley.* Retrieved September 29, 2020, from https://nature.berkeley.edu/community_forestry/Workshops/2006/WCAR%202006%20final%20draft%20Wilmsen.pdf

Wilmsen, C., Elmendorf, W. F., Fisher, L., Ross, J., Sarathy, B., & Wells, G. (2008). *Partnerships for Empowerment: Participatory Research for Community-based Natural Resource Management*. London: Earthscan.

Wilson, B. G. (1996). *Constructivist learning environments: Case studies in instructional design.* New Jersey: Educational Technology.

Wing, M. G., & Bettinger, P. (2003). GIS: An updated primer on a powerful management tool. *Journal of forestry, 101*(4), 4-8.

Winter, E., Costello, A., O'Brien, M., & Hickey, G. (2021). Teachers' use of technology and the impact of Covid-19. *Irish Educational Studies*, 40(2), 235-246.

Wolhuter, C. C. (2006). Teacher training in South Africa: past, present and future. *Education Research and Perspectives*, *33*(2), 124-139.

Wood, L. (2017). The Ethical Implications of Community-Based Research: A Call to Rethink Current Review Board Requirements. *International Journal of Qualitative Methods, 16*, 1-7.

Wumasi, F. (2013). Map Literacy and GIS in Schools Training: MapAware and MapPacks. Retrieved November 13, 2020, from http://www.ngi.gov.za/index.php/what-we-do/prof/48-map-literacy-and-gis-in-schools-training

Yap, L. Y., Ivy Tan, G. C., Zhu, X., & Wettasinghe, M. C. (2008). An assessment of the use of geographical information systems (GIS) in teaching geography in Singapore schools. *Journal of geography, 107*(2), 52-60.

Yeh, A. G. (1999). Urban planning and GIS. *Geographical information systems, 2*(1), 877 - 888.

Yeung, S. (2010). Problem-based learning for promoting student learning in high school geography. *Jounal of Geography, 109*(5), 190-200.

Zhang, B., Krajcik, J. S., Sutherland, L. M., Wang, L., Wu, J., & Qian, Y. (2005). Opportunities and challenges of China's inquiry-based education reform in middle and high schools: Perspectives of science teachers and teacher educators. *International Journal of Science and Mathematics Education*, *1*(4), 477-503.

Zhu, X. (2016). *GIS for environmental applications: a practical approach*. New York, NY: Routledge.

Zietsman, H. (2002). Geographic Information Science in South Africa. *South African Geographical Journal, 84*(1), 30-37.

Zondi, T., & Tarisayi, K. (2020). A learner perspective on the implementation of Geographic Information Systems in selected schools in KwaZulu-Natal province. *The Journal for Transdisciplinary Research in Southern Africa, 16*(1), 1-6.

Zuma, S. (2016). *Teachers' reflections of teaching Geographical Information System (GIS) at Grade 11 within CAPS in a township school in the uMhlathuze Circuit.* (Unpublished masters thesis), University of KwaZulu-Natal, South Africa.

APPENDICES

Appendix A (Ethical Clearance letter)

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

22 November 2018

Ms Thabile Aretha Zondi 206513797
School of Education
Edgewood Campus

Dear Ms Zondi

Protocol reference number: HSS/1590/018D
Project title: An inquiry based learning framework for teaching Geographic Information Systems in a rural ecology

Full Approval – Expedited Application

In response to your application received on 6 September 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol have been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

[redacted]
pp **Dr Shenuka Singh (Chair)**
Humanities & Social Sciences Research Ethics Committee

/pm

Cc Supervisor: Professor Dipane Hlalele
Cc Academic Leader ResearchDr SB Khoza
Cc School Administrator: Ms Sheryl Jeenarain

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

Appendix B (Permission letter from the Department of Basic Education)

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Phindile Duma | Tel: 033 392 1063 | Ref.:2/4/8/1612

Ms TA Zondi
2 Tivoli
10 Lilyvale Road
Ashley
3610

Dear Ms Zondi

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"AN INQUIRY BASED LEARNING FRAMEWORK FOR TEACHING GEOGRAPHIC INFORMATION SYSTEMS IN A RURAL ECOLOGY"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

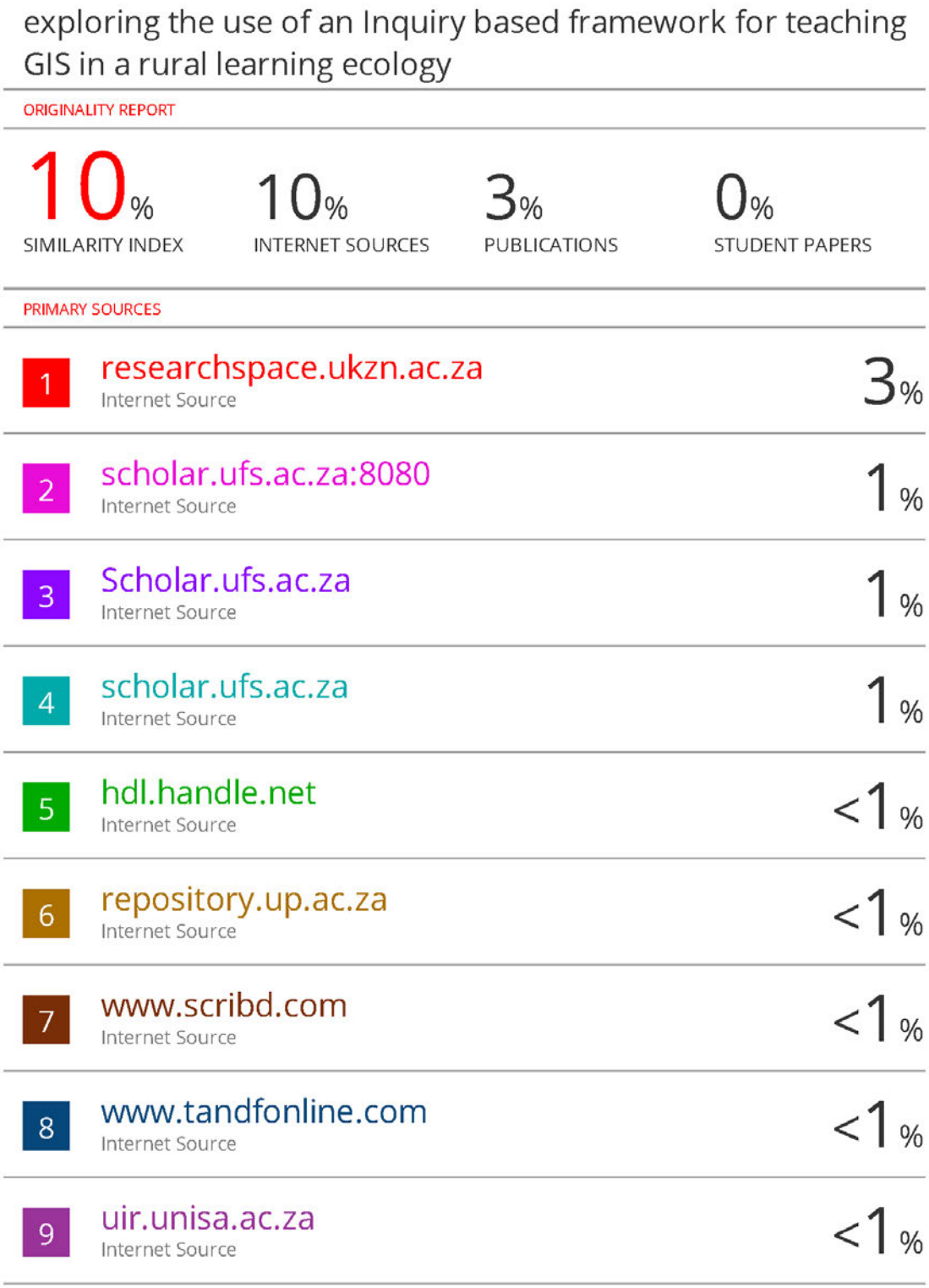
1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 30 August 2018 to 02 March 2021.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Phindile Duma at the contact numbers below,
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report/dissertation/thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

(PLEASE SEE LIST OF SCHOOLS ATTACHED)

[redacted]

Dr. EV Nzama
Head of Department: Education
Date: 30 August 2018

Appendix C (Turnit in report)



exploring the use of an Inquiry based framework for teaching GIS in a rural learning ecology

ORIGINALITY REPORT

10%	10%	3%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	researchspace.ukzn.ac.za Internet Source	3%
2	scholar.ufs.ac.za:8080 Internet Source	1%
3	Scholar.ufs.ac.za Internet Source	1%
4	scholar.ufs.ac.za Internet Source	1%
5	hdl.handle.net Internet Source	<1%
6	repository.up.ac.za Internet Source	<1%
7	www.scribd.com Internet Source	<1%
8	www.tandfonline.com Internet Source	<1%
9	uir.unisa.ac.za Internet Source	<1%

Appendix D (Consent to conduct research at the school: Principal)

CONSENT TO CONDUCT RESEARCH IN A SCHOOL
UNIVERSITY OF KWAZULU-NATAL
SCHOOL OF EDUCATION
DOCTOR OF PHILOSOPHY (PhD)

An Inquiry Based Learning Framework for teaching Geographic Information Systems in a Rural Ecology

To the School Principal

I am Thabile Zondi, currently studying towards the Doctor of Philosophy in Geography Education. To obtain my PhD, I am required to conduct a research study in a school. Therefore, I am writing this letter to seek permission from you as the school principal to conduct my research study in your school; [redacted] in the Pinetown district. I would like Geography Further Education and Training teachers and learners to partake in this study on Geographic Information Systems, this is because GIS is one of the challenging topics in the South African Geography curriculum. Please read the information below and I am available to address any questions or concerns relating to the research study.

- ✓ **PURPOSE OF THE STUDY**

The purpose of the study is to explore an Inquiry-based learning framework for teaching GIS in a rural learning ecology.

- ✓ **PROCEDURES**

The teachers and learners will voluntarily participate in this study by exploring an Inquiry-Based Learning framework for teaching GIS in a rural learning ecology. Furthermore, the learners' parents will be contacted to seek permission from them to allow their children to partake in the study. Pseudonyms will be used to protect the teachers and learners' identity.

- ✓ **POTENTIAL RISKS AND DISCOMFORTS**

As the researcher, I foresee no risks or discomfort in this research, as I will be conducting a participatory action research approach which seeks to improve the teaching of GIS in a rural learning ecology.

- ✓ **CONFIDENTIALITY**

Any information in connection with this study will remain confidential and it will not be disclosed without the teachers and learners' permission.

- ✓ **PARTICIPATION AND WITHDRAWAL**

The teachers and learners will be given a choice to decide whether they would like to partake in this study or not. Those that choose to participate in this study may withdraw at any time without consequences. Furthermore, the teachers and learners may also refuse to participate in activities that they may deem uncomfortable.

I can be contacted at:
Email: zondit2@ukzn.ac.za
Telephone number: 031 260 1379

My supervisor is Professor Hlalele who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.
He can be contacted at:
Email: Hlaleled@ukzn.ac.za Telephone number: 031 260 3858

You may also contact the Research office through:
Premlall Mohun
HSSREC Research Office,
E-mail: Mohunp@ukzn.ac.za Telephone number: 031 260 4557
Thank you for your contribution to this research study.

DECLARATION

I understand the procedures described above. All questions or concerns relating this consent form have been answered to my satisfaction, and I agree to allow the Further Education and Training Geography teachers and learners to participate in this study. A copy of this form has been given to me to retain.

_____ _____

Principal (Surname and initials) **Signature**

_____

Date

School Stamp

Appendix E (Informed consent: Teachers)

University of KwaZulu-Natal
College of Humanities
School of Education
Geography Education

Dear Geography Teacher

INFORMED CONSENT LETTER

My name is Thabile Zondi. I am a PhD candidate studying at the University of KwaZulu-Natal, School of Education. I intend doing a research study which aims at bringing about change in the teaching of Geographic Information Systems (GIS) in a rural ecology. With this letter, I would like to request you to take part in this research study. Should you agree, your participation in the study with take an hour or less for each session on average. You are kindly requested to avail yourself for the different activities during the course of the study. The times and dates of sessions are negotiable so as to ensure that you are not distracted from your other duties.

Please note that:

- Your confidentiality is guaranteed since I will use pseudonyms when reporting and discussing the generated data.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You are given a choice to participate or not to participate. Furthermore, you have a right to stop participating in the research process. You will not be penalised for taking such an action and you will not be asked to state a reason for your withdrawal.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.

If you are willing to take part in the study, please indicate (by ticking as applicable) whether or not you are willing to allow for the sessions to be recorded by the following equipment:

	willing	Not willing
Audio equipment		

I can be contacted at:

Email: zondit2@ukzn.ac.za

Telephone: 031 260 1379

My supervisor is Professor D. Hlalele who is located at the School of Education, Edgewood Campus of the University of KwaZulu-Natal

Tel: 031 260 3858 E-mail: Hlaleled@ukzn.ac.za

You may also contact the Research Office through:

P. Mohun

HSSREC Research Office,

Tel: 031 260 4557 E-mail: mohunp@ukzn.ac.za

Thank you for your contribution to this research study.

DECLARATION

I…… (Full name and surname of participant) hereby confirm that I understand the contents of this document and the nature of the research study, and I consent to participate in this research study.

I understand that I am at liberty to withdraw from the study at any time, should I wish to do so. A copy of this document has been given to me to retain.

Signature of participant **Date**

_____ _____

Appendix F (Informed consent: Student Teachers)

University of KwaZulu-Natal
College of Humanities
School of Education
Geography Education

Dear Geography Student Teacher

INFORMED CONSENT LETTER

My name is Thabile Zondi. I am a PhD candidate studying at the University of KwaZulu-Natal, School of Education. I intend doing a research study which aims at bringing about change in the teaching of Geographic Information Systems (GIS) in a rural learning ecology. With this letter, I would like to request you to participate in this research study. Should you agree, your participation in the study with take an hour or less for each session on average. You are kindly requested to avail yourself for the different activities during the course of the study. The times and dates of sessions are negotiable so as to ensure that you are not distracted from your other duties.

Please note that:

- Your confidentiality is guaranteed since I will use pseudonyms when reporting and discussing the generated data.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You are given a choice to participate or not to participate. Furthermore, you have a right to stop participating in the research process. You will not be penalised for taking such an action and you will not be asked to state a reason for your withdrawal.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.

If you are willing to participate in this study, please indicate (by ticking as applicable) whether or not you are willing to allow for the sessions to be recorded using the following equipment:

	willing	Not willing
Audio equipment		

I can be contacted at:
Email: zondit2@ukzn.ac.za
Telephone: 031 260 1379

My supervisor is Professor D. Hlalele who is located at the School of Education, Edgewood Campus of the University of KwaZulu-Natal
Tel: 031 260 3858 E-mail: Hlaleled@ukzn.ac.za

You may also contact the Research Office through:
P. Mohun
HSSREC Research Office,
Tel: 031 260 4557 E-mail: mohunp@ukzn.ac.za

Thank you for your contribution to this research study.

DECLARATION

I…… (Full name and surname of participant) hereby confirm that I understand the contents of this document and the nature of the research study, and I consent to participating in the research study.

I understand that I am at liberty to withdraw from the study at any time, should I wish to do so. A copy of this document has been given to me to retain.

Signature of participant **Date**

_____ _____

Appendix G (Informed consent: Subject advisor)

University of KwaZulu-Natal
College of Humanities
School of Education
Geography Education

Dear Geography Subject Advisor

INFORMED CONSENT LETTER

My name is Thabile Zondi. I am a PhD candidate studying at the University of KwaZulu-Natal, School of Education. I intend doing a research study which aims at bringing about change in the teaching of Geographic Information Systems (GIS) in a rural learning ecology. With this letter, I would like to request you to participate in this research study. Should you agree, your participation in the study with take an hour or less for each session on average. You are kindly requested to avail yourself for the different activities during the course of the study. The times and dates of sessions are negotiable so as to ensure that you are not distracted from your other duties.

Please note that:

- Your confidentiality is guaranteed since I will use pseudonyms when reporting and discussing the generated data.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You are given a choice to participate or not to participate. Furthermore, you have a right to stop participating in the research process. You will not be penalised for taking such an action and you will not be asked to state a reason for your withdrawal.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.

If you are willing to participate in this study, please indicate (by ticking as applicable) whether or not you are willing to allow for the sessions to be recorded using the following equipment:

	willing	Not willing
Audio equipment		

I can be contacted at:
Email: zondit2@ukzn.ac.za
Telephone: 031 260 1379

My supervisor is Professor D. Hlalele who is located at the School of Education, Edgewood Campus of the University of KwaZulu-Natal
Tel: 031 260 3858 E-mail: Hlaleled@ukzn.ac.za

You may also contact the Research Office through:
P. Mohun
HSSREC Research Office,
Tel: 031 260 4557 E-mail: mohunp@ukzn.ac.za

Thank you for your contribution to this research study.

DECLARATION

I…… (Full name and surname of participant) hereby confirm that I understand the contents of this document and the nature of the research study, and I consent to participate in this research study.

I understand that I am at liberty to withdraw from the study at any time, should I wish to do so. A copy of this document has been given to me to retain.

Signature of participant **Date**

_____ _____

Appendix H (Informed consent: Lecturers)

University of KwaZulu-Natal
College of Humanities
School of Education
Geography Education

Dear Lecturer

INFORMED CONSENT LETTER

My name is Thabile Zondi. I am a PhD candidate studying at the University of KwaZulu-Natal, School of Education. I intend doing a research study which aims at bringing about change in the teaching of Geographic Information Systems (GIS) in a rural learning ecology. With this letter, I would like to request you to participate in this research study. Should you agree, your participation in the study with take an hour or less for each session on average. You are kindly requested to avail yourself for the different activities during the course of the study. The times and dates of meeting are negotiable so as to ensure that you are not distracted from your other duties.

Please note that:

- Your confidentiality is guaranteed since I will use pseudonyms when reporting and discussing the generated data.
- Any information given by you cannot be used against you, and the collected data will be used for purposes of this research only.
- Data will be stored in secure storage and destroyed after 5 years.
- You are given a choice to participate or not to participate. Furthermore, you have a right to stop participating in the research process. You will not be penalised for taking such an action and you will not be asked to state a reason for your withdrawal.
- Your involvement is purely for academic purposes only, and there are no financial benefits involved.

If you are willing to participate in this study, please indicate (by ticking as applicable) whether or not you are willing to allow for the sessions to be recorded using the following equipment:

	willing	Not willing
Audio equipment		

I can be contacted at:
Email: zondit2@ukzn.ac.za
Telephone: 031 260 1379

My supervisor is Professor D. Hlalele who is located at the School of Education,
Edgewood Campus of the University of KwaZulu-Natal
Tel: 031 260 3858 E-mail: Hlaleled@ukzn.ac.za

You may also contact the Research Office through:
P. Mohun
HSSREC Research Office,
Tel: 031 260 4557 E-mail: mohunp@ukzn.ac.za

Thank you for your contribution to this research study.

DECLARATION

I…… (Full name and surname of participant) hereby confirm that I understand the contents of this document and the nature of the research study, and I consent to participate in this research study.

I understand that I am at liberty to withdraw from the study at any time, should I wish to do so. A copy of this document has been given to me to retain.

Signature of participant **Date**

_____ _____

Appendix I (Parent permission letter)

University of KwaZulu-Natal
College of Humanities
School of Education
Geography Education

Mzali othandekayo

Incwadi yesicelo sokwenza ucwaningo nabantwana

Igama lami ngingu Thabile Zondi. Ngifundela izifundo zobudokotela eUnivesithi yaKwa Zulu Natal, eEdgewood. Nginesifiso sokwazi ngabanzi ngokufundiswa kwe Geographical Information Systems engaphansi kwe Geography lefundwa umntwana wakho esikoleni. Ngifisa ukuqondisisa ukuthi umntwana wakho uyifundiswa kanjani iGeographic Information Systems nawukuthi imuphethe kanjani ngenxa yokuthi ucwaningo olwenziwe ngaphambilini ngemiphumelo yakamatikuletsheni, luveza ukuthi izingane aziyiphasi kahle iGeographic Information Systems. Ukuzengithole lemininigwane, ngingajabula uma ungavumela umntwana wakho ukuthi abambe iqhaza kulolucwaningo engifisa ukulwenza.

Ngicela wazi lokhu okulandelayo:

- Igama lomtwana wakho lizohlala liyimfihlo njalo, kanye nemibono yakhe kulolucwaningo.
- Ngizocela ukuthi abhale phansi imibono yakhe kanye nokakade wakhe mayelana ne Geographic Information Systems. Ngaphezulu kwalokho ngingafisa ukuxoxa naye mayelana nokufundiswa kweGeographic Information Systems.
- Imibono engizoyithola kumntwana wakho ngeke ngiyisebenzise kabi.
- Umntwana wakho unelungelo lukunqaba ukuba ingxenye yocwaningo, futhi unelungelo lokuyeka ashiye phakathi nanoma ingasiphi isikhathi uma ezizwa kabi ngokuqhubeka. Futhi ngeke ajeziswe ngokwenzenjalo.
- Asikho isipho semali esizotholwa umntwana wakho uma uvuma ukuthi abe ingxenye yalolu cwaningo.

Uma uvuma ukuthi umntwana wakho abambe iqhaza kulolucwaningo, ngicela usayine lapha ngezansi. Ngicela futhi uveze ukuthi uyavuma yini ukuthi ngiqophe izinkulumo esizoba nazo naye mayelana nalolucwaningo.

	Ngiyavuma	Angivumi
Ukuqopha izinkulumo		

Mina ngitholakala kulemininingwane elandelayo:

Email: zondit2@ukzn.ac.za
Inombolo yocingo: 031 260 1379

Induna yami engibhekile njengoba ngenza lolucwaningo itholakala kulemininingwane elandelayo:
USolwazi D. Hlalele
Email: hlaleled@ukzn.ac.za
Inombolo yocingo: 031 260 3856

Ungathinta ne hhovisi locwaningo kulemininingwane elandelayo:
P. Mohun
HSSREC Research Office,
E-mail: mohunp@ukzn.ac.za
Inombolo yocingo: 031 260 4557

Ngiyalubonga usizo lwakho kulolucwaningo.

Isivumelwano

Mina _____ (amagama omzali) ngiyavuma ukuthi ngiyaqonda okubhalwe kuleliphepha mayelana nocwaningo lokufundiswa kwe Geographic Information Systems. Ngiyavuma ukuthi umntwana wami abeyinxenye yaloluncwaningo. Ngiyaqonda futhi ukuthi umntwana wami angasula nanomayinini uma engasathandi ukuba ingxenye yalolucwaningo.

Kusayina umzali Usuku

_____ _____

Appendix J (Informed Assent: Learner)

University of KwaZulu-Natal
College of Humanities
School of Education
Geography Education

Mfundi we Geography

<u>Incwadi yesicelo sokuba ube ingxenye yocwaningo</u>

Igama lami ngingu Thabile Zondi. Ngifundela izifundo zobuDokotela eUnivesithi yaKwa Zulu Natal, eEdgewood. Nginesifiso sokwazi ngabanzi ngokufundiswa kwe Geographical Information Systems engaphansi kwe Geography lefundwa esikoleni sakho. Ngifisa ukuqondisisa ukuthi uyifundiswa kanjani iGeographic Information Systems nawukuthi ikuphethe kanjani ngenxa yokuthi ucwaningo olwenziwe ngaphambilini ngemiphumelo yakamatikuletsheni, luveza ukuthi ozakwenu abayiphasi kahle iGeographic Information Systems. Ukuzengithole lemininigwane, ngingajabula uma ungavuma ukuthi ubambe iqhaza kulolucwaningo engifisa ukulwenza.

Ngicela wazi lokhu okulandelayo:

- Igama lakho lizohlala liyimfihlo njalo, kanye nemibono yakho kulolucwaningo.
- Ngizocela ukuthi ubhale phansi imibono yakho kanye nokakade lwakho mayelana ne Geographic Information Systems. Ngaphezulu kwalokho ngingafisa ukuxoxa nawe mayelana nokufundiswa kweGeographic Information Systems.
- Imibono engizoyithola kuwena ngeke ngiyisebenzise kabi.
- Unelungelo lukunqaba ukuba ingxenye yocwaningo, futhi unelungelo lokuyeka ashiye phakathi nanoma ingasiphi isikhathi uma uzizwa kabi ngokuqhubeka. Kanti futhi ngeke ujeziswe ngokwenzenjalo.
- Asikho isipho semali ozosithola uma uvuma ukuthi ube ingxenye yalolu cwaningo.

Uma uvuma ukubamba iqhaza kulolucwaningo, ngicela usayine lapha ngezansi. Ngicela futhi uveze ukuthi uyavuma yini ukuthi ngiqophe izinkulumo yethu maleyana naloluncwaningo.

	Ngiyavuma	Angivumi
Ukuqopha izinkulumo		

Mina ngitholakala kulemininingwane elandelayo:

Email: zondit2@ukzn.ac.za
Inombolo yocingo: 031 260 1379

Induna yami engibhekile njengoba ngenza lolucwaningo itholakala kulemininingwane elandelayo:
USolwazi D. Hlalele
Email: hlaleled@ukzn.ac.za
Inombolo yocingo: 031 260 3856

Ungathinta ne hhovisi locwaningo kulemininingwane elandelayo:
P. Mohun
HSSREC Research Office,
E-mail: mohunp@ukzn.ac.za
Inombolo yocingo: 031 260 4557

Ngiyalubonga usizo lwakho kulolucwaningo.

Isivumelwano

Mina _____ (amagama akho nesibongo) ngiyavuma ukuthi ngiyaqonda okubhalwe kuleliphepha mayelana nocwaningo lokufundiswa kwe Geographic Information Systems. Ngiyavuma ukubayinxenye yaloluncwaningo. Ngiyaqonda futhi ukuthi ngingasula nanomayinini uma ngingasathandi ukuba ingxenye yalolucwaningo.

Kusayina umfundi Usuku

_____ _____

Appendix K (Conversation Schedule)

An Inquiry-Based Learning Framework for teaching Geographical Information Systems in a Rural Ecology

Conversation schedule

1. What is your understanding of Geographic Information systems (GIS)?
2. What is your view regarding the inclusion of GIS in the Geography curriculum?
3. Would you say that GIS is a challenging topic in the Geography curriculum?
4. How do you teach GIS?
5. Which resources do you use to teach GIS?
6. How do the learners perform in GIS assessment sections?
7. Tell me about any GIS training opportunities that you have been exposed to.

Appendix L (Focus Group Discussion Schedule)

An Inquiry-Based Learning Framework for teaching Geographical Information Systems in a Rural Ecology

Focus group discussion Schedule

1. What is the common teaching approach that you use often?
2. What do you understand about the Inquiry-Based Learning approach to teaching?
3. Do you think that applying the Inquiry-Based Learning approach can improve the teaching of GIS?
4. How do you think the Inquiry-Based Learning may be used to teach GIS?
5. What are the possible benefits and or impediments to the use of Inquiry-Based Learning to teach GIS?
6. What are the implications for the use of Inquiry-Based Learning to teach GIS in a rural ecology?
7. How do you plan your lessons?
8. Do you reflect after teaching each lesson?

Appendix M (Reflective Journal prompts)

Please reflect on your experiences of learning GIS from grade 10:

What stood out for you in today's GIS lesson? What captured your attention and why?	**What worked well in today's lesson?**
How was I taught?	**How did I learn?**
How did I interact with other learners?	**What did not work or could have been more effective in today's lesson? What was missing or needed?**

Please feel free to add any more information about the lesson and the kind of support that you require from your teacher and peers:

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Name _____ **Date** _____

Lesson Topic _____

Appendix N (Classroom observation schedule)

An Inquiry-Based Learning Framework for teaching Geographical Information Systems in a Rural Ecology

Classroom Observation Schedule

Name of the teacher: _____ Time: _____

Name of the observer: _____ Grade: _____

Lesson topic _____

	Exceed Expectations	Meets Expectations	Needs Improvement	Unacceptable	Not Observed
Teaching Methods					
Technology is incorporated into the lesson	☐	☐	☐	☐	☐
The question and answer method is used in the lesson	☐	☐	☐	☐	☐
Learner centredness, is evident during the lesson	☐	☐	☐	☐	☐
Problems are posed to learners	☐	☐	☐	☐	☐
Learners are encouraged to work in groups (small/large)	☐	☐	☐	☐	☐
Critical thinking skills are encouraged	☐	☐	☐	☐	☐
Teacher-learner Interaction					
All learners are engaged and active	☐	☐	☐	☐	☐
Solicits learner input	☐	☐	☐	☐	☐
The teacher serves as a facilitator and supports all	☐	☐	☐	☐	☐

learners during the lesson					
The lesson includes demonstration	☐	☐	☐	☐	☐
Content					
The teacher is knowledgeable about Geographic Information Systems	☐	☐	☐	☐	☐
Relates Geographic Information Systems concepts to learners' everyday experiences	☐	☐	☐	☐	☐
Selects learning experiences appropriate to level of learning	☐	☐	☐	☐	☐

Comments:

_____

_____

_____

_____

_____

_____

_____

_____ _____

Observer Signature Date

Appendix O (Language editing certificate)

ASOKA ENGLISH LANGUAGE EDITING
45 Vausedale Crescent, Escombe, 4093.

CELL NO.: 0836507817

DECLARATION

THIS IS TO CERTIFY THAT THE THESIS ENTITLED

AN INQUIRY-BASED LEARNING FRAMEWORK FOR TEACHING GEOGRAPHIC INFORMATIONS SYSTEMS IN A RURAL LEARNING ECOLOGY

Candidate: Zondi T

HAS BEEN ENGLISH LANGUAGE EDITED.

[redacted]

DISCLAIMER

Whilst the English language editor has used electronic track changes to facilitate corrections and has inserted comments and queries in a right-hand column, the responsibility for effecting changes in the final, submitted document, remains the responsibility of the client and the editor cannot be held responsible for the quality of English Language expression used in corrections or additions effected subsequent to the transmission of this certificate on 09/11/2021.

Prof. Dennis Schauffer, M.A.(Leeds), PhD, KwaZulu (Natal), TEFL(London), TITC Business English, Emeritus Professor UKZN. Univ. Cambridge Accreditation: IGCSE Drama. Hon. Research Fellow, DUT. Durban University of Technology.