

**UNIVERSITY OF KWAZULU-NATAL**

**GEOGRAPHY TEACHERS' PERCEPTIONS OF IMPLEMENTING PAPER-BASED  
GEOGRAPHIC INFORMATION SYSTEMS IN A RURAL LEARNING ECOLOGY**

**By**

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**Submitted in fulfilment for the Masters of Education Degree (Geography Education),  
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## **DECLARATION**

I, Thulasizwe Fredrick Mkhize, declare:

- (i) The research reported in this dissertation, except where otherwise indicated is my original work.
- (ii) This dissertation has not been submitted for any degree or examination at any other university.
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## **SUPERVISOR'S STATEMENT**

This dissertation has been submitted with/without my approval

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**Date:** \_\_\_\_\_

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## **DEDICATION**

I dedicate this study to my mother and son, Jabulisiwe Doris Mkhize and Lisakhanya Zekhethelo Mvelo Mkhize, for being a positive influence in my life. I love you mom and son.

## **ABSTRACT**

The purpose of the study was to explore the Geography teachers' perceptions of implementing paper-based Geographic Information Systems (paper-based GIS) in a rural learning ecology. Three research questions were identified to give direction to the study; 1) what are geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology, 2) how do geography teachers implement paper-based Geographic Information Systems in a rural learning ecology, 3) why do teachers implement paper-based GIS in a rural learning ecology the way that they do. The Unified Theory of Acceptance and Use of Technology (UTAUT) constituted the theoretical framework that was used to understand the Geography teachers' perceptions in this inquiry. Qualitative research methods; semi-structured interviews and a focus-group interview were used to generate data to answer the research questions. Four Geography teachers from a rural learning ecology made up were purposively selected to participate in this study. The data generated from the field was then analysed thematically. The findings reveal that Geography teachers experience challenges in implementing paper-based GIS in a rural learning ecology. These challenges include inadequate teacher training, lack of information, resources and financial constraints, lack of teaching time, poor facilitating conditions, and complex paper-based GIS concepts. The study proposes that the Department of Basic Education in collaboration with institutions of higher education should provide GIS teacher training opportunities for teachers that wish to advance their knowledge of GIS.

## **LIST OF ABBREVIATIONS**

ANC	African National Congress
DIME	Dual Independent Map Encoding
DBE	Department of Basic Education
EMIS	Educational Management Information System
ESRI	Environmental Systems Research Institute
GBF	Geographic Base File
GIS	Geographic Information Systems
ICT	Information Communication Technologies
IEB	Independent Examinations Board
IT	Information Technology
MOE	Ministry of Education
NASCA	National Senior Certificate for Adults
NBE	National Board of Education
NCGIA	National Centre for Geographic Information and Analysis
NCS	National Curriculum Statement
NePAD	New Partnership for Africa's Development
NIE	National Institute of Education
PGIS	Paper-based Geographic Information Systems
RNCS	Revised National Curriculum Statement
SASA	South African Schools Act
WCDE	Western Cape Department of Education
ATP	Annual Teaching Plan

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## **CHAPTER ONE**

### **BACKGROUND AND ORIENTATION TO THE STUDY**

#### **1.1 INTRODUCTION**

This chapter introduces the entire research study. In developing this chapter, the background to the study, the problem statement, rationale of the study, the significance of the study, the aim and purpose of the study, and key research questions that form the basis for the study are presented. This chapter also provides an overview of the research design and methodology and gives an outline of the study.

#### **1.2 BACKGROUND OF THE STUDY**

The potential positive impact of Geographic Information System (GIS) on geography instruction has led to a global movement to include it in the school curricula (Fleischmann & van der Westhuizen, 2016). In South Africa, GIS was listed as a skill to be acquired in the National Curriculum Statement (NCS) in 2003, although its actual inclusion in the curriculum was only phased in from 2006. In 2006, the Department of Basic Education (DBE) introduced GIS as part of the grade 10 geography syllabus for the first time and it extended this to include grades 11 and 12 in 2007 and 2008, respectively (Fleischmann & van der Westhuizen, 2016). However, research conducted during 2008 on the implementation of GIS in schools revealed that teachers were faced with challenges when teaching this topic in the classroom (Scheepers, 2009). Among concerns, researchers noted a lack of any theoretical grounding and practical experience in using GIS by teachers (Zietsman, 2002), and Fleming (2015) stated that teachers in South Africa lack professional development in the teaching of GIS.

Another concern regarding the implementation of GIS in the classroom is the lack of funding and infrastructure in schools (Nxele, 2007). The lack of funds and infrastructure in South Africa has resulted in a challenge when attempting to implement computerised GIS teaching methods, especially in technologically disadvantaged schools (Breetzke, Eksteen, & Pretoius, 2011). Computer-based GIS is a system that allows geographically referenced information to be captured, stored, edited, displayed, analysed, and printed (Human Sciences Research Council (HSRC), 2011). User-friendly curriculum-orientated GIS software that is affordable requires computer hardware and teachers' GIS teaching knowledge; hence the integration of GIS into instructional practice has stalled because of the lack of hardware and lack of teacher knowledge

(Fleischmann & van der Westhuizen, 2016). The challenges encountered utilising computer-based GIS in developing countries such as South Africa gave birth to the development and distribution of a manual paper-based system for use in teaching GIS in resource-poor schools (Breetzke et al., 2011). This research investigated teachers' perceptions about paper-based GIS to discover whether they are teaching and implementing it as expected by the DBE.

### **1.3 STATEMENT OF THE PROBLEM**

The purpose of the study was to explore how geography teachers perceive and implement paper-based GIS in a rural learning ecology. GIS is a geography topic that has been included in the South African curriculum for over a decade. GIS was introduced into the geography curriculum of South African schools from 2006 to 2008 as part of the NCS for Grades 10-12 (Breetzke, Eksteen, & Pretoius, 2011). The introduction of the computer-based GIS appeared to be problematic for geography teachers, especially in developing countries where the majority of the schools are poorly-resourced. Computer-based GIS requires considerable financial input in terms of purchasing the necessary software, hardware, electricity, educational materials, as well as money for the training of educators for successful implementation (Breetzke et al., 2011). This has resulted in learners who are expected to learn the basics of GIS and cartography, understand the potentials of different GIS applications, and be able to process, interpret and visualise geographical data with GIS without practically using the actual computer-based GIS tools.

Despite large government spending on education, research has shown that the South African schooling system, especially in rural areas, is struggling to convert resources into learner performances and is failing to promote social equity (Naidoo, Van Eeden, & Munch, 2014). Several schools in poor rural communities are also still constrained by the legacy of large classes, deplorable physical conditions, and the absence of learning resources (Breetzke et al., 2011). A recent study by Bayat, Louw, and Rena (2014, p. 184) reveals that, in terms of schools' infrastructure, according to the National Educational Infrastructure Management Systems (NEIMS, 2009) 3,600 public schools have no electricity, only 21% have a library, and 23% have a computing facility. This is problematic since it means that too many public schools have limited access to necessary resources. The factors that have been discussed above seem to be mostly affecting rural schools since GIS is linked to technology and requires competent teachers in technology (Breetzke et al., 2011).

The emerging challenges of teaching computer-based GIS in resource-poor schools led to the birth of paper-based GIS as an answer to the inability to and lack of access to computers for teaching and learning of GIS. According to Breetzke et al. (2011), the paper-based GIS initiative is the output of a project managed by Environmental Systems Research Institute (ESRI) South Africa (Pty) Ltd. and supported by the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (UP) in South Africa. ESRI is the international supplier of GIS and geodatabase management applications; the company is headquartered in Redlands, California (Breetzke et al., 2011). The aim of the project facilitated by the ESRI team was to introduce GIS in resource-poor schools in South Africa through the development and distribution of a paper-based educational package (Breetzke et al., 2011). The educational material contained within the package included a 1:50 000 topographic map, a 1:10 000 orthophotograph, tracing paper, a ruler, coloured crayons, adhesive, an exercise book for learners, and a handbook for educators. The idea of introducing paper-based GIS in resource-poor schools is for teachers to not just teach GIS concepts to learners but to also teach learners application skills of the GIS definitions using topographical map and orthophoto map (Innes, 2012), to assist with solving geographical problems

Although ESRI introduced paper-based GIS as an alternative to computer-based GIS to be taught in resource-poor South African schools, the Department of Basic Education (2015) revealed in a diagnostic report for National Senior Certificate (NSC) that fundamental knowledge of GIS was lacking as indicated by poor learners' performance in GIS. The DBE reported that certain geography teachers were not familiar with GIS and were just teaching definitions but not the application of the techniques and skills as were expected in paper-based GIS (DBE, 2015). Furthermore, this also suggested that certain geography teachers are not integrating paper-based GIS knowledge across the various topics of the subject. For instance, learners should be asked to also apply GIS concepts to topics such as climate and weather, geomorphology, settlement geography, and the economic geography of South Africa (DBE, 2015; DBE, 2016). The NSC diagnostic report of 2016 is in line with that of 2015 with regards to geography paper two learners' performance, particularly with regards to GIS although there was a slight improvement over the previous year. The diagnostic report of 2016 indicates that GIS questions were poorly answered by candidates (DBE, 2016). The DBE concluded that poor GIS learners' performance was as a result of certain teachers not devoting ample time to planning these lessons (DBE, 2016).

#### **1.4 RATIONALE AND MOTIVATION FOR THE STUDY**

The following three elements will be discussed under this section related to motivation for the study: personal factors, professional factors, and literature on Geographic Information System. The researcher matriculated in 2007 before GIS was introduced in the geography syllabus at matric level and as a result, was not taught GIS at secondary school. The researcher enrolled for the Bachelor of Education (BEd) in 2009 and majored in geography but was not introduced to GIS during 2009 and 2010. It was only in 2011 that the researcher found that GIS had been introduced into the geography curriculum; this was done while the researcher was completing his teaching practice. The mentor teacher was asked to guide how to teach the GIS topic, but the mentor teacher revealed that she was uncertain of the topic as it was still new in the curriculum. The researcher then had to read the textbooks to become familiar with the GIS concepts. The researcher was not introduced to GIS during the time of undergraduate Bed study. Even a guest lecturer, who was invited to lecture on the map-work section for the geography method module during the third year of Bed study, covered almost every topic except GIS.

In 2012, the researcher completed undergraduate studies and became qualified as a geography teacher. In 2013, the researcher was deployed by the DBE in one of the schools in UGU district to teach geography. GIS was one of the topics that the researcher was expected to teach. The researcher once again approached a colleague who was also taught the subject, with the hope of receiving assistance with teaching the GIS content. This teacher had more experience but said they did not teach the section to learners and even requested that this researcher teach her classroom the GIS topic. The teacher also informed this researcher that she never assessed learners on GIS in the past and instead, simply excluded the topic on her question papers causing learners to miss out on knowledge they should have acquired before moving to the next grade. In geography workshops that are conducted by the DBE, it was observed that geography teachers complained to the subject advisor. Conversations with this researcher and other teachers during these workshops indicated that these other teachers had similar problems as this researcher with regards to GIS implementation in the classroom. The mutual problem shared by the teachers and others in understanding GIS then triggered the idea to conduct a research study aimed at exploring geography teachers' perceptions about the implementation of paper-based GIS in secondary schools.

Reviewing the literature showed that the challenge of GIS implementation is a global issue. GIS is under-utilised both in developed and developing countries (Fleischmann & van der Westhuizen, 2017). The concerns noted in developed and developing countries are; the lack of user-friendly curriculum-orientated GIS software, insufficient computer hardware and the teachers' lack of GIS teaching knowledge (Fleischmann & van der Westhuizen, 2017). Countries such as Austria, Canada, India and New Zealand struggle to integrate Internet and computer use in the classroom setting (Kerski, Demirci, & Milson, 2013). Teachers are also constrained by limited available time required to become familiar with and implement complex GIS software (Baker, Palmer, & Kerski, 2009). The overall complexity of GIS software demands extensive professional teacher development and technical preparation (Baker, 2005), as well as additional instructional time. A marked hesitancy amongst teachers, even in technologically advanced countries, may reflect an underlying uncertainty about how to maximise the benefits of GIS in classroom instruction (National Research Council, 2006).

It is against the backdrop of these challenges that this study seeks to investigate the teachers' perceptions about the paper-based GIS implementation in a rural learning ecology situated in KwaZulu-Natal Province in the Ugu district. It is also evident that in the literature reviewed so far, none of the studies have explored the teacher usage of paper-based GIS and this is the gap in knowledge that will be filled by this study.

## **1.5 SIGNIFICANCE OF STUDY**

The purpose of the study was to explore geography teachers' perceptions of implementing paper-based GIS in a rural learning ecology. GIS was introduced in the South African Basic Education curriculum in 2006 (Fleischmann & van der Westhuizen, 2016). However, research about the implementation of GIS in South African schools reveals that teachers are faced with many challenges. Some of the challenges include lack of professional development for teachers (Fleming, 2015), the lack of funds, and limited time and infrastructure (Breetzke, Eksteen, & Pretoius, 2011). This study will benefit geography teachers and DBE officials in the implementation of paper-based GIS in the rural learning ecology. The teachers and DBE officials may be exposed to other geography teachers' perceptions and recommendations of paper-based GIS implementation in the rural learning ecology. In this way, the teachers' perceptions and recommendations of paper-based GIS implementation may assist them and other teachers in teaching the topic in the classroom. The DBE officials may also realise

strategies that they can use to equip these teachers with knowledge they can use for effective implementation of paper-based GIS in the rural learning ecology.

## **1.6 AIM AND PURPOSE OF THE STUDY**

The research study aimed to understand geography teachers' perceptions of implementing paper-based GIS in a rural learning ecology of basic education in UGU district, Kwa-Zulu Natal. The main purpose was to allow these teachers to voice how they received paper-based GIS ever since it was first introduced to them. Therefore, geography teachers that were participants for the study were either from A or B in a rural learning ecology.

## **1.7 RESEARCH OBJECTIVES AND KEY RESEARCH QUESTIONS**

### **1.7.1 RESEARCH OBJECTIVES**

1. To explore geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology.
2. To determine how geography teachers implement paper-based Geographic Information Systems in a rural learning ecology.
3. To identify why do teachers implement paper-based GIS in a rural learning ecology in the way that they do?

### **1.7.2 KEY RESEARCH QUESTIONS**

1. What are geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology?
2. How do geography teachers implement paper-based Geographic Information Systems in a rural learning ecology?
3. Why do teachers implement paper-based GIS in a rural learning ecology the way that they do?

## **1.8 RESEARCH DESIGN AND METHODOLOGY**

This study adopted the qualitative research design. Such an approach is deemed appropriate because qualitative findings are always based on human experiences and stories which cannot be measured, counted or controlled (O' Leary, 2004; Cohen, Manion, & Morrison, 2007). In

line with the view expressed above, Patton (2001) argues that qualitative research uses a naturalistic approach that seeks to understand phenomena in context-specific settings, such as a real-world setting [where] the researcher does not attempt to manipulate the phenomenon of interest. The qualitative research design was suitable for this study because it hoped to understand the geography teachers' perceptions of implementing paper-based GIS in a rural learning ecology, from the teachers' perspective. Therefore, the study was conducted in such a way as to allow findings to unfold naturally in their context.

The interpretive paradigm was best suited for this research as it enabled this researcher to understand how teachers perceived and implemented paper-based GIS in a rural ecology. In the same way, Bertram and Christiansen (2014) posit that the purpose of the interpretive paradigm is to develop a greater understanding of how people make sense of the contexts in which they live and work. This concurs with the notion that interpretivists believe that reality is socially constructed and that there are as many intangible realities that construct. Chilisa and Kawulich (2012) add that reality is, therefore, mind-dependent and a personal or social construct. Constructivists also believe that knowledge is subjective because it is socially constructed and mind-dependent and truth lies within the human experience (Bertram & Christiansen, 2014; Chilisa & Kawulich, 2012; Thanh & Thanh, 2015). For this reason, the interpretive paradigm was suitable for this study since the geography teachers' experiences were subjectively engaged in as a way to understand the journey they had in teaching paper-based GIS in a rural ecology.

## **1.9 METHODS OF DATA GENERATION**

The purpose of data gathering in qualitative research is to provide evidence for the experience it is investigating (Polkinghorne, 2005). The study used two data collection tools namely: semi-structured individual interviews and focus group interviews. The semi-structured interview data generation method has features of both structured and unstructured interviews and, therefore, uses both closed and open questions, which is advantageous (Patten & Newhart, 2017). To be consistent with all participants, the interviewer had a set of pre-planned core questions for guidance such that the same areas were covered with each interviewee (Mann, 2016). As the interview progressed, the interviewee was given the opportunity to elaborate or provide more relevant information if he/she opted to do so (Mann, 2016).

To generate data, semi-structured in-depth interviews were conducted in such a way to provide room for the development of ideas. The semi-structured interview, as stated earlier, often asks open-ended questions and probes the responses (Jamshed, 2014). This researcher was able to ask geography teachers further questions on the paper-based GIS which emanated from insights gained by the discussions in the interviews. Cohen, Manion, and Morrison (2001) add that interviews enable participants to discuss their interpretations of the world in which they live and to express how they regard situations from their point of view. The merit of the semi-structured qualitative interview is that it allows for dialogue between the interviewer and interviewee (Bertram & Christiansen, 2014). Therefore, the interviewees may feel more content having a conversation with the researcher as opposed to filling out papers in a survey. During the interview, participants were audio-recorded to obtain every piece of information discussed about the implementation of paper-based GIS in a rural ecology.

A focus group interview is a planned discussion where a group of participants is asked a set of semi-structured questions to obtain perceptions on a defined area of interest in a non-threatening environment (Carey & Asbury, 2016). To generate data, a group of four geography teachers was asked to avail themselves for a focus group interview. This is because four teachers were small enough for everyone to have an opportunity to share insights and yet large enough to provide a diversity of perceptions about the implementation of GIS in a rural learning ecology.

### **1.9.1 SELECTION OF PARTICIPANTS**

The selection of participants involves making decisions about which people, settings, events or behaviours to include in the study (Creswell, 2009; Maree, 2007). A purposive sample was utilised in this study because it is representative, non-random, and participants that were selected had the needed information. The participants of this research study were four geography teachers from two poorly-resourced schools who were purposively chosen. Purposive sampling targets knowledgeable people with in-depth knowledge about certain issues like professional role, power, expertise or experience (Cohen, et al., 2011). Hence, the experienced teachers were chosen to provide in-depth knowledge with regards to their perceptions about teaching paper-based GIS in a rural learning ecology. Purposive sampling enabled research to be conducted in two schools that offered geography as one of the matric subjects.

### **1.9.2 DATA ANALYSIS**

Data was analysed using thematic analysis. Thematic analysis is a method for identifying and interpreting patterns of meaning across qualitative data (Clarke & Braun, 2014). Thematic analysis is approached as a six-phase process: familiarisation, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes, and producing the report (Clarke & Braun, 2014). To become familiar with data, the researcher listened to the audio-tape recordings at least twice then transcribed the data. Thereafter, the researcher played the audio-tape and read the transcriptions to ensure that data had been transcribed verbatim. Thereafter, initial codes were generated which assisted in the search for themes. Potential themes were reviewed and then defined and named to produce the report (Vaismoradi, Jones, Turunen, & Snelgrove, 2016).

Data was analysed using deductive and inductive thematic analysis. The deductive thematic analysis uses the theoretical framework to analyse data (Bertram & Christiansen, 2014). Hence, the Unified Theory of Acceptance and Use of Technology (UTUAT) constitute the study to identify and interpret meaning across data generated from semi-structured interviews and focus group discussions. In the inductive thematic analysis, themes emerge from data collected from the field. Therefore, there was data that emerged from the research site which was used to identify and interpret themes that were not covered by the UTUAT theoretical framework (Bertram & Christiansen, 2014; Clarke & Braun, 2014).

### **1.9.3 ETHICAL CONSIDERATIONS**

Permission to conduct research at the schools was requested from the Department of Basic Education (DBE) as the main gatekeepers of the schools. Permission to conduct research was also requested from the school principal as a gatekeeper through a permission letter. The researcher also applied for ethical clearance for the UKZN ethics office. According to Murphy and Dingwall (2001), it is the responsibility of the researcher to respect the autonomy of all participants involved in the research study. This means that research participants' values and decisions should be respected. Before approaching participants for data generation through interviews, the gatekeepers' permission letters were shown to all participants while individually requesting their consent to take part in the study. All participants participated voluntarily and held a right to withdraw at any time (Bertram and Christiansen, 2014). The consent letter that was provided to the participants also included the following: willingness to

be interviewed, and allowed for the use of audio equipment during the interview and focus group interviews.

To avoid any identification of individuals, the confidentiality of the sources was guaranteed by the usage of pseudonyms for the schools and participants. This is called non-maleficence according to Bertram and Christiansen (2014), where harm is avoided to those involved in the research. The researcher asked participants to share their experiences of implementing paper-based GIS in their classrooms but did not specify participants' names or school names in the presentation findings.

#### **1.9.4 LIMITATIONS FOR THE STUDY**

Limitations are hindrances that the researcher encounters while generating and analysing data for the research (Maree, 2007). Hence, it is significant to highlight limitations to make the reader aware of how the researcher arrived at the conclusions. The use of a case study research methodology was limiting in a sense that it allowed for the selection of a small geographical area and a very limited number of individuals as the subjects of study. For this reason, Cohen et al. (2001) hold the view that no specific person can possess detailed knowledge of anything more than the particular section of society in which he or she participates. This implied that the participants of this research study may provide findings based on their experiences related to their context. Therefore, findings cannot be generalised to other contexts since different contexts and subjectivity results in multi-layered realities about events.

#### **1.10 DEMARCATIONS TO THE STUDY**

The study was conducted in public high school located in Ugu district, KwaZulu-Natal Province. The nearest town to this research site in the Ugu district municipality is Izingolweni. This is a rural learning ecology that is a resource-poor and provides education to learners from disadvantaged backgrounds. The population of this district that earns a living through primary economic activities in the countryside of Port Shepstone.

## **1.11 OUTLINE OF CHAPTERS**

This thesis is presented in five chapters and below is presented a synopsis of each chapter.

### **1.11.1 CHAPTER ONE: BACKGROUND AND ORIENTATION TO THE STUDY**

This chapter presents an overview and orientation of this study. This chapter presents the background, statement of the problem, rationale and motivation, and significance for the study. The researcher also discusses the aim and purpose, as well as outlines the research questions addressed in the study. The chapter concludes by discussing a brief overview of the research design, methodology, as well as the outline of the study.

### **1.11.2 CHAPTER TWO: LITERATURE REVIEW**

This chapter is divided into sections. The first section presents the understanding and links between geography education and Geographic Information Systems (GIS). The second section presents a review of international literature relating to the implementation of GIS in schools. The third section presents the review of national literature relating to the implementation of paper-based GIS in rural learning ecologies. The last section presents the theoretical framework of the study, namely The Unified Theory of Acceptance and Use of Technology (UTAUT).

### **1.11.3 CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY**

This chapter presents the research design and methodology adopted in the study. The chapter gives special attention to the interpretive paradigm, qualitative research, phenomenological case study as well as, the sampling process. The chapter then discusses the research setting, selection of participants, profile of participants, and data collection methods, namely: semi-structured interviews and focus group interviews. Lastly, it explains the data analysis, the ways of ensuring trustworthiness. As well as ethical considerations and the limitations of this study.

### **1.11.4 CHAPTER FOUR: RESEARCH FINDINGS AND DISCUSSION**

This chapter presents and discusses data generated from semi-structured interviews as well as focus-group interviews. The analysis of data is then facilitated by interrogating the research

questions. The findings from the semi-structured interviews and focus group interviews are then discussed based on the use of thematic analysis.

### **1.11.5 CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS**

This is the final chapter which presents conclusions that are derived from the findings of the study and subsequently provides a summary of the study. Furthermore, recommendations to the Department of Basic Education and geography teachers are also presented in this chapter.

### **1.12 CHAPTER SUMMARY**

This chapter presented an overview and orientation of this study. This chapter presented the background, statement of the problem, rationale and motivation, and significance for the study. The researcher also discussed the aim and purpose as well as outlined the research questions that are addressed in the study. I concluded the chapter by discussing a brief overview of the research design and methodology as well as the outline of the study.

This research study explored geography teachers' perceptions of paper-based Geographic Information Systems in a rural learning ecology. It argues for the importance of providing such teachers with adequate training and resources in paper-based GIS for its effective implementation in a rural learning ecology. It is also an arena for allowing teachers a way to share their experiences of paper-based GIS implementation and to articulate the reasons for them having such experiences. The study is also underpinned by the view that geography teachers should work collaboratively to ensure the effective teaching and learning of paper-based GIS in a rural learning ecology. This chapter has provided a layout of all the chapters to show the development of the entire research project. The next chapter will present a review of the literature and the theoretical framework adopted in the study.

## **CHAPTER TWO**

### **REVIEW OF RELEVANT LITERATURE AND THEORETICAL FRAMEWORK**

#### **2.1 INTRODUCTION**

In the previous chapter, the researcher discussed the introduction to the study by clarifying the rationale, objectives and critical questions for the research. This chapter presents the review of literature on teachers' perceptions about the implementation of paper-based geographic information system (paper-based GIS) in a rural learning ecology. The literature review did not only contribute to the study with regards to demonstrating the existing knowledge around the phenomenon being researched, but it also assisted in identifying the gaps in knowledge (Walker, 2014). For this reason, writing a review does not only require an examination of past research but it includes making a chart for future research.

When reviewing literature, it is common to identify the claims made in literature and assess the strength of the support offered for those claims (Knopf, 2006; Walker, 2014). Apart from the literature review, the chapter also presents the theoretical framework of the study, which in this study is UTAUT. In developing the chapter, first, the key concepts are clarified, second, the literature is discussed thematically, and finally, the theoretical framework is presented.

#### **2.2 CONCEPTUALISATION OF KEY CONCEPTS**

This section presents the keys concepts that inform this study.

##### **2.2.1 RURAL LEARNING ECOLOGY**

The literature reveals that there are numerous ways to define the concept of ecology. In a broad sense, many believe that ecology is the science of ecosystems, environment, the science of general and specific manifestations of the struggle for survival, as well as the science of processes and methods which living organisms use to adjust to continuously changing living conditions (Barron, 2004; Hill, Wilson, & Watson, 2004; Custovic, Kovacevic, & Tvica, 2013). Others believe that ecology studies the totality of relations that living organisms have with each other (common life) and their natural environment (Custovic, Kovacevic, & Tvica, 2013). This means that living organisms are interdependent on one another and on the environment in which they live. Haeckel (1869) sees ecology as purely biological science, which studies mutual relations between organisms as well as their relation to the environment, organic and

inorganic. The above definitions all highlight the importance of relationships and complex interactions in organisms and the environment in which they live.

The concept 'ecology' can be expanded to the concept of 'learning ecology' if the physical environment on which organisms interact with one another provides learning opportunities. The learning ecology is the accessed set of contexts, comprised of configurations of activities, material resources, and relationships, found in the physical environment that provide opportunities for learning (Barron, 2004, 2006). This definition emphasises the need to understand how learning occurs across different contexts and spaces, and how this insight can potentially be used to supplement or support the traditional classroom based-learning which is still the norm in many schools, particularly in rural areas. Hlalele (2014) is in line with Barron (2004, 2006) in adding that learning ecology encompasses different activities, material resources, relationships, and the interactions that emerge from them. Different schools have different resources and services and may engage in many practices that may differ from one school to another. Therefore, a learning ecology is an environment that is consistent with how learners learn in a certain context.

The learning ecologies feature both formal learning settings and informal learning settings. The formal learning settings are ecologies that are largely determined by institutions and teachers, and informal learning settings, are ecologies that are largely determined by individuals and groups without the mediation of people whose business is education (Jackson, 2013). The main insight is by recognising that learning happens across different contexts, one can potentially enhance the way learners learn by leveraging both formal and informal contexts in their learning ecology. Formal learning ecologies have a structure determined by the designers in which there are objectives, content, resources and processes that engage learners in activities through which they learn and some of their learning is assessed (Jackson, 2013). Hence, teachers in schools are expected to implement the curriculum formulated by the DBE that stipulates the objectives to be carried out in the teaching and learning process (Hlalele, 2014b). It is these GIS teaching aims that are stated by the DBE that the researcher seeks to explore and to see if teachers understand and implement following the curriculum document.

A school aiming to achieve the objectives of a pre-determined curriculum needs to present supportive infrastructure within the school environment and there should be excellent teacher and learner, and learner and learner interactions, and use of technologies that best facilitate interaction and learning (Jackson, 2013). According to Barron (2006), the school-determined ecology for learning includes people - learners, teachers and others who help learners, a physical environment including classroom spaces, social spaces, resources centre, and perhaps virtual spaces where learners and teachers interact for learning. The learning ecology for this study is in the rural context, thus, the concept 'learning ecology' has been expanded to the concept 'rural learning ecology'.

According to Hlalele (2014a), about 54% of South African children live in rural households, which is almost 10 million children. In South Africa, these children are made vulnerable because service provision and resources in rural areas lag far behind urban areas (DBE, 2010). The definition of rural learning ecologies acknowledges the context and conditions that rural learners find themselves in and seeks to reinforce learning within, between and across the rural school, home, and community (Hlalele, 2014a). Hence, the rural learning ecology focuses on teaching and learning in rural schools. For this research, a school setting is regarded as a rural learning ecology in which exist different components such as learners, teachers, working staff, and parents whose core responsibility is to work together for the goal of effective teaching and learning. The rural school is identifiable as a rural learning ecology because individuals survive through interactions and interdependence to adapt to changes that may occur over time.

### **2.2.2 DEFINING GEOGRAPHY**

Scholars define geography as per their viewpoint. A Greek scholar Eratosthenes was the first to coin the term geography (Roller, 2010). The term geography is derived from the two Greek words 'Geo' which means 'earth' and 'graphe' means description. This means that geography is a description of the earth's surface and the entire phenomenon appearing on it (Reinfried & Hertig, 2011). Geography is thus related to the distribution of various features natural and man-made on the surface of the earth. However, the nature of the science of geography reveals that there are several epistemological approaches (Robinson, Block, & Rees, 2017). Some geographers understand geography as a science aiming at comprehending the world; for others

the subject aims at describing and measuring the world. Geography deals with the understanding of the spatial science of the earth to the physical and human aspects.

Geography is the science that seeks to explain the character of places, the distribution of people, features and events, and the way they occur and develop over the surface of the earth (Fatima, 2016). Bonnett (2008) stated that geography refers to the study of the physical features of the earth and its atmosphere, and of human activity as it affects and is affected by these, including the distribution of populations and resources and political and economic activities. Therefore, through the definitions of Fatima (2016) and Bonnett (2008) it is evident that geography involves many elements that are part of living and non-living things and all the processes that occur.

Some geographers consider the world itself to be the object of the discipline (physical geography), whereas others think that it should concern the relationships between humans and space (human geography) (Fatima, 2016). According to Gober (2000) and Jensen (2018), geography increasingly is seen and valued as a bridge discipline; one that can connect the study of human and natural systems, and show the interconnectedness between the two phenomena. Geography is concerned with human-environment interactions in the context of specific places and locations (Reinfried & Hertig, 2011). Furthermore, it is then through the utilisation of GIS that the human-environment interactions can be better understood.

### **2.3 GEOGRAPHY EDUCATION**

The nature of geography has been debatable that either it is a science subject or a social science subject. Geography has a unique position between social and science subjects (Kubiatko, Mrazkova, & Janko, 2012). To study geography is to study the world. The subject has two branches namely: Physical Geography and Human Geography. Physical Geography as a science studies the earth's surface and its characteristics representing spatial relationships and varying regional patterns (Demirci, Gonzalez, Bednarz, 2018); this focuses on the earth's natural environment, which includes landforms, atmosphere, animals, plants, soils, and the processes that affect them. Human Geography studies the patterns of human activities in an environment (Demirci, Gonzalez, Bednarz, 2018), and includes human, political, cultural, economic aspects of the social sciences.

It is therefore clear that it is not obvious whether geography is a science subject or social science subject. This is because some parts of the subject have their strongest affiliations with mathematics and natural sciences, while others with history, philosophy, and social sciences. Hence, in geography, while it is important to sort any issue based on political, social and economic backgrounds, it is also important to sort it out geographically (Fatima, 2016). Thus, geography is the connecting point between social science and physical science.

#### **2.4 DEFINING GEOGRAPHIC INFORMATION SYSTEM (GIS)**

Most of the current definitions are geared to GIS in the context of IT, referring microcomputers, hardware, software, databases, database management systems, and digitising. According to Green (2001) and the Environmental Systems Research Institute (ESRI, 2008), GIS is a computer-based system comprising one or more databases together with a set of tools for collecting (capturing), storing, checking, editing, retrieving, integrating, manipulating, transforming, analysing, and displaying geographical referenced data. Similarly, Kerski, Demirci, and Milson (2013) define GIS as a set of integrated software programs designed to store, retrieve, manipulate, analyse, and display geographical data-information. Longley et al. (2005) add that GIS is a container of maps in digital form, a computerised tool for solving geographical problems, a spatial decision support system, a mechanised inventory of geographically distributed features and facilities, a tool for revealing what is otherwise invisible in geographic information, a tool for performing operations on geographic data that are too tedious or expensive or inaccurate if performed by hand.

It is apparent from these definitions that GIS transitions from being viewed as a computerised system for a specific application (Longley et al., 2005; Green, 2001; ESRI, 2008) to being defined as a general set of hardware and software tools that are used to facilitate the utilisation of geographic information to analyse and model data, and to solve problems (Kerski, Demirci, & Milson, 2013; Wieczorek & Delmerico, 2009). These definitions, whilst perhaps suitable at the upper end of school education, are hardly appropriate at the introductory level or for schools where IT is currently unavailable (Alibrandi & Palmer-Moloney, 2001; Green, 2001). These definitions are also perhaps a little too technical for poorly resourced learning ecologies in Africa where GIS is paper-based.

The GIS definition is also deconstructed by defining individual terms contained within the definition. According to Sharma (2018), GIS consists of geography, information, and system. Geography relates to all the features and process that occur on the surface of the earth (Bonnet, 2012; Holt-Jensen, 2018; Montello, 2018). Information is the hearth of GIS, where a vast amount of data is stored and analysed (Audet & Ludwing, 2000, p. 6). Therefore, GIS makes geographic analysis and location analysis easier, so users of GIS applications increase and the scope expands. With such vast ways of defining GIS, everyone has their definition of a GIS, and there are many to choose from. For this research, the above definitions seem to not define the type of GIS that is currently being used in South Africa. In many South African schools, computers are not used to teach GIS but it is taught through the use of geography textbooks.

There is, therefore, a need to create a new set of GIS definitions which relate to the different parts of the world and levels of attainment of the learning ecology learners, since learners are at different stages in their learning, vocabulary, comprehension and grasp of concepts (Demirci, 2011). The definitions would need to be written to avoid confusion at a later stage when other more advanced definitions, including elements of information technology, will be introduced. The GIS definition for this study is the one that looks at its implementation in rural learning ecologies utilising topographic and orthographic maps rather than computers. Geography teachers need to ensure that learners understand that they are learning about GIS and not learning with GIS.

## **2.5 LINK BETWEEN GEOGRAPHY EDUCATION AND GIS**

The link between geography education and GIS is based on the notion that geography deals with the study of the earth (Fatima, 2016), and GIS is a computer software programme that works with geographic information. Therefore, the introduction of GIS had translated to a better understanding of geography because it works with digital geographic information that is usually displayed in maps, graphs, and table formats in computers making it efficient to work with and understand. Weichhart (2003) adds that since geography comprises multiple aspects, it contributes towards planning, utilisation of natural resources, environmental management, and the carrying out of the spatial analysis. This is why scientists use remote sensing, GIS, and communication technology for creating databases about the earth and the environment.

From the development of geography as a science during the Greek classical period and until the early nineteenth century, geography consisted mainly of cartography, astronomy and the description of natural phenomena and local or regional features of the earth's surface. Today geography is a “human-environment-society science” (Weichhart, 2003), that is characterised by an integrative approach that uses modern spatial and statistical techniques and technologies. Such technologies are Geographic Information Systems (GIS), the global positioning system (GPS), and remote sensing (RS).

## **2.6 THE BIRTH OF GIS**

Most government agencies, utilities, industries with distribution networks, real estate, and travel agencies use GIS daily. A comprehensive history of the development of GIS is not currently available and is recognised as a difficult task because it developed along many parallel paths (Wieczorek & Delmerico, 2009); however, some major milestones are recognisable. The earliest development of computer-based GIS was designed in the 1960s for the government of Canada (Goodchild, 2002). Dr. Roger Tomlinson is recognised as the father of GIS which he developed for the Canada Land Inventory in the early 1960s (Coppock & Rhind, 1991; Wieczorek & Delmerico, 2009). Canada GIS was a mainframe-based system used to store geospatial data for the Canada Land Inventory (Longley, Goodchild, Maguire & Rhind, 2011). The mainframe-based system assisted in the development of regulatory procedures for land-use management and resource monitoring in Canada.

GIS utilisation began to expand during the 1970s, primarily still using mainframe-based approaches. According to Wieczorek and Delmerico (2009), the mainframe-based system is computers used by large organisations for bulk data processing such as census, industry, and consumer statistics. Although GIS began during the 1960s, the Harvard Laboratory for Computer Graphics and Spatial Analysis was one of the main academic groups focusing on developing mapping software for broader distribution during the 1970s (Wieczorek & Delmerico, 2009). This software, SYMAP, was originally developed for mainframe systems and provided access to thematic mapping, which provided rough map output online printers. Started in the 1960s, but best known for its release with the 1980 US Census, Geographic Base File/Dual Independent Map Encoding (GBF/DIME) files provided the basic geographic information for mapping (Wieczorek & Delmerico, 2009). Thus, GBF and DIME became the source of geographic information to be utilised in mapping during this time.

Commercial GIS applications began to appear in the 1970s. Most notable of these applications was the initial release of ARC/INFO by ESRI in 1981 (Fleischmann & van der Westhuizen, 2016). This era highlights the development of GIS as a more general geographic data and analysis tool as compared to a specialised dedicated application. ARC/INFO was designed to operate on minicomputers, which were small multiuser computer systems in comparison to mainframes, and these predated the single-user personal computer (Wieczorek & Delmerico, 2009). The development of GIS followed the trend of personal computing in the 1990s with the release of GIS software that operated on Windows NT workstations and eventually on PCs (Wieczorek & Delmerico, 2009). Since then, much progress has been made in developing tools for working with digital geographic information, and in bringing these tools to a wider audience through commercialisation (Fleischmann & van der Westhuizen, 2016). Today, GIS has become a widely available approach for a large number of needs, from earth science to local decision-making.

## **2.7 GLOBAL EDUCATION HISTORY OF GIS**

The approach to GIS implementation in learning ecologies varies between countries depending on their technological, pedagogical, and administrative conditions. According to Baker (2005), learning ecologies are either *teaching with GIS* or *teaching about GIS*. The former allows learners to learn about the subject concerned and use GIS to answer questions pertinent to the subject. Hence, GIS is very much viewed as a tool for teaching subjects such as geography, mathematics, social studies, and environmental science (Baker 2005). The latter teaches GIS as the main subject in its own right to teach the related technologies. In countries such as Turkey, South Africa, Taiwan, and the United Kingdom, GIS is embedded in the geography curriculum (Akinyemi, 2015; Breetzke, et al., 2011; Chen, 2012; Demirci, 2009; Fargher and Rayner, 2012). Therefore, GIS is used more widely and effectively where geography has a strong place in learning ecology education programs. Below, is a discussion of GIS implementation in the learning ecologies in different regions of the world.

### **2.7.1 GIS IN THE UNITED STATES (US) LEARNING ECOLOGIES**

Although many programs that offer GIS lessons in the US and Canadian universities began in the 1980s, the topic was incepted in the early 1990s in the United States (US), and has diffused slowly into select groups of K-12 classrooms through the efforts of geography and environmental teachers (Bednarz & Schee, 2006). This was a result of GIS increasingly being seen as an essential element which could introduce secondary learning ecology learners to the

use of technology, and motivate them towards careers in science and engineering (Singh, Kleeman, & Bergen, 2012). According to Demirci (2008), in the US and Canada, GIS implemented in the secondary learning ecology is computer-based. Computer-based GIS means that teachers in the US and Canadian secondary learning ecology teach different curriculum subjects to learners through GIS (Kerski et al., 2013). For this reason, GIS in US and Canadian secondary learning ecology is a set of integrated software programs designed to store, retrieve, manipulate, analyse, and display geographical data-information concerning people, places, and the environment.

The select groups of K-12 classrooms that are using computer-based GIS are supported by key organisations and GIS vendors, and have worked under the assumption that GIS offers the potential to support classroom learning through learner-driven inquiries in the natural and social domains (Demirci, 2008). Due to these pedagogical advantages, GIS has found a place in secondary school curriculums in diverse programs including science, chemistry, biology, mathematics, environmental and social sciences along with geography in the US, and Canada.

### **2.7.2 GIS IN THE UNITED KINGDOM (UK) LEARNING ECOLOGIES**

The first UK development in GIS education was heavily influenced by US initiatives. The most important being the development of the core GIS curriculum, led by the US National Centre for Geographic Information and Analysis (NCGIA) (Kemp & Goodchild, 1991). Although nowadays, teaching using GIS in learning ecologies takes place in several countries because of its close links to everyday life in connection with work or free time activities (Milson et al., 2012). However, certain UK countries like France, Sweden, England, Wales and Finland curriculums, have found difficulties incorporating GIS in their geography classrooms (Riihela & Maki, 2015). In the national core curriculum for England and Wales, for example, GIS was mentioned for the first time in 1991 but without any major effects on educational practice, it disappeared by 2000 (Riihela & Maki, 2015). GIS in education is currently a topical issue in Finland, too.

In Finland, the National Board of Education (NBE) reformed the national core curriculum for upper secondary learning ecologies and produced an outline in 2002. In that outline, the teaching of GIS in connection with the optional advance course entitled “Regional Studies” was provided in all upper secondary learning ecologies (Riihela & Maki, 2015). The aim was to use the teaching of GIS in learning ecologies to educate young citizens with the skills

necessary to participate in the information society during both work and free time (de Miguel Gonzalez & Donert, 2014). In 2004, the Finnish national core curriculum introduced cross-curricular themes such as active learning, technology and society, active citizenship and media skills, and GIS education is connected to each of them (Riihela & Maki, 2015). For this reason, applying GIS as a tool for making individual regional analyses became reality, at least on paper.

In practice, however, many teachers were puzzled by the different GIS software, data formats and various technical issues. Data products offered by Finnish authorities were expensive and buying them from different sources was time-consuming (de Miguel Gonzalez & Donert, 2014). The idea of using GIS for active learning was widely recognised, but practical realisation seemed impossible to achieve in most learning ecologies. As a result, learners were in danger of being treated unequally, as the use of GIS depended on the technical interests of the teachers, the learning ecology budget, and on the data policy of the municipality where the learning ecology was located.

From 2012 to 2016, NBE was tasked with revising the national core curriculum, to which municipalities and then schools revised their local curriculums. The NBE's responsibility was to guide and support the curriculum implementation in learning ecologies (Riihela & Maki, 2015). This reform period opened new opportunities to examine GIS education in Finnish learning ecologies (Milson et al., 2012). In the same way as the US, UK GIS implementation in the learning ecologies is computer-based. However, the impediments that surrounded computer-based GIS implementation in the UK, called for the national core curriculum to be revised.

### **2.7.3 GIS IN THE ASIAN LEARNING ECOLOGIES**

In Taiwan, GIS is growing rapidly in the discipline of geography at the university level. The new high school curriculum in Taiwan is inspired by the university curriculum; it is no wonder that the GIS content in Taiwan's high school geography education is on the rise (Lay, Chen & Chi, 2013). Evidence of this rise can be traced back to 1999 when the concept of GIS was first incorporated into the national geography curriculum guidelines (Wang & Chen, 2013). The guidelines called for a three-hour GIS class session for twelfth graders wishing to major in the humanities or social sciences at the university level. The proportion of GIS learning further increased in the 2006 and 2010 curriculum guidelines (Chen, 2012). One-third of the geography course in the first semester of the tenth grade is related to GIS.

GIS applications in various areas of life are taught in these classes. While the 1999 curriculum guidelines stress the teaching of GIS concepts, the 2006 and 2010 guidelines add examples of how GIS can be applied to monitor mudslides, diseases, floods, and urban planning, among other topics. GIS application is stressed in thematic lectures on topography, demography, spatial planning, medical geography, and other aspects because these themes are believed to help stimulate students' spatial thinking (Lay, Chen & Chi, 2013). GIS implemented in Taiwan learning ecologies is similar to GIS implemented in the South African learning ecologies in the sense that GIS concepts are applied to solve geography problems.

In Singapore computer-based GIS was first introduced to primary and secondary schools and junior colleges in 1998. One of the efforts in integrating GIS into school classrooms has been the development of GIS resource package for use with ArcView, such as Singapore's EduGIS, developed jointly by the National Institute of Education (NIE) and the Ministry of Education (MOE) (Liu & Zhu, 2008). A typical GIS resource package contains isolated lessons of specific topics relating to a particular curriculum. Each lesson contains a sequence of step-by-step instructions on how to explore a set or several sets of geographic data using a particular GIS software system to answer many questions listed in a learner's worksheet (Liu & Zhu, 2008). Recent experience in Singapore suggests that the creation of data and instructional materials alone does not guarantee successful uptake and use of such resources by teachers in schools.

Many factors may limit the uptake and use of resources in Singapore. Among the top reasons why teachers do not use these resources are insufficient curriculum time, the perceived irrelevance of the data and instructional materials to meet learning objectives, and the complexity of GIS software (Liu & Zhu, 2008). Singapore is not the only country with such hindrances related to GIS implementation in schools. These are global impediments that exist in almost every country that implements GIS in schools. In Malaysia, according to Singh, Kleeman, and Bergen (2012), GIS was not yet introduced to secondary school geography due to a lack of ability, lack of ground facilities and Information Communication Technologies (ICT). The lack of ground facilities and ICT has also been an issue for South Africa in the implementation of GIS schools. However, South Africa has resorted to the implementation of paper-based GIS which requires the use of topographic and orthophoto maps, and textbooks instead of computers.

#### 2.7.4 GIS IN TURKEY LEARNING ECOLOGIES

The Republic of Turkey is located in both the continents of Asia and Europe (Serement & Chalkley, 2016). Turkey is a developing country which initiated a new secondary school geography curriculum in 2005 with a strong emphasis on ICT (Demirci, 2008). The national geography curriculum of Turkey has undergone radical changes and new secondary school programs were introduced in 2005 by the Turkish Ministry of National Education (MEB) (Demirci, 2008; Incekara, 2010). These changes included the adoption of GIS technology in the geography curriculum.

The first GIS workshop for teachers was organised in 2004 and aimed to capacitate geography teachers with GIS content such that they would be able to implement GIS in the geography curriculum (Incekara, 2010; Serement & Chalkley, 2016). The geography program of 2005, which was activity-based rather than objective-based emphasised the adoption of technology, geographic skills, active learning process, and used effective evaluation and assessment methods (Serement & Chalkley, 2016). When the new secondary school geography curriculum recommended the use of GIS for lessons, more teachers became interested and started learning the technology (Demirci, 2009), such that more workshops and symposiums have been held since that time. A Turkish-language version of ArcView 9.2 GIS software became available in 2007. NetCad is a Turkish GIS company and its GIS software is available in Turkish (Incekara, 2010), and is easy for teachers in Turkey to obtain. Teachers may obtain old versions of GIS software from companies free of charge or they can get the newest versions at a reasonable price (Demirci, 2009). A book entitled *GIS for Teachers* was published in 2008 with the support of ESRI (Demirci, 2009). This book, which is available for geography teachers in the country include almost everything teachers need to incorporate GIS into their lessons. Sample lesson plans, digital data, and ArcView 9.2 accompany the book, with a one-year free license for the software (Serement & Chalkley, 2016). Turkey seems to be one of the countries that are well-equipped with the resources required for GIS implementation in learning ecologies.

The book titled *GIS for teachers* seems to contain almost all the relevant information a Geography teacher would need in implementing GIS. Although an increasing number of high schools and geography teachers have obtained this book, the number of high schools that are using GIS in Turkey seems to be not more than 1% today (Serement & Chalkley, 2016). It is not clear why such a low percentage of schools implement GIS in Turkey. However, it is evident in the literature that many developments in Turkey had been made to support teachers

in implementing GIS in the geography curriculum. One of the reasons that might have caused such a low percentage on the effective teaching of this topic in Turkey may be that GIS is only discussed at a very rudimentary level in some textbooks and this is also evident in South Africa (Serement & Chalkley, 2016). Thus, teachers may lack confidence in teaching content that is not explained in detail to them.

## **2.8 GIS IN THE AFRICAN CONTINENT**

It had been over a decade since GIS was introduced in most African countries such as Rwanda, Uganda, Tanzania, and South Africa (Akinyemi 2014; Ayorekire & Twinomuhangi 2012; Eksteen et al. 2012; Forster, Burikoko, & Nsengiyumva, 2012). The literature based on African countries is discussed below to unveil the implementation of GIS in these learning ecologies.

In Rwanda, GIS was introduced into secondary learning ecologies in 2007. Jack Dangermond, President of ESRI, assisted Rwanda by donating the ArcGIS software license to all secondary learning ecologies in 2006 (Forster et al. 2012; Milson & Kerski, 2012). Rwanda is a developing country; however, secondary learning ecologies are eligible to have the ArcGIS software for use in teaching and learning (Akinyemi, 2014; 2015; 2016). This forms part of Rwanda's 2020 vision to become the Singapore of Africa by promoting the rapid advancement of ICT (Majtenyi, 2008). To ensure a smooth take-off of GIS use in the Rwandan learning ecologies, a GIS specialist worked with learning ecologies to train teachers in GIS (Forster et al. 2012). This exemplifies a joint partnership between the Rwandan Ministry of Education (MINEDUC) and ESRI in support of the government's ICT in education policy for both formal and non-formal education (Akinyemi, 2014; 2016). Therefore, teachers in Rwanda are supported by GIS specialists with skills through training to ensure that GIS is taught effectively in schools.

GIS in Rwanda started with only ten secondary learning ecologies. Thirty teachers from these ten selected learning ecologies received training in basic and advanced aspects of GIS and its applications (Forster et al., 2012; Kerski, Demirci, & Milson, 2013; Milson, Demirci, & Kerski, 2012). The basic GIS course includes an introduction to the concepts as well as ArcGIS desktop applications such as ArcCatalog, ArcMap, and Arc-Toolbox (Forster et al., 2012). Teachers were also taught how to digitise and edit, create maps and do basic exercises in spatial analysis (Akinyemi, 2015; Forster et al., 2012). The latter was meant to assist them in learning to ask

specific spatial questions that can be answered by using GIS. This training eased the process of GIS uptake in schools as teachers started teaching GIS immediately after being trained. The roll-out of GIS to other schools is incremental as trained teachers in turn were to train other teachers from nearby schools, that is, *teachers-train-teachers*. Over the six-year period, about 166 teachers have been trained in GIS (Forster et al. 2012). This shows that the programme of using teachers to train other teachers has been a success over these years.

A week-long summer camp is organised each year for upper secondary learning ecology learners in Rwanda. These are the best learners in GIS that are competitively selected based on the quality of the map and motivation letter submitted (Schmidt, 2013a). Usually, 150 to 200 pupils participate in the map competition from which the best twenty are selected to participate in the summer camp (Schmidt, 2013a). During the summer camps, pupils conduct an applied GIS project that seeks to solve a real-life problem using geographic information technologies. In teams of four or five learners, geographic and attribute data are collected using GPS and questionnaires. Datasets that are created are analysed in ArcGIS by the learners with support from their mentors. The teams present their results to an audience comprised of government officials from collaborating ministries, as well as local and international GIS specialists (Schmidt, 2013b). The camp allows them to link GIS concepts they were taught in learning ecology with practical fieldwork. According to Schmidt, 2013b), six of such summer camps have already been organised to date, under different themes, with about 120 learners trained. This demonstrates that Rwanda aims to implement computer-based GIS in schools to solve geographic problems just like in Singapore, the US, UK, and Turkey.

Rwanda with the assistance of ESRI is one of the countries that has done a great job in ensuring the availability of GIS teaching resources in schools. In 2009, a Rwandan GIS textbook for teachers and learners was produced with exercises based on local examples where possible (Treier, Bieri, & Wuthrich, 2008). There are also several ICT initiatives in the Rwandan education sector that complement GIS implementation in learning ecologies. Examples are the Rwanda Education Commons (REC) where teachers and learners share resources and ideas (Treier et al., 2008), Educational Management Information System (EMIS), One Laptop Per Child pilot initiative (OLPC), and New Partnership for Africa's Development (NePAD) e-Schools initiative. The EMIS is the most relevant to GIS as it incorporates spatial information to support GIS use in learning ecology planning (Forster et al., 2012); for example, access of

educational facilities to utilities such as electricity, water supply pipes, and roads can be compared.

In Uganda, they are still experiencing problems concerning the ICT curriculum. Although the ICT curriculum is available in the learning ecologies, urban learning ecologies have recorded a greater increase in the use of ICTs than rural learning ecologies (Akinyemi, 2015). This is because most rural learning ecologies are faced with challenges that constrain their use of ICT such as lack of electricity, inability to afford computers, and a limited number of teachers with ICT skills. Computer-based GIS involves the introduction of ICTs into the geography curriculum. Therefore, it becomes impractical to implement computer-based GIS in the rural learning ecologies of Uganda because of the lack of necessary resources. To address the rural-urban ICT digital divide in learning ecologies, many initiatives and projects are developed by the government with support from some international organisations (Akinyemi, 2015). If the necessary resources are made available this will make it possible for GIS implementation in Ugandan learning ecologies.

In Namibia, the factors that promote and impede the use of ICT in learning ecologies have been similar to those found in Uganda and South Africa. Innes (2009) stated that apart from changing political agendas related to development, a perceived need for technology by education officials was an important promotional factor. To counter this, the impeding factors included: inequalities between core and peripheral areas, lack of infrastructure, inadequately devised adoption strategies, and lack of vision and guidance from policymakers. Lundall and Howell (2000) cited the following as factors preventing widespread computer use in South Africa, similar to Namibian education: insufficient funds, too few computers, lack of computer literacy among teachers, lack of computer-trained subject teachers and the absence of a computer skills curriculum. The above factors create challenges in Namibia due to the lack of required resources for GIS implementation.

The number of obstacles surrounding GIS implementation in schools is not limited to African countries. It is reported that low levels of adoption of GIS in American schools can be attributed to limited access to hardware and software in schools, intimidating software, insufficient time available for learning to use the software, and low levels of technology training for teachers (NRC, 2006). Therefore, the difficulties facing GIS implementation in schools are a global

issue. For GIS implementation to be a success in Namibian learning ecologies, ICT must be available in schools and teachers need to be empowered with necessary computer and GIS skills.

## **2.9 GIS EDUCATION HISTORY IN SOUTH AFRICA (SA)**

It has been almost two decades since GIS was included in the learning ecologies of South Africa. During 2006, the Department of Basic Education (DBE) launched the integration of GIS as a section of the Grade 10 Geography syllabus (Fleischmann & Westhuizen, 2015) and re-embraced GIS in the Curriculum Assessment Policy Statement (CAPS) document of 2011 (DBE, 2011). However, according to a study conducted in the Western Cape revealed that in practice, minimal GIS integration has occurred since introduction into the curriculum (Scheepers, 2009). Fleming (2015) reveals that most teachers were ill-equipped to teach GIS when was introduced in grade 10 to 12 geography curriculum. For this reason, the matric 2014 paper 2 (map skills) results showed that the GIS questions were often not attempted by learners. Similarly, the poor learner performance on GIS was also evident in the diagnostic report of 2016 and 2017 (DBE, 2016; DBE, 2017). Teachers' lack of GIS knowledge might have been partly responsible for the poor learner performance in GIS.

The GIS challenges that geography teachers in South Africa face are worldwide. Kerski et al. (2013) discovered that GIS implementation in South Africa has stalled due to the same challenges faced by Hungary, Lebanon, Rwanda, Finland, and Columbia, which include teachers' lack of GIS knowledge and skills, lack of lesson preparation time, and the need for pedagogical guidance. Although it was anticipated that GIS instruction would enhance the reputation of geography within a school's curriculum (Rød, Larsen, & Nilsen, 2010) and clarify the role of geography within academia globally (Oberle, Joseph, & May, 2010), observers such as Innes (2011) and Britz and Webb (2016) differ in their views of GIS education within SA. These researchers foresee many challenges that come with the adoption of GIS in the South African learning ecologies because many developments are needed in schools before effective implementation can be achieved.

Some of the geography teachers' practices when teaching GIS to learners are revealed by the Independent Examinations Board (IEB). IEB is an independent assessment body that offers external assessment per legislation and Umalusi directives for schools registered with grade 12

for National Senior Certificate (NCS) (Ettershank, Nel, & von Solms, 2017). The IEB examiner revealed that teachers taught GIS theory and only what was required for the final grade 12 assessments (Fleming, 2015). Seldom were learners exposed to practical GIS lessons. Tertiary institutions, the private sector, and publishing houses have developed workshops to help teachers to up-skill. The inclusion of GIS in the new National Senior Certificate for Adults (NASCA) Human and Social Sciences curriculum is also encouraging (Fleming, 2015). Here, adults will be able to enter the labour market with a good understanding of GIS concepts.

The Western Cape Department of Education (WCDE) in 2006 to 2008 organised the two-day workshops with the aim was to familiarise geography curriculum advisors (CAs) and teachers with GIS, which until now has chiefly been taught at universities and other tertiary institutions as part of their under- and post graduate curricula (Fleischmann & Westhuizen (2015). The feedback from these workshops was very positive and the consensus was that one of the biggest hurdles to GIS practical lessons in the classroom is access to IT labs. ISASA (private) schools pay for teachers to attend similar courses (Scheepers, 2009). Although the lack of ICT is one of the main obstacles to the introduction of GIS into schools, other challenges include the level of preparedness of education departments, as well as teachers.

## **2.10 PAPER-BASED GIS IN SOUTH AFRICAN RURAL LEARNING ECOLOGIES**

Major differences exist between rural and urban learning ecologies with rural learning ecologies lagging behind in resources, such as well-qualified teachers and access to electricity, infrastructure, and funding. These limitations need to be addressed when GIS material for learning ecologies was being developed. However, instead of attending to these hindrances, the government relied heavily on the private sector to facilitate the introduction of GIS. Therefore, the ESRI distributor in South Africa took the initiative to assist and approached former geography teachers and other key people to guide the development of educational material. Complete GIS materials were developed to address the full spectrum of GIS educational needs in the DBE. The new school materials include three separate approaches corresponding to the fundamental steps for learning GIS: namely, paper GIS, ArcExplorer, and ArcView.

The paper-based GIS was developed in collaboration with the Department of Land Affairs and the University of Pretoria. The paper-based topic targets schools with no computer access. This included fundamental training, covering the basics of GIS theory. At the beginning of the year,

geography curriculum advisors countrywide were flown or driven to GIMS's Midrand offices to attend a GIS training course. Approximately one hundred curriculum advisors attended the three-day training over a period of three weeks. Day one saw the facility transformed into a training center for schools with no GIS computer facilities. The geography curriculum advisors were given a simple GIS task to complete with the aid of maps (courtesy of the Department of Land Affairs), crayons, and tracing paper. The task involved searching for the best location to evacuate residents in the event of a flood.

This paper GIS proved very important for teaching conceptual issues of GIS before moving to the computer. Fleischmann and Westhuizen (2015) point out that the GIS training programme helped teachers to learn how to help poorer schools without computers to do GIS. This made teachers happy because their schools will not be left behind. A paper-based GIS initiative, managed by ESRI South Africa (Pty) Ltd., envisages the introduction of GIS to resource-poor (without electricity and/or computers) schools in South Africa (Breetzke et al., 2011; Kerski et al., 2013; Fleischmann & Westhuizen, 2015). Although this praiseworthy effort aims to enhance GIS teaching in these schools, the authentic potential of GIS can only be unlocked when learners and teachers can utilise available digital GIS platforms, such as ArcView 3.3, Quantum GIS (QGIS), and Web-based software (Fleischmann & Westhuizen, 2015). Therefore, outcomes are limited because of the lack of such platforms.

## **2.11 GIS BENEFITS**

The benefits of GIS implementation are discussed under two sub-topics below. The first sub-topic discusses the benefits of implementation using the GIS programme on the computers. This is discussed to show how teachers and learners in the developed countries benefit in implementing computer-based GIS in schools. The second sub-topic discusses the benefits of paper-based GIS in South Africa that uses topographic maps and orthophoto maps in the rural learning ecologies. The paper-based GIS benefits focus on the fact that it is implemented without computers in the rural learning ecologies of South Africa. Therefore, paper-based GIS is discussed to show how teachers and learners in South Africa as a developing country benefit in implementing this form of GIS in rural learning ecologies.

### **2.11.1 EDUCATION BENEFITS OF GIS IMPLEMENTATION**

Many studies have highlighted a number of benefits of GIS implementation in schools. Studies by Milson and Earle (2008), Singh, Kleeman, and Bergen (2012), and Sumari, Shao, and Kira (2018), have shown that GIS can improve content knowledge and also act as an additional motivation for learners to learn geography. This is because GIS is implemented to solve geography problems. Sharma (2018) reveals that GIS is one of the technologies that evolve to allow people to solve many geographic problems quickly, effectively, and easily with the ability to make an analysis. In this way, according to Johansson (2006), Milson and Earle (2008), Singh et al. (2012), and Sharma (2018), GIS has the potential to facilitate the use of problem-based learning and inquiry-based learning methods in the classroom. Therefore, geography concepts are used to formulate solutions to any geography problem and this may result in a better understanding of GIS for both teachers and learners.

Other authors have highlighted the importance of GIS in shaping the attitudes of users. Sharma (2018), for instance, has found a significant improvement in the attitudes towards technology and geographical data due to the use of GIS in teaching. This means that certain teachers are excited about using GIS in teaching geography. The geography teachers' positive attitudes might have developed because of accepting the technology that comes with GIS. According to a study conducted by Whitaker (2011), it was evident that using GIS in the science classroom had a variety of benefits. Its use is supported by the constructivist learning theory that encourages and supports an interdisciplinary and multicultural approach to learning (Whitaker, 2011). Learners' attitudes towards science improve when GIS is used as a teaching strategy. In fact, as a strategy, GIS lessons encourage higher order thinking and science processing skills such as analysis, synthesis, and application (Whitaker, 2011). It increases learner engagement and a willingness to take ownership of a data driven project.

Other authors have found similar benefits with GIS lessons. For instance, according to Bednarz and Van der Schee (2006), teachers are using GIS due to the three major reasons: it supports geography teaching and learning, GIS is a tool for investigating geographical problems at different scales, and GIS is a necessary tool for the business world in the 21st century. The educative argument for GIS is that it helps learners to learn geography by practicing spatial thinking (Bednarz, 2004) because it models the processes of spatial thinking. GIS, by using procedures and steps to produce maps, demonstrates for learners the cognitive strategies used in spatial thinking. Learners benefit from using a GIS to produce maps, because it practices

and sharpens their cognitive mapping skills, such as assessing similarity and proximity; and their spatial thinking skills, such as associating and correlating spatially distributed phenomena.

### **2.11.2 PAPER-BASED GIS BENEFITS IN SOUTH AFRICAN RURAL LEARNING ECOLOGIES**

The benefit of paper-based GIS is more focused on support for teachers to educate them about the concepts and enabling learners to apply GIS concepts using topographic maps and orthophoto maps. For example, using the 1: 50 000 topographic maps, paper-based GIS expect teachers to ask learners to identify the three basic entity types: points, lines, and polygons (Breetzke et al., 2011; Fleischmann & Westhuizen, 2015). Based on Hochberg (1978), spatial thinking begins with distinguishing and identifying spatial features of the real world on a map. Therefore, if teachers understand application skills involved in paper-based GIS, it will enable learners to not only increase their map literacy but to also generate a mental representation of space (Breetzke et al., 2011). This means that the paper-based GIS enables teachers to use topographic maps to stimulate learners' visual understanding of the area that the map represents. This understanding is made possible because learners would have learned a skill that topographic maps use points, lines, and polygons to represent geographic features on maps. Therefore, a learner then has a visual understanding of the kinds of geographic features that may be found in that specific mapped area.

Paper-based GIS is similar to computer-based GIS in the sense that it may motivate geography teachers and learners. According to Scheepers (2009), introducing paper-based GIS into the geography curriculum makes geography more interesting. Through paper-based GIS, learners learn how to apply knowledge and skills obtained from textbooks about GIS to make well informed decisions in problem-solving using maps. The teachers also feel that instead of being just passive spectators, learners will become more involved in assisting with problem solving (Scheepers, 2009). There is also a general feeling that, as long as the data provided for a paper-based lesson is relevant or localised, the role of paper-based GIS becomes effective. This works well when teachers engage learners with maps of a local area that learners are familiar with, making it easier for learners to relate to the problem and thereafter make up solutions to address the problem.

## **2.12 GIS CHALLENGES**

The challenges of GIS implementation are discussed under two sub-topics below. The first sub-topic discusses the challenges of GIS implementation using the GIS programme on computers. This is discussed to show how teachers and learners in developed and developing countries are hindered in implementing computer-based GIS in schools. The second sub-topic discusses the challenges of paper-based GIS in South Africa that uses topographic maps and orthophoto maps in the rural learning ecologies. The paper-based GIS challenges focus on the fact that GIS is implemented without computers in rural learning ecologies. Therefore, paper-based GIS is discussed to show how teachers and learners in South Africa as a developing country experience problems when implementing the paper-based GIS in rural learning ecologies.

### **2.12.1 CHALLENGES OF GIS IMPLEMENTATION IN EDUCATION**

Although the potential benefits of GIS for learners and teachers have been widely documented in the literature, its integration into secondary school education remains a challenge. According to Akinyemi (2015) and Demirci (2008), the adoption of GIS in secondary education is related to three major obstacles, namely: technical factors such as the availability of hardware, software and data; lack of teacher training and curriculum materials; and systemic issues that encourage or discourage innovation in education. Bednarz and Van der Schee (2006) added that GIS software has high technical demands, is a challenge to master, was not designed for a teaching and learning function and does not appear to many teachers to offer obvious opportunities for teaching and learning. According to Gonzalez and Donert (2014), despite the GIS potentials, many secondary schools in Finland, France, Sweden, England, and Wales still lack the resources and know-how required to use GIS in education. For this reason, only a few international secondary schools have started to integrate GIS into their lessons, especially in the teaching of geography.

The developing countries are also experiencing many challenges when it comes to the implementation of GIS in the secondary schools. According to Akinyemi (2015), the excessive number of learners in classes, insufficient infrastructure in terms of ICT, lack of interest and ability of teachers to use new technologies, and teaching methods are among the most important factors restricting education, especially in developing countries. These obstacles prevent lessons from being learner-centered, problem-based, and application oriented (Akinyemi, 2015). In this environment, it is not easy to use a new technological system like GIS and test its effectiveness on learners' achievement in geography lessons which have been mainly based

on textbooks and administered as teacher-centered. The lack of necessary resources for the teaching and learning of GIS proves that countries have a long way to go towards achieving effective implementation of GIS.

In South Africa, there are a number of key issues that were considered obstacles to using GIS in the learning ecologies. Among these issues were limited access to and availability of hardware and software, time constraints, and inadequate skills in technology and geospatial ideas and data (Johansson, 2006). These impediments have led to paper-based GIS becoming an alternative for South African rural learning ecologies. I discussed the challenges of GIS implementation in South Africa according to sub-topics to provide an in-depth discussion of how these factors hinder GIS. Thereafter, I discussed the challenges of implementing the paper-based GIS although it was seen as an alternative to computer-based GIS in South Africa.

#### **2.12.1.1      *Lack of Funds***

The introduction of computerised GIS in any schooling system requires considerable financial input. The financial input is required for purchasing the necessary software, hardware, and educational materials, as well as for the training of teachers (Zeller & Wise, 2002; Scheepers, 2009; Breetzke *et al*, 2011; Fleischmann & Westhuizen, 2015). However, segregationist education policies introduced by the nationalist government during apartheid notably the Bantu Education Act of 1953 resulted in the skewed distribution of financial resources in favour of former whites-only schools to the detriment of black schools (Breetzke, 2008). Although two decades have passed in a democratic South Africa, there remains a sharp imbalance in the availability of resources between urban and rural schools.

The dawn of democracy initiated a pursuit of race-blind policies in both the funding and structure of public education by the newly elected African National Congress (ANC). The ANC sought to redress the policies of racial inequity in education through the introduction of a battery of laws, including the 1995 *White Paper on Education and Training*, and the South African Schools Act (SASA) of 1996. It is discouraging to note, however, that despite these advances almost 90% of schools in the country still did not have computers in 2000 (Breetzke, 2008). Also, 80% of schools had no functioning libraries. A study in the Eastern Cape Province of South Africa by Nxele (2007) highlighted the fact that 41% of schools in the province still do not have electricity and only 48% of secondary schools have computers. Contrast this with

the over 1,900 U.S. high school classrooms that have a desktop GIS (Baker 2005), and it becomes increasingly evident that South Africa is still some way off technologically from establishing a suitable environment for GIS education.

#### **2.12.1.2      *Lack of support***

Much research has shown that a lack of support is an additional factor impeding the widespread adoption of GIS in schools. Kidman and Palmer (2006) outline three levels of support required: first, support from school leadership and the school community; second, support from local tertiary institutions offering teacher education programs; and third, support from government and industry. According to Breetzke et al. (2011), support from the school leadership is important to ensure that funds and facilities are available for the development and sustainability of the GIS program in the school. Additional support from those members of the school community not directly involved in teaching GIS is also vital and much dependent on the benefits they perceive GIS can offer the school. Support from local tertiary institutions offering teacher-training programs is also of paramount importance. Unfortunately, teachers who wish to develop professionally by taking a program aimed at training them in GIS face many challenges.

The first challenge is that there are no public formal or regulated teacher-training GIS programs. Scheepers (2009) and Breetzke et al. (2011) reveal that the reasons why the training of GIS teachers in South Africa has shifted away from educational authorities could be the lack of individuals in public educational institutions in South Africa with specialist knowledge in GIS. This mandate has fallen largely on the GIS industry in South Africa with several private companies currently training teachers and guiding the development of GIS educational material (Breetzke et al., 2011; Fleischmann & Westhuizen, 2015). Companies such as ESRI South Africa (Pty) Ltd, and Geomatica (Pty) Ltd. have taken the lead in this regard and conducted a number of training courses aimed at teaching curriculum advisors and teachers about GIS (Breetzke et al., 2011). Only a limited number of these workshops have taken place and they have been restricted to the training of a handful of curriculum advisors and teachers (Breetzke et al., 2011; Fleischmann & Westhuizen, 2015). Therefore, it is a long process to ensure that all geography advisors and teachers are trained in GIS.

### **2.12.1.3      *Lack of time***

Other researchers regard a lack of time as the single biggest impediment to getting GIS into classrooms. This refers to the time required for teachers to attend professional development (PD) workshops to learn the necessary software; the time required to develop or modify instructional materials supported by GIS; as well as the time required in the curriculum of various subjects to effectively educate learners about the technology (Baker, 2005; Breetzke et al., 2011; Chalmers, 2006; Fleschmann & Westhuizen, 2015; Kerski, 2003). Thus, it might be a challenging and time-consuming task to train a teacher on how to operate GIS software because it requires someone who had already acquired computer skills. In the same way, it may be time-consuming and learners may also struggle when they are taught using the software. Again, instructional material and curriculums of various subjects required to teach GIS to prove that effective GIS implementation in schools requires more time than what schools and the department of education are prepared to offer.

The time constraints placed on teachers in South Africa are further exacerbated by an ever-changing national curriculum framework. Educational transformation in the country has seen the adoption of some national curriculum frameworks including Curriculum 2005 (C2005), the National Curriculum Statement (NCS), and the Revised National Curriculum Statement (RNCS). Essential as these changes may appear in theory; their implementation in classrooms throughout the country has proven difficult in resource-poor contexts such as in South Africa. These curriculum changes have resulted in a general lack of understanding by teachers regarding the interrelationship between, and the “transcendence” from Curriculum 2005 to the NCS to the RNCS (Pudi 2006). For this reason, geography teachers’ lack of understanding about the changes in the curriculum may impact negatively on the teaching and learning of GIS in schools.

### **2.12.1.4      *Infrastructure constraints***

Infrastructure constraint is one of the biggest GIS implementation hindrances in the classroom. This is because electronic systems require stable power supplies and good air conditioned housing free of damp and bugs (Burrough, 1992, Zeller, 2002). Many developing countries cover huge areas of land yet the people may be concentrated in a few small areas around large cities. To cover the whole country at a reasonable scale is very time- consuming and expensive (Burrough, 1992). Furthermore, certain schools in rural areas are facing problems pertaining to the availability of electricity because of expenses, and because they are situated away from the

cities. The lack of electricity hinders the implementation of GIS in the classroom since it requires power. In addition, these schools are distant from commercial support services, which are troublesome when problems occur with the hardware or software (Kerski et al., 2013).

To support GIS use in resource-poor schools, a paper-based GIS educational package was developed by ESRI for use in teaching. The paper-based package is trying to address the inadequacy of ICT equipment; and poor infrastructure in schools (including the lack of electricity) (Breetzke et al., 2011; Eksteen et al. 2012). This means that the package is used instead of computers for introducing the use of maps in teaching and learning of GIS in resource-poor schools. Teachers are expected to teach learners to apply the GIS concepts on topographic and orthophoto maps without the use of computers. In this way, teachers would be teaching learners about what they would have done on a certain concept if there were software available on computers.

#### **2.12.1.5      *Data Constraints***

The GIS implementation in the classroom is very often hampered by the limited availability of useful data. There are two aspects to this problem that are going to be discussed namely, the existence of data, and accessibility of existing data (Akinyemi, 2015). Regarding data existence, making maps as well as updating them is a costly and time-consuming activity and, therefore, detailed and current maps are scarce (Akinyemi, 2015). Often many field surveys have to be done to cover the whole area with at least a detailed topographical map. In addition, information about natural resources, soils and vegetation, climate and geology are often not available (Akinyemi, 2015; Kerski et al., 2013). Therefore, it is crucial to know the most important information influencing decisions in the country. Again it is better to start with a minimal solution for a GIS than waiting for the all or nothing alternative. Moreover, socio-economic phenomena like population density, growth, and movement tend to be much more variable and harder to predict than in developed countries (Kerski et al., 2013). This means that also the maintenance of a GIS might involve more work in developing countries.

#### **2.12.1.6      *Political stability***

While the problems of support, time, infrastructure, data, and funding GIS education in schools is relatively widespread, the situation is exacerbated in South Africa when one considers the country's political history. Segregationist education policies introduced by the nationalist

government during apartheid - notably the Bantu Education Act of 1953 - resulted in the skewed distribution of financial resources in favour of former whites-only schools to the detriment of black schools (Kerski et al., 2013). At the peak of apartheid, schools serving white learners had more than ten times the funding per learner than schools serving black learners (Breetzke et al., 2011). This divide formed according to race has led to the problems related to lack of resources in certain South African schools today.

The dawn of democracy initiated a pursuit of race-blind policies in both the funding and structure of public education by the newly elected African National Congress (ANC). The ANC sought to redress the policies of racial inequity in education through the introduction of a battery of laws including the *1995 White Paper on Education and Training*, and the *South African Schools Act* (SASA) of 1996 (Akinyemi, 2015). The initial achievements made by the ANC government to fashion a racially equitable state education system were substantial and a number of their accomplishments are outlined in the *School Register of Needs Survey* conducted by the DoE in 2000. The results of the survey indicated significant advances in the provision of electricity, computers, and telephones in schools throughout the country from 1996 to 2000. It is discouraging to note, however, that despite these advances almost 90% of schools in the country still lack computers (Breetzke et al., 2011). This is a challenge because computers are primary to the implementation of GIS in schools.

Currently, the government placed responsibility for the overall growth and development of GIS in the country on the key role players in the GIS industry such as the Chief Directorate: Surveys and Mapping, and the Chief Surveyor-General of South Africa (Breetzke et al., 2011). The idea is to provide a basic geospatial framework for data (Zietsman 2002). Other government departments provide ancillary data and include the Department of Water Affairs and Forestry (DWAF), the Department of Agriculture (DA), and the Department of Environmental Affairs and Tourism (DEAT) (Breetzke et al., 2011). However, the financing of such projects over a long period is not only very difficult, but it is also hard to predict how stable the political system of the country is since the political stability of the country is significant in financial provision to such projects (Akinyemi, 2015). As the installation of a fully functioning GIS takes a lot of time, there is a risk, that these projects may not be accomplished.

### **2.12.2 CHALLENGES OF PAPER-BASED GIS IN SOUTH AFRICAN RURAL LEARNING ECOLOGIES**

Paper-based GIS in South African learning ecologies is taught using textbooks and maps. Since maps are designed and drawn by humans, there may be human error giving distorted information (Breetzke et al., 2011; Fleischmann, 2012). Furthermore, the printed maps mostly rely on symbols to represent data. These symbols are sometimes not clear. Maps are drawn and designed by different entities that may have certain biases towards certain areas and hence not give full information regarding an area (Breetzke et al., 2011; Fleischmann, 2012; Scheepers, 2009). Maps mostly use symbols to represent objects on land and these require interpretation. This means that map reading requires some skills that may not be available to all. Cartography has allowed maps to show only specific features that are important to users at a specific time available in an area.

### **2.13 TEACHERS' PERCEPTIONS OF PAPER-BASED GIS IN SOUTH AFRICAN RURAL LEARNING ECOLOGIES**

In South Africa, available literature discusses the implementation of paper-based GIS as a strategy that was introduced to resolve the hindrances in schools without computers in implementing GIS. The literature further expounds that the alternative of introducing paper-based GIS in schools without computers made teachers happy that they were not going to be left behind in teaching this topic to learners (Fleischmann and Westhuizen, 2015). However, there is a dearth of literature specifically regarding the perceptions of teachers on whether paper-based GIS is or is not effective in teaching about GIS in rural learning ecologies. The available literature discusses more challenges of GIS implementation from the perspective of utilising computers (Akinyemi, 2015). There is a lack of literature about teachers' perceptions of implementing paper-based GIS in rural learning ecologies. Yet it has been over two decades since paper-based GIS was introduced into South African schools.

Given the prominence of the acceptance and use of technology in schools, it is expected that teachers could accept and implement paper-based GIS effectively in rural learning ecologies. It is against this background that this study seeks to use UTAUT as a lens to investigate geography teachers' perceptions about the implementation of paper-based GIS.

## **2.14 THEORETICAL FRAMEWORK**

The use of a theoretical framework is one of the most important aspects of research that guides the researcher to make meaning of a phenomenon. According to Green (2017), a theoretical framework serves as the guide on which to build and support your study, and also provides the structure to define how you will philosophically, epistemologically, methodologically, and analytically approach the dissertation as a whole. Another definition by Grant and Osanloo (2014) defines a theoretical framework as a structure that guides research by relying on a formal theory constructed by using an established, coherent explanation of certain phenomena and relationships. From these definitions, we learn that the theoretical framework consists of the selected theory (or theories) that support your thinking with regards to how you understand and plan to research your topic, as well as the concepts and definitions from that theory that are relevant to your topic. The study has adopted the UTAUT as a theoretical framework. The UTAUT model was chosen to understand a teacher's perception of the implementation of paper-based GIS.

### **2.14.1 THE UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY (UTAUT)**

Several models have emerged out of research pertaining to user acceptance and intention to use new technology. The UTAUT model was developed in 2003 (Liebenberg, Benade, & Ellis, 2018; Venkatesh, Morris, Davis, & Davis, 2003). This model synthesised elements across eight well-known technology acceptance models: The Theory of Reasoned Action (TRA), the Technology Acceptance Model (TAM), the Motivational Model (MM), the Theory of Planned Behaviour (TPB), the combined TAM and TPB, the Model of PC Utilisation (MPTU), the Innovation Diffusion Theory (IDT) and the Social Cognitive Theory (SCT) (Chiemeké & Ewwiekpaefe, 2011; Liebenberg et al., 2018; Venkatesh et al. 2003). The objective of combining technology acceptance models for the formulation of the UTAUT model was to achieve a unified view of user acceptance (Venkatesh et al., 2003). Thus making the UTAUT model a broad, robust, and powerful model in Information System (IS) adoption. The UTAUT model claims to be a useful tool to assess the likelihood of acceptance of new technology within an organisation. It also helps for understanding factors that drive acceptance of new technology so that appropriate features can be designed to facilitate user acceptance of new technology (Venkatesh et al, 2003).

The UTAUT model presents four core determinants of intention and four moderators of key relationships. The four determinants of intention and usage are performance expectancy, effort expectancy, social influence, and facilitating conditions. The four moderating effects are age, gender, experience, and voluntariness of use. However, since the Department of Basic Education (DBE) instituted mandatory use of paper-based GIS, the researcher could not include voluntariness of use as one of the moderating effects for this research. Therefore, the researcher controlled for voluntariness of use in the UTAUT model. Furthermore, self-efficacy, anxiety, and attitude towards using technology are the mediators and therefore not direct determinants of behavioural intention. Liebenberg et al. (2018) clarify the terms mediator and moderator as follows: A mediator serves to explain the nature of the relationship between the independent effect and dependent effect. A mediator implies that the independent effect influences the mediator effect, which in turn, influences the dependent effect. A moderator is a third effect that affects the direction and/or strength of the relationship between both a dependent effect and an independent effect. A discussion of the determinants, moderators, and mediators follows below.

## **2.14.2 FACTORS OF UNIFIED THEORY OF ACCEPTANCE AND USE OF TECHNOLOGY**

### **2.14.2.1 FACILITATING CONDITIONS**

Facilitating conditions/compatibility refer to the degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the system (Gupta, Dasgupta, & Gupta, 2008). Rogers and Kowal (1995) defined compatibility as the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. Facilitating conditions as a determinant of intention in the acceptance and use of GIS was suitable for this research in understanding whether geography teachers are accepting and finding paper-based GIS useful due to the limited access to and availability of hardware and software, and electricity in many South African rural learning ecologies (Johansson, 2006).

### **2.14.2.2 PERFORMANCE EXPECTANCY**

Performance expectancy can be seen as the degree to which an individual believes that using a system will help him/her attain gains in job performance and therefore enhance the quality of

his/her work (Liebenberg et al., 2018; Mutlu & Der, 2017; Venkatesh et al., 2003; Venkatesh, 2013). Liebenberg et al. (2018) state that individuals form intentions towards behaviours which they believe will increase their performance and they further assert that beliefs have an influence on attitudes, which lead to intentions and therefore cause behaviours. The performance expectancy as a determinant of intention is applicable to this study and it enabled the researcher to unfold whether geography teachers do hold a belief that paper-based GIS will enable them to better deliver the curriculum content to learners based on GIS, with good results.

#### **2.14.2.3 EFFORT EXPECTANCY**

Effort expectancy is defined as the degree of ease associated with the use of a certain system (Gupta et al., 2008; Liebenberg et al., 2018; Mutlu & Der, 2017). Venkatesh (2013) and Chiemeké and Ewwiekpaefe (2011) refer to this as perceived ease of use and claims that it refers to the degree to which an individual believes using a particular system would be free of effort. People will more likely use and accept the use of an application that is perceived as easier to use than others. The effort expectancy is applicable to the study and might be related to learner performance in a sense that a teacher teaches to meet lesson outcomes. Therefore, the results can be judged through learner performance. So you might find that the teacher expects learners to perform well yet they do not according to the diagnostic reports. Effort expectancy is a factor that enabled me to be knowledgeable when collecting data from the field and to assess whether or not geography teachers are encountering problems when using paper-based GIS in their classrooms.

#### **2.14.2.4 SOCIAL INFLUENCE**

Social influence is the degree to which an individual perceives that others believe it is important that she should use the new system (Gupta et al. 2008; Mutlu & Der, 2017; Venkatesh, 2013). This means that a person is influenced by important people within his/her social environment in terms of using a system (Liebenberg et al., 2018; Sarfaraz, 2017; Williams & Dwiyedi, 2015). Social influence is related to the study. For example, during geography workshops, a geography teacher who has achieved great performance in matric pass rates may be highly respected by peers because they believe that he or she teaches well. So this teacher might appear knowledgeable about GIS which may then influence their colleagues. Therefore, the social influence determinant enabled me to reveal whether teachers influence one another in the use

of paper-based GIS. This will serve as a way of disclosing whether or not geography teachers do consider their peers' beliefs with regards to the acceptance of paper-based GIS in rural learning ecologies.

### **2.14.3 THE MEDIATORS OF THE UTAUT MODEL**

The self-efficacy, anxiety and attitude towards using technology are the mediators. This means they are not direct determinants of behavioural intention. According to Liebenberg et al. (2018) a mediator serves to explain the nature of the relationship between the independent effect and dependent effect. The independent effects are performance expectancy, effort expectancy, social influence, and facilitating conditions while the dependent effects are gender, age, experience, and voluntariness of use (Venkatesh, 2013). A mediator implies that the independent effect influences the mediator effect, which in turn influences the dependent effect. The mediators are applicable to this study. This is because the researcher was able to investigate whether performance expectancy, effort expectancy, social influence, and facilitating conditions as independent effects influence self-efficacy, anxiety, and attitude as mediators in the implementation of paper-based GIS in rural learning ecologies. In turn, the researcher was also able to investigate whether the mediators influence gender, age, and experience as dependent effects.

#### **2.14.3.1 SELF-EFFICACY**

Self-efficacy is defined by psychologist Bandura (1995) as a person's belief in their own ability to succeed in a specific situation or in accomplishing a task. Self-efficacy as a mediator towards using technology applies to this study. This is because self-efficacy as a mediator towards using technology enables the researcher to investigate whether or not geography teachers believe in their abilities in implementing paper-based GIS in rural learning ecologies. In turn, the researcher could explore if geography teachers accept the use of paper-based GIS implementation in rural learning through understanding their abilities. This is because self-efficacy can play a major role in how geography teachers approach goals, tasks, and challenges of paper-based GIS in rural learning ecologies.

The availability and degree to which a geography teacher feels at ease in using paper-based GIS resources, and belief a teacher holds that the paper-based GIS helps in job performance may influence the teacher's ability to implement paper-based GIS in rural learning ecologies. Furthermore, the belief a teacher holds that paper-based GIS reduces effort when teaching and the influences from peer geography teachers in workshops may influence the individual teacher's ability to use paper-based GIS. In turn, self-efficacy can influence dependent effects such as age, gender, and experience (Venkatesh et al., 2003). For example, an older, female, and inexperienced geography teacher may have a belief that he/she lacks the ability to use paper-based GIS in rural learning ecologies or vice versa.

### **2.14.3.2 ANXIETY**

Anxiety is a sense of worry, nervousness, or unease about something with an uncertain outcome (Oxford English Dictionary, 2014). The anxiety as a mediator towards using technology is applicable to this study. because anxiety it enables the researcher to investigate whether geography teachers have a sense of worry and nervousness because of being uncertain about implementing paper-based GIS in rural learning ecologies. In turn, it is then possible to explore whether or not geography teachers accept paper-based GIS implementation in the rural learning ecologies. The performance expectancy, effort expectancy, social influence, and facilitating conditions as independent effects may influence a teacher's sense of worry, and nervousness towards implementing paper-based GIS. In turn, anxiety can influence dependent effects such as age, gender, and experience (Venkatesh et al., 2003). For example, older, female, and inexperienced geography teachers may have a sense of worry, nervousness and unease about the use of paper-based GIS in rural learning ecologies or vice versa.

### **2.14.3.3 ATTITUDE**

Attitude towards using technology can be seen as a person's overall affective reaction to using a system (Venkatesh et al., 2003). The attitude as a mediator towards using technology is applicable to this study since it enables the researcher to investigate the geography teachers' reactions towards the implementation of paper-based GIS in rural learning ecologies. In turn, geography teachers' perceptions enable the exploration of whether or not they accept paper-based GIS implementation in the rural learning ecologies. The performance expectancy, effort

expectancy, social influence, and facilitating conditions as independent effects may influence teachers' perceptions towards the implementation of paper-based GIS in rural learning ecologies. In turn, attitude can influence dependent effects such as age, gender, and experience (Venkatesh et al., 2003). For example, older, female, and inexperienced geography teachers may perceive the use of paper-based GIS in rural learning ecologies differently from younger, male, and experienced geography teachers or vice versa.

#### **2.14.4 MODERATING EFFECTS OF THE UTAUT MODEL**

##### **2.14.4.1 AGE**

The moderating effect of age relates to the age of particular users (Muhsin & Nurkhin, 2016). The moderating effect of age in the context of a general adoption environment is applicable to the study is because this effect enables the researcher to investigate whether or not age influences the acceptance and implementation of paper-based GIS in rural learning ecologies. The Theory of Planned Behaviour (Venkatesh and Morris, 2000) and UTAUT (Venkatesh et al., 2003) found that age is a significant moderator, whereas other acceptance models such as TAM, TRA and others did not examine the role of age as a moderator. However, this finding is limited to western contexts, such as adoption in the USA. For this study, the researcher considers age as a moderating effect in the adoption environment of paper-based GIS in South Africa.

The basic premise that information systems are adopted and accepted more easily by younger individuals may be true in the developed world since they have been exposed to the computing environment at an early age, but this is not so true in developing countries such as South Africa. In South Africa, a significant portion of the population, including young people, do not have access to computers (Venkatesh & Morris, 2000). In the rural learning ecology where this study was based, younger geography teachers may have a better understanding and exposure to information systems than their older counterparts or vice versa. This may trigger younger teachers in rural learning ecologies to more readily accept and implement paper-based GIS more or vice versa.

#### **2.14.4.2 GENDER**

The moderating effect of gender relates to sexual categories of the technology users which is either male or female (Muhsin & Nurkhin, 2016). The moderating effect of gender in the context of a general adoption environment is applicable to the study. According to Venkatesh et al. (2003), gender is a significant moderating effect on the acceptance and use of technology. Therefore, gender enabled me to understand whether or not geography teachers' attitudes towards acceptance and the use of paper-based GIS in rural learning ecologies have a connection to their gender. Chiemeké and Ewwiekpaefe (2011) reveal that certain studies confirmed that women are more driven by ease of use and subjective norms while men are more driven by usefulness. Hence, gender is considered to reveal whether or not female teachers receive paper-based GIS in rural learning ecologies differently to male geography teachers. Moreover, gender as a moderating effect in the adoption environment enables me to further explore the geography teachers driving factors that lead them to receive paper-based GIS differently or similarly to one another.

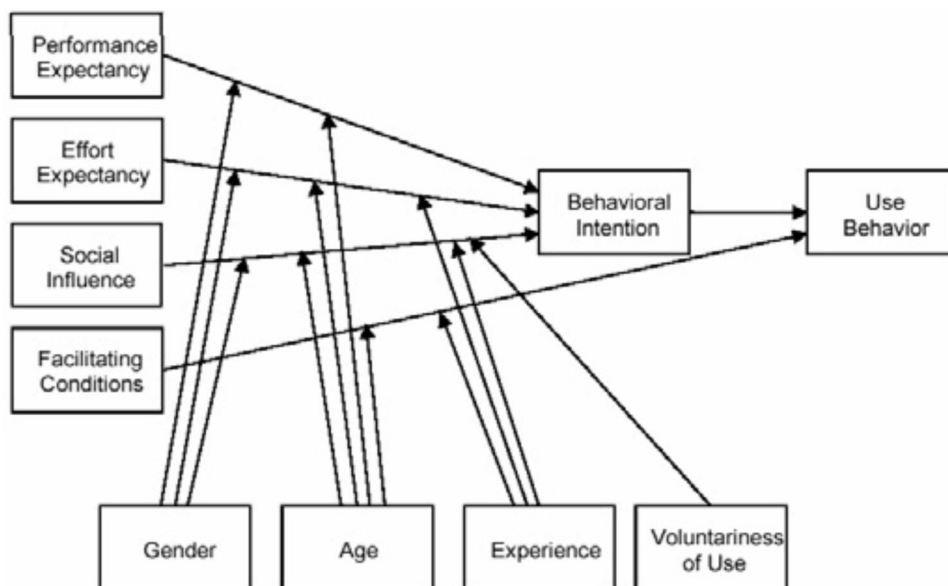
#### **2.14.4.3 EXPERIENCE**

The moderating effect of experience in the context of a general adoption environment is applicable to the study. This is suitable for the study since geography teachers' experiences in teaching and learning may play a role in the acceptance and the use of paper-based GIS. Generally, research has shown that experienced users are driven by usefulness and inexperienced users are more likely to pay attention to ease of use (Chiemeké & Ewwiekpaefe, 2011). Therefore, experienced teachers may be motivated by the usefulness of paper-based GIS. Hence, usefulness may result in experienced geography teachers accepting paper-based GIS more than inexperienced teachers. The inexperienced teachers may be motivated by the ease of use of paper-based GIS. The ease may result in inexperienced teachers accepting paper-based GIS more than experienced geography teachers. Chiemeké and Ewwiekpaefe (2011) note that after obtaining some experience with the technology, users will turn to explore the benefits of it. Thus, novice teachers may pay attention to the benefits of paper-based GIS after obtaining some experience.

### 2.14.5 BEHAVIOURAL INTENTION

Behavioural intention refers to an individual's intention to use technologies in the future, whether or not he or she is currently using it. According to Ajzen (1991) intentions are assumed to capture the motivational factors that influence a behaviour; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behaviour. The behavioural intention is applicable to this study. The behavioural intention enables this researcher to investigate the effort geography teachers exert in the implementation of paper-based GIS in rural learning ecologies, and further explore whether or not these teachers are willing to try hard to use paper-based GIS. According to Venkatesh (2003), the general rule is that the stronger the intention is to engage in a behaviour, the more likely should be its performance. Thus, if Geography teachers are more willing to implement paper-based GIS in rural learning ecologies, the effort they exert may ensure the use of paper-based GIS in their schools in the future.

The following diagram shows Venkatesh's model of Unified Theory of Acceptance and Use of Technology.



*Figure 2.1: The UTAUT model*  
(Venkatesh et al, 2003, p 447)

## **2.15 CHAPTER SUMMARY**

The first part of this chapter presented the literature on geography teachers' implementation of GIS in a rural learning ecology. The literature was presented in ways that provided the history, current trends, debate, and challenges of GIS. The literature also presented paper-based GIS, and the benefits associated with this. The involvement of geography teachers in implementing paper-based GIS in rural learning ecologies was also described. The second part of this chapter discussed the theoretical framework of the study and included a description of one theory that formed a framework of the study; namely, the Unified Theory of Acceptance and Use of Technology. In the next chapter, I present the research design and methodology utilised in carrying out the study.

## CHAPTER THREE

### RESEARCH DESIGN AND METHODOLOGY

#### 3.1 INTRODUCTION

In the previous chapter, the researcher discussed the relevant literature and the theoretical framing of the study. The current chapter presents the methodological process of the study. This chapter aimed to achieve the following research objectives:

4. To explore geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology.
5. To determine how geography teachers implement paper-based Geographic Information Systems in a rural learning ecology.
6. To identify why do teachers implement paper-based GIS in a rural learning ecology the way that they do?

The above-stated research objectives will be achieved by addressing the following critical research questions:

1. What are geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology?
2. How do geography teachers implement paper-based Geographic Information Systems in a rural learning ecology?
3. Why do teachers implement paper-based GIS in a rural learning ecology the way that they do?

To achieve the three objectives and answer the three critical research questions of teachers' perceptions of implementing paper-based Geographical Information Systems (paper-based GIS) in a rural learning ecology, it is necessary to discuss the research paradigm (interpretive paradigm), case study research methodology, sampling (purposive), and the data generation methods (semi-structured interviews and focus group interviews). Further, this chapter discusses thematic data analysis, inductive and deductive reasoning, ethical issues, and trustworthiness (transferability, dependability, confirmability and credibility). Lastly, the chapter describes some of the limitations of this study.

### 3.2 RESEARCH DESIGN

Research design is fundamental because everything ultimately flows from the design choice. The research design is the overall strategy that one chooses to use to integrate the different components of the study coherently and logically to effectively address the research problem (Labaree, 2009). Thus, the research design choice is the one most tied to the investigator's research questions. Cooper, Schindler, and Sun (2012) add that research design refers to the basic methods of collecting evidence: surveys, interviews, experiments, observations (participant and naturalistic), archival research (data and textual archives), and combinations of these methods. The choice of the research design is driven by whether a study uses quantitative, qualitative, or mixed methods (Bertram & Christiansen, 2014). This study adopted a broad category of qualitative research design. There are several types of qualitative research designs, namely: grounded theory, ethnographic, narrative research, historical, case studies, and phenomenology (Creswell, 2014). In adopting a qualitative research design, the researcher wanted to investigate geography teachers' perceptions of paper-based GIS implementation in a rural learning ecology.

Qualitative research can be interpreted as "an approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem" (Creswell, 2014, p. 32). According to Flick (2018) and Merriam and Tisdell (2016), a qualitative study incorporates several salient characteristics. First, a qualitative study aims to understand the experiences that people have. Second, the instrument for data generation and data analysis is primarily the researcher. Third, the data from the study is analysed both inductively and deductively. Inductively, from the data, the researcher will generate explanations in the form of concepts, hypotheses, or theories. Deductively, the researcher uses the theoretical framework to analyse the experiences of participants. Finally, a rich description will be produced from multiple sources of data such as documents, field notes, and interviews. Therefore, geography teachers' rich descriptions were produced concerning their perceptions of paper-based GIS in a rural learning ecology.

Glesne (2016) and Merriam and Tisdell (2016) further affirmed that qualitative research aims to reveal the meaning of an occurrence for people who are involved in it. Thus, teachers' experiences about paper-based GIS implementation were investigated since they were the ones teaching geography in their classrooms. In conducting a study qualitatively, researchers are

concerned with identifying how people describe their own experiences, “how they construct their worlds, and what meaning they attribute to their experiences” (Merriam & Tisdell, 2016, p. 6). Therefore, geography teachers were suitable as participants for the study since paper-based GIS is included in the geography curriculum. Hence, these teachers were able to construct meaning about the implementation of paper-based GIS in rural learning ecologies. Rahi (2017), adds that the qualitative approach is usually used by the interpretive paradigm. The interpretive paradigm occurs when there is a researcher that seeks experiences, understanding, and perceptions of participants about a certain phenomenon. Antwi and Hamza (2015) and Creswell (2014) have explained that this approach is used when the researcher wants to observe or interpret an environment to produce a rich description.

### **3.3 RESEARCH PARADIGM**

Paradigms are essential in the way we view the world. The term paradigm is derived from Greek, meaning pattern (Kivunja & Kuyini, 2017) and has been broadly defined by many academics differently. For example, Hughes (2010) perceived paradigm as a way of seeing the world that frames a research topic and influences the way that researchers think about the topic. Furthermore, Kamal (2019) explains that social scientists approach their subject via explicit or implicit assumptions about the nature of the social world and how it may be investigated. In this study, geography teachers were approached from a specific lens according to the chosen paradigm for the study. According to Neuman (2000) and Creswell (2003) paradigm is referred to as epistemology or ontology, or even research methodology. One’s view of reality and being is called ontology and the view of how one acquires knowledge is termed epistemology. Together, ontological and epistemological assumptions make up a paradigm. Creswell (2009), and Cohen, Manion and Morrison (2011) stated that it is important for a research study to outline the research paradigm since it clarifies the direction that is taken by the researcher in collecting data.

There are four commonly used research paradigms in educational research, namely: interpretive, positivist, critical, and post-structural. Interpretivism’s main tenet is that research can never be objectively observed from the outside, rather it must be observed from inside through the direct experience of the people (Mack, 2010). Positivists aim to test a theory or describe an experience "through observation and measurement to predict and control forces that surround us" (O’Leary, 2004, p.5). On the other hand, the critical paradigm holds a view

that reality is created and shaped by social, political, cultural, economic, ethnic, and gender-based forces that have been reified or crystallised over time into social structures that are natural or real (Guba & Lincoln, 1994). On the contrary, post-structuralism is an extension and critique of structuralism in a sense that it rejects definitions that claim to have discovered absolute truths or facts about the world (Harcourt, 2007). Hence, different research paradigms view the world differently from one another.

Through different paradigms, the world can be understood in many different ways. Every researcher has a particular understanding of what knowledge and truth entail (Chilisa & Kawulich, 2012). Such understandings shape researchers' thoughts and views about themselves and other people as much as the researchers' thoughts and views about the world (Kamal, 2019). In essence, paradigms represent the researchers' beliefs and values about the world, the way they define the world, and the way they work within the world (Antwi & Hamza, 2015; Brooke, 2013; Kivunja & Kuyini, 2017). For this reason, knowledge and truth can only be defined through the paradigm of the study.

### **3.4 INTERPRETIVE PARADIGM**

This study is located within the interpretive paradigm to understand the experiences of participants. The main assumption of this paradigm is that reality is socially constructed and that there are as many intangible realities that people construct (Bertram & Christiansen, 2014; Chilisa & Kawulich, 2012; Thanh & Thanh, 2015). As an interpretive researcher, the researcher investigated how teachers perceive and implement paper-based GIS in a rural learning ecology. In this way, different interpretations from participants were obtained because their realities were not the same. Thus, the researcher was able to engage in geography teachers' experiences subjectively to understand their journeys. (Creswell, 2014). According to Bertram and Christiansen (2014), the purpose of the interpretive paradigm is to develop a greater understanding of how people make sense of contexts in which they live and work. Thus, I got to understand how geography teachers in different contexts of the rural learning ecologies made sense of paper-based GIS implementation.

The interpretive paradigm turns away from the de-humanised, objective research towards a re-humanised, contextual and reflexive approach, which centralises the making of human meaning and knowledge claims (Yanow & Schwartz-Shea, 2014). Hence, this paradigm recognises that

the teachers have emotions and their way of thinking that affects the construction of meaning. It also recognises that meaning is context-based. This implies that geography teachers might have constructed different meanings according to different contexts of rural learning ecologies. Therefore, the interpretive paradigm is also referred to as constructivism because it emphasises the ability of the individual to construct meaning (Antwi & Hamza, 2015). The role of the researcher in the interpretive paradigm is to, understand, explain, and demystify social reality through the eyes of different participants.

Mack's (2010) model below breaks down the ontological and epistemological assumptions of the interpretive paradigm. According to Lincoln and Guba (2013), ontological assumption of interpretivism is relativism. Relativism is the view that reality is subjective and differs from person to person (Guba & Lincoln, 2013). Ontology according to Lincoln and Guba (2013, p. 39), deals with the questions, "What is there that can be known?", or, "What is the nature of reality?" Our realities are mediated by our senses. Without consciousness the world is meaningless. Reality emerges when consciousness engages with objects which are already pregnant with meaning (Crotty, 1998, p. 43). Reality is individually constructed; there are as many realities as individuals. Language does not passively label objects but actively shapes and moulds reality (Antwi & Hamza, 2015; Mohd, Adnan, Yusof, Ahmad, & Kamal, 2019). Thus, reality is constructed through the interaction between language and aspects of an independent world.

The epistemological assumption of interpretivism is one of subjectivism which is based on real world phenomena. The world does not exist independently of our knowledge of it (Grix, 2004, p. 83). Regarding trees, Crotty (1998) elaborates that we need to remind ourselves here that it is human beings who have constructed it as a tree, given it the name, and attributed to it the associations we make with trees. A tree is not a tree without someone to call it a tree. Meaning is not discovered; it is constructed through the interaction between consciousness and the world. Consciousness is always consciousness of something (Crotty, 1998, p. 44). Therefore, epistemology has been explained as the process by which the investigator comes to know the truth and reality or, put another way, how do we know what we know? As such, epistemology examines the relationship between the inquirer and that which is inquired into (Guba, 1990, p. 27).

To experience a world is to participate in it, simultaneously molding and encountering it (Heron & Reason, 1997, p. 3). Therefore, the experiences that geography teachers possessed about the implementation of paper-based GIS was because of their participation in the teaching and learning of it. This made it possible to highlight the issues pertaining to paper-based GIS in a rural learning ecology. Corty (1998) further claimed that the meaning of the world that one experiences is generated through social interaction among people. “The generation of meanings could be influenced by many factors such as one’s prior experience and knowledge, political and social status, gender, race, class, sexual orientation, nationality, personal and cultural values” (Lincoln & Guba, 2013, p. 40). This implies that geography teachers may perceive the implementation of paper-based GIS differently from one another because of the factors mentioned above. Hence, in this study the researcher engaged in the participants’ construction of meaning with regards to paper-based GIS.

The following table shows the main ontological and epistemological assumptions of the interpretive paradigm.

<b>Ontological Assumptions</b>	<b>Epistemological Assumptions</b>
<ul style="list-style-type: none"> <li>• Reality is indirectly constructed based on individual interpretation and is subjective.</li> <li>• People interpret and make their meaning of events.</li> <li>• Events are distinctive and cannot be generalised.</li> <li>• There are multiple perspectives on one incident.</li> <li>• Causation in social sciences is determined by interpreted meaning and symbols.</li> </ul>	<ul style="list-style-type: none"> <li>• Knowledge is gained through a strategy that “respects the differences between people and the objects of natural sciences and therefore requires the social scientist to grasp the subjective meaning of social action” (Bryman as cited in Grix, 2004, p. 64).</li> <li>• Knowledge is gained inductively to create a theory.</li> <li>• Knowledge arises from particular situations and is not reducible to simplistic interpretation.</li> <li>• Knowledge is gained through personal experience.</li> </ul>

Table 3.1: Mack’s model of the epistemological and ontological assumptions of the interpretive paradigm (Mack, 2010, p 8)

The criteria used to evaluate the findings generated by research within the interpretive paradigm differ from those applied within the positivist paradigm (Ponelis, 2015). While the value of the latter is judged by the degree to which results can be generalised to the wider population, the value of the understanding that emerges from an interpretive study is determined by the degree to which it fits and works with the perspectives of participants (Millar & Dowling, 2018). Methodologically, many positivists adopt quantitative methods to make generalisability claims, whereas interpretivists draw on a range of methods, tools, and techniques to secure an in-depth understanding of the phenomenon under investigation (Dean, 2018; Denzin & Lincoln, 2011). The unique entanglement of the researcher, with their research and the researched, is central to interpretivists' reflexive research practice (Antwi & Hamza, 2015).

### **3.5 CASE STUDY METHODOLOGY**

The case study is one of the most frequently used qualitative research methodologies. This study adopted a case study research methodology because the case study research methodology systematically captured the reality of the teachers' lived experiences of implementing paper-based GIS in a rural learning ecology. The research methodology is the specific procedures used to identify, select, process, and analyse information about a research topic (Zainal, 2007). Case study research designs can be based on their function, characteristics, or disciplinary perspective. One's selection of a research design is determined by how well it allows full investigation of a particular research question.

According to Yazan (2015), a case study is an empirical inquiry that investigates the case or cases. Hence, this enabled this researcher to inquire about geography teachers through their experiences about their views on the implementation of paper-based GIS. Ponelis (2015) and Yazan (2015) refer to a qualitative case study as an intensive, holistic description and analysis of a bounded phenomenon such as a program, an institution, a person, a process, or a social unit. For the case of this research, geography teachers' descriptions and analysis of data collected from the research sites about paper-based GIS in rural learning ecologies were the focus. The case study draws from various lines of evidence for triangulating purposes and avails itself of "prior development of theoretical propositions to guide data collection and analysis" (Yin, 2012, pp. 13-14). Thus, in this study, a literature review and theoretical framework were engaged in to gain knowledge before data collection took place.

This is indicative of how meticulous the researcher's approach was in terms of the cohesion and consistency among the design components and phases of the case study. Therefore, this researcher was able to provide the logic behind the case study of this research, which conformed with the theoretical propositions and the characteristics of the case. Yin (2012) suggests four types of design that case study researchers can use. They include single holistic design, single embedded design, multiple holistic designs and multiple embedded designs. The holistic designs require one unit of analysis (Yin, 2012). In other words, this is the major entity of 'what' or 'who' that is being studied. The embedded designs require multiple units of analysis. An embedded case study provides a means of integrating quantitative and qualitative methods into a single research study (Scholz & Tietje, 2002; Yin, 2013).

This study adopted a single holistic design in conducting research. This is because only the qualitative methodology was used. Furthermore, the unity of analysis includes individuals, groups, social, and social organisation. For the above reasons, the holistic design enabled an in-depth and systematic research to be conducted that was descriptive in nature and based on individual participants in rural learning ecologies. Yin (2013) advises that skilled researchers select the design which provides them with the maximum instrumentality to answer their research questions, and to consider the strengths and limitations of each design, and the pitfalls to be avoided while implementing each of them. The three types of case study research designs include exploratory, explanatory, and descriptive (Yin, 2013). Exploratory designs seek to define research questions of a subsequent study or to determine the feasibility of research procedures. These designs are often a prelude to additional research efforts and involve fieldwork and information collection prior to the definition of a research question.

Explanatory designs seek to establish cause-and-effect relationships. Their primary purpose is to determine how events occur and which ones may influence particular outcomes. For example, a middle school teacher may conduct an explanatory case study to identify factors in his students' home environments that affect their classroom performance. This study adopted a descriptive case study research design. This is because descriptive designs attempt to present a complete description of a phenomenon within its context, which was what was desired in this research. Hence, the researcher was able to gain a thorough description of teachers' perceptions of implementing paper-based GIS in a rural learning ecology. The defining feature of case

study research is its focus on ‘how’ and ‘why’ questions (Myers, 2009) and for this reason, it is appropriate for descriptive and exploratory studies (Mouton, 2001).

From Yin’s (2013) perspective, the case study research design is comprised of five components: a study’s questions; its propositions (if any), its unit(s) of analysis, the logic linking the data to the propositions, and the criteria for interpreting the findings. For this reason, this study has research questions aimed at exploring geography teachers’ views about paper-based GIS implementation using the UTAUT theoretical framework that is in line with the research questions, and by use of a deductive and inductive approach in data analysis. The criteria for interpreting the findings allowed analysis of the data to be descriptive and in-depth.

Yin (2012) directs extra attention to the fourth and fifth components, which refer to the planning for the data analysis steps in the case study method. He also advises that case study researchers plan these “least well-developed components” very conscientiously and rigorously so that their inquiry has a solid foundation for the analytic operations (Yin, 2012, p. 26). Concerning these components, Yin (2012) emphasises that researchers need to review the relevant literature and include theoretical propositions regarding the case under study before any data collection begins; this approach distinguishes it from such methodologies as grounded theory and ethnography. In grounded theory qualitative research, a researcher seeks to create a theory that explains some action, interaction, or processes (Hancock & Algozzine, 2006). The investigator is the primary instrument of data collection and attempts to inductively derive meaning from the data. Ethnographic design is used when one wants to investigate the intact cultural or social groups to find and describe beliefs, values, and attitudes that structure the behaviour, language, and interactions of the group (Hancock & Algozzine, 2006). In the ethnographic design, findings are based primarily on observations by the researcher, who is immersed in the group’s setting for an extended period of time.

Thomas (2016) claimed that case study research designs may also be classified as intrinsic, instrumental, or collective. Researchers engage in intrinsic case study research when they want to know more about a particular individual, group, event, or organisation. Using an intrinsic case study, researchers are not necessarily interested in examining or creating general theories or in generalising their findings to broader populations (Hancock & Algozzine, 2006). Using this approach enhances understanding of the particular issue being examined and is of secondary importance to a greater insight into the theoretical explanation that underpins the

issue (Hancock & Algozzine, 2006). The collective case study research design applies to this study. This type of case study research attempts to address an issue in question while adding to the literature base and helping us to better conceptualise a theory (Hancock & Algozzine, 2006). Hence, the use of deductive and inductive data analysis approaches enabled this researcher to use the theoretical framework to analyse data and, subsequently, other themes emerged from the data that was collected. Thus, the findings from research sites substantiated the theory while simultaneously providing insights into how people thought and behaved in the implementation of paper-based GIS in rural learning ecologies.

The case method supports both theory building and theory testing (Yin, 2009). The case study methodology supports theory building and is particularly useful in areas where existing theoretical and conceptual frameworks are inadequate (Chetty, 1996). Furthermore, the case study method enables a researcher to closely examine the data within a specific context (Polnelis, 2015; Zainal, 2007). Therefore, the use of this research method will allow for the selection of a small geographical area and a limited number of individuals as the participants of the study. For this study, the case is the geography teachers' implementation of paper-based GIS in a rural learning ecology.

### **3.6 THE RESEARCH SETTING**

The participants of this study were geography teachers in two rural schools in KwaZulu-Natal Province, in UGU district, South Africa. In this research, the research site is referred to as rural learning ecologies since their geographic area is located outside of the town of Port Shepstone. The nearest small town is iZingolweni. The size of iZingolweni area is 6,43 km<sup>2</sup>. The population size is estimated at 5294 in the area of iZingolweni (Mkhize & Cele, 2017). The population density is 820 people/km<sup>2</sup>. The area consists of 100% black' communities with more than 90% Zulu-speaking people and slightly above 2%, a mixture of people speaking other indigenous languages speaking (Sithole, Perez-Feranandez, & Magadlela, 2019). These are poor communities with a high dependency ratio in the population. A large number of people work on farms to earn a living (Cele, 2016). The two rural learning ecologies are resource-poor and learners come from disadvantaged backgrounds.

The quintile categorisation of both rural learning ecologies is the same with both of the rural learning ecologies qualified as no-fee schools (Hall & Giese, 2009). These schools are under

quintile two and learners do not pay fees because the schools are located in poor communities. The quintile of a school is based on the relative wealth of the surrounding communities (Kern, Graber, Shen, & Hillman, 2018).

### **3.7 SELECTION OF PARTICIPANTS**

The selection of participants in social science study is a process of selecting a sample of units from data set to measure the characteristics, beliefs, and attitudes of the people (Rahi, 2017). This means the research sample is selected from a population. A population can be defined as all people or items that one wishes to understand while sampling is the process of selecting a segment of the population for investigation (Etikan, Musa, & Alkassim, 2016). The selection of the sampling method depends on the nature of the research study; it may include theoretical and practical issues (Rahi, 2017). There are broadly two types of sampling methods, probability and non-probability sampling. Probability sampling is a sampling approach in which each unit has an equal chance or probability to be selected (Bertram & Christiansen, 2014). This study adopts non-probability sampling in which the chance or probability of each unit being selected is not known or confirmed (Rahi, 2017). This means that participants in the non-probability sample are not given selected equal chance to participate but instead, they are selected on the basis of their accessibility or by the purpose and personal judgement of the researcher. Therefore, by utilising non-probability sampling, I was enabled to be purposive and make personal judgments in selecting participants.

According to Etikan et al. (2016), the different types of sampling includes convenience sampling, random sampling, stratified, systematic sampling, and statistical sampling. The random sampling, stratified, systematic sampling, and statistical sampling work well in the probability sampling method (Rahi, 2017). This study adopted convenience sampling, which defines a non-probability or non-random process of data generation from a population that meets certain criteria, such as geographic proximity, ease of access, availability at a given time, or the willingness to participate. Thus, convenience sampling enabled me to research two schools that offer geography as one of the matric subjects. Bertram and Christiansen (2014) point out that convenience sampling allows researchers to complete interviews or get responses in a cost effective way, and in this study, the short distances travelled meant less expense in terms of funds and time.

This study adopts a purposive sampling approach since this approach is representative, non-random, and participants selected have the needed information. The researcher thus selected geography teachers from rural learning ecologies because they are the ones who teach GIS in the resource-poor classrooms, and thus it implies that that the participants selected would have the needed information. The participants of this research study were four geography teachers from two poorly-resourced rural learning ecologies who were purposively chosen. Purposive sampling targets knowledgeable people with in-depth knowledge about certain issues like professional role, power, expertise or experience (Cohen et al., 2011 Creswell, 2009; Maree, 2007). As a researcher, I chose the experienced teachers to get in-depth knowledge with regards to teachers' perceptions about teaching paper-based GIS in a rural school. Etikan et al (2016) add that the purposive sampling technique, also called judgment sampling, is the deliberate choice of a participant due to the qualities the participant possesses.

### 3.8 PROFILE OF PARTICIPANTS

Below the researcher presents the profiles of the participants in a tabular form. The names of participants were anonymised by the use of pseudonyms for confidentiality reasons.

*Profile of participants*

<b>NAME OF PARTICIPANT</b>	<b>GENDER</b>	<b>AGE</b>	<b>QUALIFICAFICATIONS</b>	<b>SUBJECT TEACHING</b>	<b>YEARS OF TEACHING EXPERIENCE</b>
Billy	Male	28	Bachelor of Education	Geography	07
Duncan	Male	30	Bachelor of Education	Geography & Life Sciences	09
Gale	Female	38	Bachelor of Education	Geography	10
Mario	Male	32	Bachelor of Education	Geography	08

*Table 3.2: Profile of participants*

### **3.9 DATA GENERATION METHODS**

The purpose of data gathering in qualitative research is to provide evidence for the experience it is investigating (Polkinghorne, 2005). The study adopted two data generation tools namely: semi-structured interviews and focus group interviews.

#### **3.9.1 INTERVIEWS**

Interviews have become an important tool for qualitative researchers as main researchers use them as the primary mechanism for data generation. Taylor, Bogdan, & DeVault (2015) confirm that the interviewees can discuss their perceptions and interpretation regarding a given situation. According to King, Horrocks and Brooks (2018), interviews are a systematic way of talking and listening to people and another way to generate data from individuals through conversations. For this reason, the researcher has systematically structured the interview questions to obtain responses from participants that address the research topic. Silverman (2016) adds that interviews are the interchange of views between two or more people on a topic of mutual interest, sees the centrality of human interaction for knowledge production, and emphasises the social situation of research data. Choosing paper-based GIS as the area of focus in this research had been influenced by my professional identity as a geography teacher, and the particular teachers that were chosen as participants of the study were those that teach geography in which GIS is one of the topics that fall under this subject.

The researcher has to know and select the appropriate method for addressing the needs of the research question (Birmingham & Wilkinson, 2003). This means that the interview type chosen by the researcher must be the one that will allow the participants to answer in the manner that best addresses the research question. Moreover, Gill, Stewart, Treasure, and Chadwick (2008) reveal that when designing an interview schedule it is imperative to ask questions that are likely to yield as much information about the study phenomenon as possible and also be able to address the aims and objectives of the research. Furthermore, in a qualitative interview, good questions should be open-ended, neutral, sensitive, and understandable (Gill et al., 2008). In other words, a qualitative interview requires more than a yes or no answer. The purpose of the research interview is to explore the views, experiences, beliefs and/or motivations of individuals on specific matters (King et al., 2018). Qualitative methods, such as interviews, are believed to provide a 'deeper' understanding of social phenomena than would be obtained from purely quantitative methods, such as questionnaires.

It is usually best to start with questions that participants can answer easily and then proceed to more difficult or sensitive topics (Taylor et al., 2016). This can help put respondents at ease, build up confidence and rapport, and often generates rich data that subsequently develops the interview further. It is the role of the researcher to ask questions and the questions ought to elicit valid responses from respondents (Roulston, 2016). According to Castillo-Montoya (2016), the length of interviews varies depending on the topic, researcher and participant. However, on average, interviews last 20 to 60 minutes. Thus, once the interview is conducted the researcher needs to make sure that the respondents have: some idea of the probable length of the interview and that you would like to record it (explaining why); a clear idea of precisely where and when the interview will take place; and basic information about the purpose of the interview and the research project of which it is a part; and a clear idea of why they have been asked (Gillham, 2000, p. 38). The interview section in this study for individual participants lasted for about forty-five minutes to an hour and participants were informed about ethical matters before being interviewed.

Hoyle, Harris and Judd (2002) comment that interview questions have dual goals of motivating the respondent to give full and precise replies while avoiding biases stemming from social desirability, conformity, or other constructs of disinterest. Therefore, proper training and proper interviewer behaviour can help greatly in achieving the goals. This researcher has received training by attending a research course and by reading books on research in preparation to conduct this research. Gray (2004) provides the following reasons to use interviews as a research instrument for collecting data: is to attain highly personalised data, allow opportunities for probing, and allow participants who have difficulties with written language to express themselves through conversations.

There are different types of qualitative interviews which include structured, semi-structured and unstructured interviews (DiCicco-Bloom & Crabtree, 2006). This study adopted semi-structured interviews, and focus group interviews. For this study, semi-structured interviews are appropriate since they consist of several key questions that help to define the areas to be explored, but also allow the interviewer or interviewee to diverge to pursue an idea or response in more detail. The semi-structured questions enabled this researcher to investigate geography teachers' perceptions of paper-based GIS in rural learning ecologies. Hence, participants were able to provide deeper knowledge about their understanding of paper-based GIS implementation.

### 3.9.2 SEMI-STRUCTURED INTERVIEWS

The most common types of interviews used in qualitative research are semi-structured interviews (Doody, 2013) and involve the use of predetermined questions where the researcher is free to seek clarification (Mann, 2016). The interview can be flexible, with open-ended questions and the chance to explore issues that arise spontaneously (Jamshed, 2014). This study adopted semi-structured interview as one of the data generation tools. The open-ended questions enabled me to ask follow-up *why* or *how* questions. The dialogue meandered around the topic on the agenda rather than adhering slavishly to verbatim questions as is often the case in a standardised survey (Adams & Lawrence, 2018). The meandering around the research topic during the interview led to totally unforeseen issues. Similarly, Doody (2013) adds that the researcher in the semi-structured interview can explore new paths that emerge during the interview that may not have been initially considered. The semi-structured interviews enabled the researcher to word questions instinctively and develop a conversational style during the interview that focused on the topic.

Based on Longhurst (2003), a semi-structured interview is a verbal interchange where one person, the interviewer, attempts to elicit information from another person by asking questions. This means the semi-structured interviews unfold in a conversational manner offering participants the chance to explore issues they feel are important. Therefore, the researcher was enabled to draw out more information from the teachers about the implementation of paper-based GIS by asking probing questions. As stated earlier, this was because semi-structured interviews have some degree of a predetermined order of questions but still ensures flexibility in the way issues are addressed by the informants (Mann, 2016). Thus, the open nature of the questions encouraged depth and vitality, which helped new concepts to emerge. In essence, the semi-structured interview data generation method has features of both structured and unstructured interviews and therefore uses both closed and open questions (Patten & Newhart, 2017). As a result, it has the advantage of both methods of interviewing participants.

According to Doody and Noonan (2013) and Mann (2016), an interview guide is developed to collect similar types of data from all participants and create a sense of order. In this study, an interview guide was developed that was common to all the geography teachers. In this way, data could be gathered that addressed similar questions across the participants in the research sites. However, the researcher was free to vary the order and wording of the questions, depending on the direction of the interview, and to ask additional questions. Mann (2016)

reveals that the opportunity of the interviewee to elaborate further as the interview progresses provides more relevant information if he/she opts to do so. This increases the validity of the study by assisting in the generation of rich data for analysis. Adams and Lawrence (2018) point out that about one hour is considered a reasonable maximum length for semi-structured interviews to minimise fatigue for both interviewer and respondent. For this study, semi-structured interviews that were conducted lasted for about thirty minutes each. This minimised the chances of mental tiredness which might have disrupted the data collection process.

To generate data in this study, individual semi-structured in-depth interviews were conducted to set questions for the interviewee that provides room for the development of ideas. The semi-structured interview, as stated earlier, often asks open-ended questions and probes the responses (Jamshed, 2014). The researcher asked the geography teachers further questions on paper-based GIS; some of which may have emanated from the discussions that occurred during the interviews. Cohen et al. (2001) add that interviews enable participants to discuss their interpretations of the world in which they live and to express how they regard situations from their point of view. The merit of the semi-structured qualitative interview is that it allows for dialogue between the interviewer and interviewee (Bertram & Christiansen, 2014). Therefore, the interviewees might have felt more content having a conversation with the researcher as opposed to filling out papers in a survey. During the interview, participants were audio-recorded to obtain every piece of information discussed the implementation of paper-based GIS in a rural learning ecology. The reason for audio-recording was explained explicitly to the participants.

### **3.9.3 FOCUS GROUP INTERVIEWS**

Focus group interviews share many common features with less structured interviews, but there is more to them than merely generating similar data from many participants at once. According to Carey and Asbury (2016), a focus group interview is a planned discussion where a group of participants is asked a set of semi-structured questions to obtain perceptions on a defined area of interest, in a non-threatening environment. Similarly, Ryan, Gandha, and Culbertson (2014) point out that focus group interviews are a particular type of group interview where the researcher asks a set of targeted questions designed to elicit collective views about a specific topic. This means that the researcher defines the topic, and generates data through group interaction. The group is focused in that it involves a collective effort. This study adopted focus group interviews because focus groups work particularly well to explore perceptions, feelings,

and thinking about issues, products, services, or opportunities (Krueger & Casey, 2014). For this reason, the researcher was able to explore geography teachers' perceptions of paper-based GIS implementation in rural learning ecologies through group interaction.

On the other hand, Rabiee (2004) defines a focus group interview as a technique involving the use of in-depth group interviews in which participants are selected because they are purposive, although not necessarily representative, a sample of a specific population, this group being focused on a given topic. In this research study, the researcher purposefully chose geography teachers in two rural schools because their contribution to the research topic was possible since they taught GIS in their classrooms. Therefore, these specific teachers were able to provide in-depth knowledge about issues around paper-based GIS in rural learning ecologies. Richardson and Rabiee (2001) add that participants in focus group interviews are selected on the criteria that they would have something to say on the topic, and are within the age-range, have similar socio-characteristics, and would be comfortable talking to the interviewer and each other. However, Niewenhuis (2006) cautions that it is possible that some participants may experience a group encounter as threatening, and therefore not fully participate. Therefore, the researcher observed the group process. Therefore, the researcher did not allow one or two participants to dominate the discussion by asking for responses from silent participants.

Wilkinson & Birmingham (2003) reveal that the product of a focus group interview is a unique form of qualitative information that brings understanding about how people react to an experience or product. Through the focus group interviews, the researcher was able to understand geography teachers' thoughts, feelings, attitudes, or opinions of paper-based GIS implementation in rural learning ecologies. Romm (2015), highlight that focus groups rely for their success on how groups of people naturally engage in conversations. For example, all participants have equal access to the discussion, there are no restrictions on who may speak, how often and for how long; participants do not have to wait for their turn to speak or be given permission; and, when they do speak, what they say is not specified in advance.

It is generally agreed that individuals have their thoughts, feelings or opinions about a certain issue, which are either 'brought to the table' or formed and developed during a discussion (Wilkinson & Birmingham, 2003). Hence, one aim of this research study is to gain access to

those opinions. It is also generally accepted that a relatively informal meeting, with an atmosphere conducive to self-expression, held between people who share common interests and overseen by a non-judgemental moderator, provides the most effective research tool (Wilkinson & Birmingham, 2003). It is within such a situation that geography teachers may recall details of their own experiences, release their inhibitions and feel comfortable about contributing their comments and responding to comments made by other members of the group in supportive or critical ways. Consequently, the intention is that the discussion will be richer, deeper, and more honest and incisive, than any interview with a single participant would produce.

Hess (1968) summarises the benefits from the participant interactions which focus-group interviews encourage as the five ‘S’s as shown below.

- Synergism
- Snowballing
- Stimulation
- Security
- Spontaneity

Box 3.1: *The five ‘S’s of group interaction* (Hess, 1968, p 194)

*Synergism* is a cumulative process in which individual participants react to, and build upon, the responses of other group members (Hess, 1968). The resulting combined group effort may produce a wider range of information, insight, and ideas than that likely to be revealed by any single member of the group in a one-to-one interview. Therefore, the researcher was able to obtain a wide range of information about paper-based GIS from geography teachers due to the escalation of the discussion that resulted from other participants building their discussions from others’ views. *Snowballing* is such a situation, in which a comment by one participant triggers a chain of responses from others which in turn generates new ideas and topics for discussion (Hess, 1968). Hence, snowballing led to the rich and in-depth data about paper-based GIS usage in rural ecologies due to the exposure of new ideas that were triggered by comments made by the teachers.

*Stimulation* is a situation in which the group setting works to spur members on to express their ideas (Hess, 1968). This was achieved in this study by utilising a focus group interview, where the research topic was introduced in such a way that encouraged geography teachers to express their ideas. *Security* of a focus group interview encourages group members to express their opinions more freely, especially if they find he or she shares similar opinions, or if the group members are relatively shy or lacking in confidence (Hess, 1968). During the focus group interview in this study, certain views that were raised were common to all geography teachers and this created confidence in participants to engage more openly in the discussion.

The *spontaneity* of a focus-group interview refers to the fact that no individual is obliged to have a particular view or opinion about a topic and to express that view to the rest of the group, so when a participant chooses to speak it is likely to be because he or she holds a strong opinion about a subject, or agrees or disagrees emphatically with another's comments (Hess, 1968). The spontaneity was beneficial to the study in that, the researcher was exposed to geography teachers who held different views from others and could give the reasons for these differences. This in contrast to one-to-one interviews where there is a certain pressure on the interviewee to answer all questions whether or not he or she can provide a truthful or considered answer. The intended consequence of the spontaneity effect is data that are more heartfelt, honest and meaningful than that obtained through individual interviews (Wilkinson & Birmingham, 2003). The more often this occurs the greater the confidence that the focus-group interviews will be a success.

In essence, the focus-group interview's 'socially oriented' approach mimics people's everyday interaction, and, therefore, the main advantage is that the data it yields may more accurately reflect people's genuine thoughts and feelings about a subject than that obtained through individual interviews in which respondents feel forced to answer with, perhaps, insufficient time to consider all the issues. To generate data utilising focus group interviews in this study, the researcher chose one group of all the participants. This was because four teachers were a small enough group for everyone to have an opportunity to share insights and yet large enough to provide a diversity of perceptions about the implementation of GIS in a rural learning ecology. Subramaniam (2018) confirms that an effective focus group comprises of between six and ten participants,

The generated data, representing different views, was then compared and contrasted across participants. Stewart and Shamdasani (2014) suggest that the questions in a focus group are carefully predetermined and sequenced, and questions are phrased and sequenced, so they are easy to understand and logical to the participants. For this study, in preparation for focus group interviews the researcher had a set of semi-structured questions to obtain geography teachers' perceptions implementing paper-based GIS in a rural learning ecology. According to Williamson (2013), the five or six questions selected for the discussion guide must be open-ended, phrased clearly and simply. Moreover, the questions must draw upon concrete examples to illustrate a topic. Where appropriate, the questions should be sequenced from less to more sensitive questions. In this study, five questions were selected as a focus group interview guide. However, as the moderator of the focus group interviews, I was receptive to relevant issues raised by participants that have not been anticipated in the discussion guide and I also encouraged equal participation of all those in the group (Williamson, 2013). To encourage equal opportunity by all the participants in the group ensure that discussion proceeds accordingly.

The desirable number of focus group sessions depends upon the nature and complexity of the subject under investigation and the use for which the data generated by the focus group are to be employed. According to Subramaniam (2018), from one to ten sessions are generally sufficient for most studies, since at some juncture the group's discussion will simply replicate existing data, making further sessions unnecessary. In this study, one focus group interview session was conducted. One focus group interview session for the study was sufficient to discuss all aspects of the five semi-structured questions and other relevant issues raised by participants that have not been anticipated in the discussion guide. A focus group session lasts approximately ninety to a hundred and twenty minutes (Powell, & Single, 1996). The length of the session is usually determined by the complexity of the subject under investigation or the number of participants in the group (Subramaniam, 2018). In this study, the focus group interview session lasted for approximately a hundred minutes to cover five pre-planned questions and other issues that were not anticipated. There were four participants in the focus group interview session. The focus group interview session was audio-recorded and later transcribed verbatim to obtain every piece of information about the implementation of paper-based GIS in a rural learning ecology.

### **3.10 DATA ANALYSIS**

Data analysis is the process of systematically interpreting data using analytical and logical techniques to determine useful information (Braun, Clark, Hayfield, and Terry, 2019). The purpose of qualitative data analysis is to make sense of textual information, for example, transcripts from interviews and focus groups by identifying patterns within the data relating to a specific research question (Brooks, Bee, & Rogers, 2019). Analysing data by looking for common themes (known as thematic analysis) and making sense of those commonalities is one of the most common ways of qualitative analysis (Braun et al., 2019; Brooks et al., 2019; Silverman, 2016). This study adopted the thematic data analysis approach which enabled the researcher to see and make sense of the collective or shared meanings and experiences indicated by the data set. The semi-structured interviews and focus group interview data were analysed utilising a combination of deductive and inductive thematic analysis approaches.

Assarroudi, Heshmati, Nabavi, Armat, Ebadi, Vaismoradi (2018) claim that thematic analysis is a method for systematically identifying, organising, and offering insight into patterns of meaning across a data set. The patterns of meaning that thematic analysis allows the researcher to identify needs to be important concerning a particular topic and research question being explored (Brooks et al., 2019; Silverman, 2016). For this research, thematic analysis enabled the researcher to identify and organise themes relevant to answering a particular research question. Braun et al. (2019) note that the specific question that is being answered when analysing data only becomes apparent through the analysis.

Vaismoradi, Jones, Turunen, & Snelgrove (2016) argue that thematic analysis is a flexible method that also allows the researcher to examine one particular aspect of a phenomenon in depth, which is one reason why it was used in this study. As stated earlier, the study used a combination of deductive and inductive thematic analysis approaches. The deductive thematic analysis is guided by existing theories and frameworks to analyse data (Bertram & Christiansen, 2014; Brooks et al., 2019). Similarly, Pandey (2019) and Rahi (2017) point out that the deductive approach is where the researcher explains research based on pre-existing theory generated based on conceptual and theoretical structures. For this study, the UTAUT theoretical framework was used to identify and interpret meaning across data generated from the semi-structured interviews and a focus group interview.

The inductive thematic analysis is guided only by the data collected during the study and themes emerge from the data (Brooks et al., 2019; Clarke & Braun, 2014; Bertram & Christiansen, 2014) and theory is developed (Rahi 2017) In this study, data that emerged from the research sites were utilised to identify and interpret themes that were not covered by the UTUAT theoretical framework. Hence, it was through utilising deductive and inductive approaches that the researcher aimed to provide understandings of how geography teachers perceive paper-based GIS implementation in rural learning ecologies.

Thematic analysis is a six-phase process: familiarisation, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes, and producing the report (Clarke & Braun, 2014). In phase one the researcher listened to the audio-tape recordings at least twice and then transcribed the data. Thereafter, the audio-tape was played and the transcriptions read to ensure that data was transcribed verbatim. Note-making assists the researcher and reading data as data means reading the words actively, analytically, and critically, and thinking about what the data mean (Clarke and Braun, 2014; Vaismoradi et al., 2016). In this research, reading data as data involved how geography teachers made sense of their experiences with paper-based GIS. This phase aims to become intimately familiar with your data set's content and to begin to notice things that might be relevant to your research question (Taylor, Bogdan, & DeVault, 2015).

In phase two, the researcher began generating initial codes through a systematic analysis of data. According to Clarke and Braun (2014), the codes are the building blocks of analysis. The codes in this research identified and labeled a feature of data that was potentially relevant to the research question. Codes can be done at the semantic or the latent level of meaning (Brooks et al, 2019; Taylor et al, 2015). The semantic codes are those that are descriptive and typically stay close to the content of data and the participants' meanings. Codes can also go beyond the meanings and provide an interpretation of data content (Brooks et al, 2019; Taylor et al, 2015). Such interpretive or latent codes identify meanings that lie beneath the semantic surface of the data. For this research, some codes mirror geography teachers' language and concepts; others invoke the UTAUT theoretical framework.

In phase three the researcher's analysis began to take shape as the researcher generated themes, representing a shift from the codes A theme captures something important about data in relation to the research questions and represents some level of patterned response or meaning within the data set (Clarke & Braun, 2014). For this research, certain themes were developed from the data and through utilisation of the UTAUT model. Although the phase is called searching for themes, it is an active process since themes are generated or constructed rather than discovered (Silverman, 2016).

In phase four, the researcher began reviewing potential themes. This phase involves a recursive process whereby the developing themes, that have been created, are reviewed with the coded data and entire data set (Vaismoradi et al., 2016). This phase is about quality checking in which the themes are checked against the collated extracts of data. The aim was to set themes that capture the most important and relevant elements of the data and reflect the overall tone of the data in relation to the research question. In phase five, the themes were defined and named. This phase involves being clear about stating what is unique and specific about each theme (Clarke & Braun, 2012; Clarke & Braun, 2014). Silverman (2016) claimed that a good theme should ideally have a singular focus, be related to others but should not overlap with others, should be built on previous themes, and should directly address the research question. The themes in this research study were constructed following the elements of a good theme as mentioned above.

In some cases, sub-themes within a theme may be generated. These are useful when there are one or two overarching patterns within the data, but each is played out in several different ways (Taylor et al, 2015). This was the reason why this study used sub-themes within themes. In the final stage of analysis, phase six, an in-depth report was produced. Writing and analysis are thoroughly interwoven in qualitative research (Vaismoradi et al., 2016), with the report providing a compelling story about the data based on the analysis. In this study, the report aimed to tell the rich and complex story of how geography teachers perceive and implement paper-based GIS in rural learning ecologies.

### **3.11 TRUSTWORTHINESS**

Trustworthiness in the interpretive paradigm is a way the researcher strengthens a study by ensuring that data shows the in-depth authentic experiences of the respondents. Rule and John (2011) and Connelly (2016) claim that this concept promotes values and norms such as scholarly rigour, transparency and professional ethics within the research society. In each study, researchers should establish the protocols and procedures necessary for a study to be considered worthy of consideration by readers (Amankwaa, 2016). The measures that are normally taken to ensure the quality of the research and its highest level of trustworthiness are credibility, confirmability, dependability and transferability (Maree, 2007; Rule & John, 2011).

#### **3.11.1 CREDIBILITY**

Credibility in data analysis means that the inquiry is carried out in such a way that the findings will be found to be credible (Connelly, 2016). This means that the findings should be a true reflection of the reality of the phenomenon under study. Given the interpretative nature of qualitative analysis, credibility refers to the interpretations made about the data (Brooks et al., 2019). To address credibility, emerging themes should be discussed and tested with the wider research team to ensure concepts and themes derived from the data are rooted in the raw data itself. To address credibility, the researchers must indicate how they have analysed the data (Golafshani, 2003). In this study, the researcher used both deductive and inductive thematic analysis approaches to address credibility. In using the deductive thematic analysis, the UTAUT theoretical framework was utilised to identify and interpret patterns of meaning across qualitative data (Clarke & Braun, 2014). The inductive thematic analysis approach was also used to identify and interpret themes that were grounded in the data (Clarke & Braun, 2014). The conclusions were only drawn for the participants of the study and findings were not generalised to other contexts (Bertram and Christiansen, 2014).

The researcher also used peer debriefing and member checking (Maree, 2007), and support was solicited from colleagues to check the interpretation of the data (critical peer checks) (Rule & John, 2011). The research participants were also requested to verify the accuracy of what had been reported about them (Rule & John, 2011). The interview protocol was helpful and reduced inconsistency and unintended unfairness. Creswell (2009) stated that the interview protocol establishes a standard procedure to be followed by both the researcher (interviewer) and

participants (interviewees). The subjectivity of the researcher in the research process was acknowledged. Subjectivity is based on personal opinions, interpretations, points of view, feelings and judgment (Bertram & Christiansen, 2014). The audio-recording device was used during the interview for validity of data generation since this enabled greater accuracy of transcripts (Bertram & Christiansen, 2014). Analysis of the focus group interview was in relation to the semi-structured interview and reinforced the credibility of the research findings.

### **3.11.2 CONFIRMABILITY**

Confirmability is the way the researcher addresses influences or biases in the research (Rule & John, 2011) and it is the neutrality or the degree that findings are consistent and repeatable (Connelly, 2016). Qualitative researchers keep detailed notes of all their decisions and their analysis as it progresses. In some studies, these notes are reviewed by a colleague; in other studies, they may be discussed in peer-debriefing sessions with a respected qualitative researcher (Polit & Beck, 2014). These discussions prevent biases from only one person's perspective on the research. Also, depending on the study, the researcher may conduct member-checking with study participants or similar individuals to check whether the feedback is similar. This researcher used rich, thick description to report the findings to give the reader a clear picture of the natural setting (site) to create an element of a common understanding of experiences (Creswell, 2009). The researcher also used direct quotations from the participants to maintain confirmability. The desire of this researcher to indicate biases in terms of issues of personal background like gender, culture, history and socio-economic position added the element of honesty and openness and the willingness to provide negative and discrepant details (divergent views), which in turn strengthened the credibility of the study (Creswell, 2009).

### **3.11.3 DEPENDABILITY**

Dependability refers to the stability of the findings over time and the conditions of the study (Anney, 2014; Connelly, 2016; Polit & Beck, 2014). It is similar to reliability in quantitative research, but with the understanding, that stability of conditions depends on the nature of the study. Lincoln and Guba (1985) emphasise "inquiry audit" (p. 317) as one measure which might enhance the dependability of qualitative research. This can be used to examine both the process and the product of the research for consistency (Hoepfl, 1997). Therefore, participants were involved in evaluating the findings, in other words, completing an "inquiry audit",

Dependability was ensured by making certain that all the processes involved within the study were reported in detail, thereby enabling a future researcher to repeat the work, if not necessarily to gain the same results (Shenton, 2004).

#### **3.11.4 TRANSFERABILITY**

Transferability in qualitative research is concerned with the extent to which the findings of one study can be applied to other situations with similar characteristics (Anney, 2014; Polit & Beck, 2014). Qualitative researchers focus on the informants and their stories without saying this is everyone's story. Researchers support the study's transferability with a rich, detailed description of the context, location, and people studied, and by being transparent about analysis and trustworthiness (Connelly, 2016). Researchers need to provide a vivid picture that will inform and resonate with readers (Amankwaa, 2016). Hence, it is up to the reader to decide whether conclusions arrived at for this study about geography teachers' perceptions of paper-based GIS implementation in a rural ecology may be transferred to similar settings.

Since the findings of qualitative research are specific to particular environments and individuals, it is impossible to generalise (Shenton, 2004). Although each case may be unique, it is also an example within a broader group and, as a result, the prospect of transferability should not be immediately rejected (Lincoln & Guba, 1985). Therefore, the researcher ensured that sufficient contextual information about the fieldwork rural ecology was provided to enable the reader to make such a transfer.

#### **3.12 ETHICAL CONSIDERATIONS**

Ethical considerations are important in qualitative research as this approach often intrudes on participant's lives (Flick, 2009). Principles of research ethics ask that researchers avoid harming participants involved in the process by respecting and taking into account their needs and interests (Khan, 2014). For this reason, it is the moral and professional obligation of the individual researcher to be ethical even when research participants are unaware of or unconcerned about ethics. Some general ethical issues in research are as follows: never cause unnecessary harm to participants, secure prior voluntary consent when possible and never

unnecessarily humiliate, degrade, or release harmful information about specific individuals that were collected for research purposes (Khan, 2014).

Research permission was requested from the Department of Education to interview geography teachers in selected schools within the Province of KwaZulu-Natal. The researcher requested for research permission from the school principals as gatekeepers through permission letters. The letters made the principals aware of the research that was going to be conducted in their domain. The researcher also went through the UKZN ethics application to avoid harm against participants. According to Murphy and Dingwall (2001), it is the responsibility of the researcher to respect the autonomy of all participants; this means that research participants' values and decisions should be respected. Before approaching participants for interviews were given permission letters individually requesting their consent to take part in the study. All participants participated voluntarily and held a right to withdraw at any time (Bertram & Christiansen, 2014). The consent letter that was provided to the participants also included the following: willingness to be interviewed and consented to the use of audio equipment during the interview.

To avoid any kind of identification of individuals, the confidentiality of the participants was guaranteed by using pseudonyms for the schools and participants. This is called non-maleficence according to Bertram and Christiansen (2014), where harm is avoided to those involved in the research. The researcher motivated participants to share their past experiences of implementing paper-based GIS in their classrooms but did not specify participants' names or school names in the data presented.

### **3.13 LIMITATIONS OF THE STUDY**

Limitations are hindrances that the researcher encounters while generating and analysing data (Maree, 2007). Hence, it is significant for the researcher to highlight limitations to make the reader aware of how the researcher arrived at the conclusions. The use of a case study research methodology was limiting in a sense that it allows for the selection of a small geographical area and it is very limited in the number of individuals used as the subjects of study. For this reason, Cohen et al. (2001) hold a view that no specific person can possess detailed knowledge of anything more than the particular section of society in which he participates. This implied that the participants of this research study might have provided findings based on their experiences

related only to their context. Therefore, findings are restrained from being generalised to other contexts as different contexts and subjectivity result in multi-layered realities about events. According to Connelly (2016), convenience sampling allows researchers to complete interviews or get responses in a cost effective way, however, they may be criticised for the biased selection of the participants because of the differences in the target population.

### **3.14 CHAPTER SUMMARY**

This chapter presented the research design and methodological processes that were utilised in the study. The chapter began by providing detailed discussions of qualitative design, research paradigm, and case study methodology. The research design and methodological processes that were utilised in the study were presented. The chapter went on to discuss the research methods, namely: sampling methods, data generation methods and data analysis methods. In data generation methods, the chapter presented semi-structured interviews and focus group interviews. The data analysis utilised both deductive and inductive approaches. Finally, the issues of trustworthiness and ethical considerations were discussed. The next chapter presents the research findings and discussion.

## CHAPTER FOUR

### RESEARCH FINDINGS AND DISCUSSION

#### 4.1 INTRODUCTION

The previous chapter presented the research design and methodology adopted in this study. In this chapter, the data is presented and discussed. Data was used for capturing the four geography teachers' perceptions of paper-based GIS implementation in rural learning ecologies. The chapter presents the findings from the study, according to the subthemes that emerged. This section presents a discussion of some key findings that emerged in the study, linking these to the literature, and the theoretical framework indicated in the study. The data generation tools used in this study were semi-structured interviews and focus group interviews. The findings are presented as themes, that the researcher generated using a combination of deductive and inductive approaches.

#### 4.2 PROFILE OF PARTICIPANTS

Below I present the profiles of participants in tabular form. The names of participants were anonymised by the use of pseudonyms for confidentiality reasons.

##### *Profile of participants*

<b>NAME OF PARTICIPANT</b>	<b>GENDER</b>	<b>AGE</b>	<b>QUALIFICATIONS</b>	<b>SUBJECT TEACHING</b>	<b>YEARS OF TEACHING EXPERIENCE</b>
Billy	Male	28	Bachelor of Education	Geography	07
Duncan	Male	30	Bachelor of Education	Geography & Life Sciences	09
Gale	Female	38	Bachelor of Education	Geography	10
Mario	Male	32	Bachelor of Education	Geography	08

*Table 4.1: Profile of participants*

### **4.3 PAPER-BASED GIS CHALLENGES IN A RURAL LEARNING ECOLOGY**

The participants in the study revealed that there were challenges with regards to paper-based GIS implementation. The challenges that are presented emerged from data generated from the participants. These sub-themes of paper-based GIS implementation challenges include inadequate teacher training, lack of information, resources and financial constraints, lack of teaching time, poor facilitating conditions, and complex paper-based GIS concepts. Below I discuss these challenges in detail:

#### **4.3.1 INADEQUATE TEACHER TRAINING**

The lack of proper teacher training for geography teachers seems to be one of the major impediments for the implementation of paper-based GIS in rural learning ecologies. The responses of Duncan, Gale, and Mario reveal that they were never taught GIS at the secondary school. Billy indicated that he was introduced to GIS at both secondary school and at a tertiary institution. Duncan, and Mario admitted to having been exposed to GIS at the tertiary level, although it was difficult for them since they were not introduced to it in the secondary school. However, Gale had never been introduced to GIS in either the secondary school or the tertiary institution. As a result, she experienced difficulties regarding paper-based GIS in her rural learning ecology.

Duncan noted that when he matriculated in 2004, the Department of Basic Education was still making preparations for GIS implementation in secondary schools. Duncan also revealed that although he studied GIS at the university, he was introduced to GIS under the Bachelor of Science (BSc) course and that it was different from the GIS he was expected to teach at the secondary school. Duncan (semi-structured interview) expounds:

*“...I am a very old man. Back then when I was still in school there was no GIS. So, I was never taught GIS. I only heard about GIS when I started working here. I completed my matric in 2004 and the department of education was still pregnant with GIS. At tertiary level I only did GIS in BSc but it is very different from this GIS.”*

Furthermore, Duncan adds that the Department of Basic Education is not doing enough to train geography teachers to improve GIS implementation in schools. Duncan (semi-structured interview) explains:

*“The department of education is doing something in staff developing teachers through workshops but it is not enough. That is the problem now because they would be taking teachers to workshops where we are taught about GIS and how to interact with GIS but that is not enough because...problem lies on when we trying to teach the learners. I think for the department their hands are also tight...but they are trying to give us some literature we can study.”*

In a similar way to Duncan, Mario also matriculated in 2007. As a result, he was not introduced to GIS at the secondary school level. However, Mario claims that at the university level, GIS was taught to him in detail. Mario (semi-structured interview) expounds:

*“I was not taught GIS at secondary school. I matriculated in 2007 and GIS was not there in matric by this time. I think it arrived in 2008. The time I was exposed to GIS it is when I went to university. During my second year at the university..., I did an introduction to GIS and it was taught in detail.”*

Mario further outlined that the Department of Basic Education used to coordinate workshops in which GIS was taught. However, in recent years, the department complained about a lack of funds. As a result, schools are experiencing challenges of implementing paper-based GIS. Mario (semi-structured interview) explains:

*“Previously, the department of education use to give us workshops, but now the department keeps on saying it does not have money to conduct workshops...they must give us workshops so that we can teach our learners GIS properly.”*

Billy revealed that although he was in grade 10 when GIS was introduced to him in 2006, his teachers lacked confidence owing to the fact that they lacked training themselves because GIS was still new to them since they were not taught at school. Billy also pointed out that there was a module he did at university that included GIS, however, it was different from the GIS he was expected to teach in school. Billy (semi-structured interview) explains:

*“Yes, fortunately for me when GIS was introduced in 2006 I think that is when I was in grade 10...I was amongst the first group but also if you look at it, being taught by a teacher that has never been exposed to GIS...I can also now say that even my teachers were also not confident enough to teach us that new section of GIS until we got to grade 12. Then in university, there was a module where we did part of GIS even though it was so far away from what we actually get to do in schools with learners.”*

Billy stated that although geography teachers get invited to attend GIS content workshops, they do not gain much information. He stated that this is because younger teachers end up assisting the teaching of GIS in the workshops which then leaves them undeveloped because of not gaining the additional information that they need. Billy (semi-structured interview) clarifies:

*“...you find that there is nothing much that you get from these workshops we asked to attend, the younger teachers end up taking over because you find that we have more information than what the department has prepared for us...So it is more like we end up not getting developed.”*

In a similar way to Duncan and Marion, Gale was not taught GIS at the secondary school because she completed matric long before GIS was introduced into the schools. Gale also added that although GIS was taught at the tertiary level, she chose not to take the course in GIS because she was trying to minimise her tuition costs and it was not compulsory to take the course. As a result, this led to her not being introduced to GIS at the tertiary level. Gale (semi-structured interview) explains:

*“I completed my matric in 2002 and I was not taught GIS in school. GIS was there at tertiary when I was studying even though I chose not to do it because it was not compulsory to do it. If I were to do it at tertiary it had financial implication, so I ended up deciding not to do it.”*

Unlike Duncan, Marion, and Billy, who referred to geography workshops as playing a role in training teachers about GIS still perceived DBE as not doing enough; Gale never highlighted DBE involvement in teacher training. However, she admitted that, when she was faced with challenges in teaching paper-based GIS, she approached her departmental head for assistance but it was not enough. She further stated that in some instances she had to consult a peer teacher

from another school to help teach paper-based GIS to her learners. Gale (semi-structured interview) expounds:

*“The first person that I usually consult is my HOD when I experience challenges in teaching GIS. He usually explains but at times it is not enough. I further request Mr Xolo from one of the neighbouring schools to assist me in teaching GIS.”*

From the above extracts, it is apparent that one of the paper-based GIS challenges for geography teachers in rural learning ecologies is the lack of proper teacher training. This finding resonates with the sentiments of Mzuza and Westhuizen (2019), they point out that the low intake of trainees/ students at tertiary level results in a limited number of GIS-qualified teachers, which in turn results in GIS not being taught widely in schools. Furthermore, many teachers do not have the necessary GIS skills and experience due to a lack of in-service training and rapid technological changes. Ayorekire and Twinomuhangi (2012) and Musakwa (2017) also corroborate this finding and they point out that the unavailability of teachers experienced enough to teach GIS is a common problem in Africa. The training process helps geography teachers in ensuring that they have a team of teachers that is effective at their work. This is supported by Mzuza and Westhuizen (2019) who attest that geography teachers with excellent GIS training are likely to produce quality work in GIS implementation.

#### **4.3.2 LACK OF INFORMATION**

The lack of information was raised by the participants as another obstruction that is challenging the implementation of paper-based GIS in a rural learning ecology. Duncan, Mario, and Billy revealed that they perceive DBE lacking support in providing teachers with the necessary GIS information.

Duncan revealed that the paper-based GIS that teachers teach to learners is very different from what is tested by examiners under the GIS section. Duncan explained that this is because teachers are not provided with proper guidelines on how the GIS section will be tested in the exam. Duncan (semi-structured interview) explains:

*“Lack of proper guidelines provided by the department of education to teachers as to how GIS question paper is going to be set.”*

In line with Duncan, Mario stated that the GIS information is lacking in teachers because the DBE does not ensure that all teachers are equipped in implementing paper-based GIS in rural learning ecologies. Mario described that novice teacher seems to be more clued up in GIS than their counterparts. He revealed that this was because these teachers had already been exposed to GIS at the secondary school and university-level. According to Mario, some older teachers were out of the secondary school system and others were already in the field teaching when GIS was first introduced. Mario (semi-structured interview) point out:

*“The new teachers seem to have the information on GIS than the old teachers who were already there in schools teaching us, they do not have that much information in GIS and some of them just pass the topic without teaching it. This is because they cannot teach something they do not know because the department is not assisting us.”*

Along with similar sentiments as Duncan and Mario, Billy indicated that due to the failure of DBE to provide teachers with needed information, he resorts to other options such as requesting geography teachers from other schools to share information they have developed on their own. He then further develops the information he received from these teachers for the benefit of his learners. Billy only pointed out the DBE assistance in information provision when they issue topographic and orthophoto maps that are received for the grade 12 examination; however, these maps end up being utilised in the lower grades for teaching and learning of paper-based GIS. Billy (semi-structured interview) explains:

*“There is no enough information ... It has to be myself, I have to phone people and also colleagues that I have seen having the database and also having this information on their laptops and cell phones. So we do share information then I take there and there and develop my own that would work better. The department of education only provide maps and even those maps we get them from the grade 12 examination which come as a problem for me because learners would be exposed to common paper exam to as early as grade 10 in other subjects such as Maths and Sciences ...”*

Gale revealed that the lack of support from the DoE means that she ends up teaching her learners paper-based GIS theory only. This creates difficulties for both her and the learners because she has to explain in a way that would enable learners to imagine what she is teaching in order for them to understand. Gale (semi-structured interview) comments:

*“... I teach GIS as theory by using textbooks and maps; there is nothing that we do practical. It is just theory and make learners use their imagination of something they do not even see.”*

From the above extracts, it is evident that geography teachers perceive DBE as having the role of providing teachers with information. The above extracts are also in agreement with the findings of Akinyemi (2015) who reveal that paper-based GIS implementation in the classroom is very often hampered by the limited availability of useful data. Akinyemi (2015) states that this is because making maps as well as updating them is a costly and time-consuming activity, therefore, detailed and current maps are scarce. Furthermore, Gale highlights that she only teaches the theoretical part of paper-based GIS utilising textbooks and maps. This agrees with the findings of different researchers (Loveluck, 2012; Raselimo & Mahao, 2015; Selepe, 2016) who found that many schools offer theoretical rather than practical (hands-on) teaching of GIS, mainly because the teachers themselves do not understand the content and do not have the know-how to present the content and improve their learners' understanding. It seems that the lack of computers, GPS gadgets, and internet connectivity, compounds the problem when it comes to hands-on teaching of GIS.

#### **4.3.3 RESOURCES AND FINANCIAL CONSTRAINTS**

Resources are viewed by Mzuza and Westhuizen (2019) as all the necessities required for implementing GIS in schools, including the needed tools such as computers, software, hardware, internet access, and maps. These are lacking in schools because they demand huge financial resources, which is a serious problem in many African countries (Bearman et al., 2015, 2016; Breetzke et al., 2011; Musakwa, 2017; Skelton, 2014). This is evident in Duncan and Billy's responses. First, Duncan stated that his school does not have all the required resources to even teach paper-based GIS well. As a result, geography teachers are faced with difficulties in teaching and learning of paper-based GIS because learners have to use their minds in trying to understand the GIS content. Duncan (semi-structured interview) explains below:

*“In my school, I do not have all the resources, I am currently only using maps. Especially when you are dealing with data layering and you have to explain to learners that no this is a layer of drainage, this is a layer of vegetation. It is all*

*in the mind but it is not practical. You create some sort of a vision instead of using...transparencies for data layering. I even draw on the chalkboard trying to explain data layering but it is not the same as using transparencies because learners would be having a first-hand experience.”*

Billy agrees with Duncan in stating that there are inadequate resources at his school for teaching GIS properly. This makes it difficult to teach paper-based GIS or practical GIS because there are learners who do not even have the idea of what a computer is. Billy (semi-structured interview) articulates:

*“There are not enough resources and also the learners that we working within schools which is a rural school, you find that they do not have a complete idea of a computer...We are using maps as a way of trying to indicate how GIS works in computers. GIS requires a lot of resources and they are expensive.”*

Mario also expressed that there is a lack of computers in his school, and thus he is forced to teach GIS without the benefit of utilising computers. Mario believed that the school must buy computers for learners because DBE provides the schools with funds. Mario (semi-structured interview) echoes:

*“... secondary schools are doing paper GIS because there is more use of papers and less use of computers. Myself and my learners, we never used computers in teaching and learning of GIS...the school must use the money allocated by the department of education to buy at least 20 computers for the teaching and learning of GIS...”*

From the above extracts, it appears that Geography teachers do not have all the resources they need to implement GIS. This causes learners to learn about GIS without utilising computers. Mzuza and Westhuizen (2019) have similar sentiments and they reveal that despite being ahead of other African countries, South Africa also experiences a shortage of teaching and learning resources, including tools such as computers, GIS software, and geographic data. This is consistent with Dasgupta and Gupta (2008) who state in the UTAUT theory that poor facilitating conditions and lack of resources such as needed hardware, software, and electricity in the rural learning ecologies negatively affect the implementation of GIS. Therefore, teachers may develop negative attitudes towards the implementation of GIS because of feeling uneasy about effectiveness when teaching it to learners.

The availability of funds is linked to the shortage of resources in rural learning ecologies. Financial constraints are the cause of many schools in Africa not having enough computers to install either ArcGIS or QGIS software for teaching and learning purposes (Bearman et al., 2015, 2016; Breetzke et al., 2011; Musakwa, 2017; Skelton, 2014). The government and non-governmental organisations nevertheless strive to support GIS in secondary schools, and they supply additional resources such as computers and monetary support (Lehner et al., 2017; Rust & Sweidam, 2008). However, according to the participants above this has never been the situation in their schools. Such a shortage of aids (such as computers), makes it difficult to provide effective practical exercises for the learners. Most students are, therefore, forced to simply memorise the theoretical content (Loveluck, 2012) to pass the exam, but they cannot manage real-life situations in the field.

#### **4.3.4 LACK OF TEACHING TIME**

The lack of teaching time seems to be another challenge hampering the implementation of paper-based GIS in a rural learning ecology. Duncan and Mario believe that paper-based GIS is not given enough time in schools. Duncan revealed that learners in rural learning ecologies struggle in many ways when they are taught paper-based GIS due to the lack of resources used in GIS as well as not having English as their mother tongue. Duncan (semi-structured interview) articulates:

*“...GIS is a challenge because you will spend more time busy trying to explain to learners. Whilst I think those teachers who are in urban area schools maybe they will spend less time just explaining and going through. But I will have to take a whole hour trying to explain what hardware is, what a scanner is, so that why it is more challenging.”*

Similarly, Mario expresses that there is a lack of paper-based GIS teaching time and further echoes that geography teachers usually teach paper-based GIS in a rush when examinations are about to be written. As a result, learners are exposed to very limited GIS information. This causes learners to be only introduced to a summary of what there is in the actual GIS. Mario (semi-structured interview) echoes:

*“GIS is not given enough time. We teach GIS only when learners are about to write the exam. We teach, rushing through, without teaching properly and allowing more time to learners...The learners are only given an introduction or*

*a summary of what is there in the actual GIS...So, it is not given that much time it is supposed to be given. If possible, it is important for the department of education with the department of geography to introduce a GIS subject in schools so that learners can be given more time to explore more on GIS.”*

From the extracts above, we learn that sufficient time is key to the implementation of paper-based GIS in rural learning ecologies. This finding resonates with Fleschmann and Westhuizen (2015) who they point out that time is significant for many reasons in GIS, such as the time required for teachers to attend professional development (PD) workshops to learn the necessary GIS software; the time required to develop or modify instructional materials supported by GIS; as well as the time required in the curriculum of geography subject to effectively teach learners about the technology. Tarisayi (2018) explains that time constraints in the teaching of GIS in South Africa stems from the CAPS allocation of only four hours per week to teaching geography. It can be argued, as a result, that geography is viewed as an elective in the CAPS curriculum since it has been allocated inadequate time.

The teaching of GIS becomes theoretical without any exposure to the technical and practical aspects of GIS, which is more time consuming. Furthermore, time constraints also have implications on staff development as geography teachers lack the time to attend GIS workshops and training (Breetzke et al., 2011). Thus, the implementation of paper-based GIS requires more time than that is allocated by DBE in the CAPS curriculum for geography. Adequate time may ensure teachers and learners to accept and implement paper-based GIS in the rural learning GIS.

#### **4.3.5 POOR FACILITATING CONDITIONS**

The poor facilitating conditions emerged as one of the impediments in rural learning ecologies for GIS. The participants' responses revealed that although there is the availability of electricity in their rural learning ecologies, there is a lack of technical support and computers. Duncan revealed that technology is the problem in his rural learning ecology. Therefore, he teaches learner paper-based GIS even though GIS is more computer-based. Duncan (semi-structured interview) articulates:

*“...this GIS section is the most challenging one because it is more computer-based whilst in these areas, we are teaching in more rural areas. So, when you*

*are dealing with learners who do not know how to use a computer and you are teaching them about software. So, they do not know what software is, it like they are clueless... So, the problem is with technology. Maybe GIS is very good for learners in countries where there is high technology. I think in those countries maybe GIS is one of the easiest subjects because it is more practical but to use it is very difficult...*”

Similar to Duncan, Mario responded that there are not enough computers for all the learners in his rural learning ecology and therefore, he has never taught GIS utilising computers. Mario (focus group interview) laments:

*“The learners that I teach and myself never use computers in teaching and learning of GIS because the available computers cannot accommodate all learners.”*

Similar to Duncan and Mario, Gale also attested that computers are absent in her school. According to her, this has deprived learners of an opportunity to do GIS utilising computers. Gale (focus group interview) states:

*“...learners who have not been exposed to the practicality of computer-based GIS because computers are lacking in my school”*

From the above extracts, it appears that a lack of ICT and adequate infrastructure plays a huge role in GIS implementation in rural learning ecologies. Along the same lines, findings of Musakwa (2017) and Rust (2008) point out that inadequate infrastructure in some secondary schools challenges many African countries, especially in remote areas. Some schools do not have enough classrooms and computer laboratories, which is not conducive to effective learning of GIS in rural learning ecologies. Therefore, to ensure that GIS is well implemented in schools, there is a need to provide schools with the necessary infrastructure and ICT facilities (Akinyemi, 2015). According to Mzuza and Westhuizen (2019), the government efforts in providing facilities are not in direct response to the specific needs of implementing GIS in schools but as a necessity to create an enabling environment for the uptake of ICT in schools. This means that although the government might assist in ICT support in schools, technical support such as software required to teach GIS will still be lacking in schools.

The study has established that poor facilitating conditions are related to the acceptance and use of technology in the UTAUT model. The UTAUT model explicates that facilitating conditions is the degree to which teachers believe that technical infrastructure exists in rural learning ecologies to support the use of GIS (Gupta, Dasgupta, & Gupta, 2008). Therefore, the poor facilitating conditions are based on the already existing theory of UTAUT model and serve as an explanation as to how the lack of necessary infrastructure and ICT facilities challenges the implementation of GIS in rural learning ecologies (Liebenberg et al., 2018). This is evident in my study where geography teachers expressed that there is a lack of computers which hinders the implementation of GIS in their rural learning ecologies.

#### **4.3.6 COMPLEX PAPER-BASED GIS CONCEPTS**

The complexity of paper-based GIS concepts stood out in certain geography teachers' interviews as one of the obstacles for the implementation of paper-based GIS in rural learning ecologies. The responses of Duncan and Billy show that this complexity is a result of having learners who utilise English as their first additional language and not their mother tongue.

Duncan noted that the paper-based GIS concepts are difficult for the learners to understand. He states that this is because paper-based GIS requires someone who has a better understanding of English as a language to easily grasp the GIS concepts. He further explained that he ends up spending more time trying to describe the paper-based GIS concepts so that his learners understand because they are English second speaking learners. Duncan (semi-structured interview) expounds:

*“... The complexity of GIS concepts need learners who have a better understanding of English as a language...you will spend more time busy trying to explain to learners.”*

Similarly as Duncan, Billy also viewed paper-based GIS concepts as challenging to his learners. Although Billy understands that the complexity of concepts as a challenge is caused by the language barrier, he further revealed that this impediment is made worse by the fact that the learners do not take mathematics and physics, which at times incorporate some of the same concepts used in GIS. Therefore, it becomes even more difficult for learners because they only

get to hear about these concepts in the geography curriculum. Mario (semi-structured interview) expounds:

*“...if you look at GIS even though we are basing our teaching on paper-based GIS, there are a lot of concepts learners have to understand for them to have a broader understanding of GIS. My learners are only doing life sciences, agriculture, and maths literacy so they find it very challenging because most GIS concepts are taken from what would have been done in mathematics and physics studies.”*

From the extracts above, we learn that language is another issue impeding learners' understanding because of the complexity of paper-based GIS concepts in rural learning ecologies. Drawing from the literature, Hlalele (2014a) notes that a rural learning ecology consists of learners who speak English as their first additional language because it is not their mother tongue. Therefore, paper-based GIS concepts may be complex to such learners. Resultantly, learners in rural learning ecologies may not understand and accept paper-based GIS. It is also evident that misunderstanding may be worsened if subjects are not integrated. This is because learners tend to learn about paper-based GIS concepts for the first time in the geography subjects. After all, they are not utilised in other subjects that they normally study.

#### **4.3.7 IMPROPER PAPER-BASED GIS EXAMINATION PAPER SETTING**

Duncan and Mario lamented that they are not happy with the way GIS part as set in paper two. Both participants pointed out that the examiners do provide teachers with proper guidance as to how the part will be assessed. Mario added that GIS is not allocated adequate marks in papers and this should also be investigated. Duncan, on the other hand, further complained about the complexity in the level of questioning, stating that examiners ask more practical questions, whereas he perceives questioning as something that is supposed to be textbook-based due to the lack of resources in rural learning ecologies. Duncan (semi-structured interview) comments:

*“... and also the problem is with the guys in the exam section. When they set questions, they are different from those we teach. They are more practical, whilst they are supposed to be asking questions that are more textbook-based*

*because they have the understanding that the level of technology in our schools is not the same.”*

Duncan reveals that the approach examiners use in setting paper-based GIS in examinations often causes learners to obtain lower marks in this section compared with any other section. He further commented that in the past GIS questioning was simpler than it is recently. He, therefore, perceived paper-based GIS as requiring a good understanding of English for learners to be successful in answering questions. Duncan (semi-structured interview) laments:

*“Hence, you will find that learners in paper two, learners pass question 1, 2, and 3, but when it comes to question 4, which is GIS now learners are failing. So, one thing is that when we started GIS it was simpler, the level of question was fine. In terms of level one, learners were able to try answering but now even level one is more complex you need learners who have a better understanding of English as a language.”*

Again, Duncan advised that guidance provision by examiners is crucial considering that rural learning ecologies are doing the curriculum that includes paper-based GIS. Duncan (semi-structured interview) advises:

*“... When they included GIS, they were supposed to provide specified guidelines to say these are the type of questions that I might ask GIS is not like geography that had been there for many years. They were supposed to give us the scope that says these are the questions we are going to be asking from taking into account that these learners are disadvantaged in terms of the technology and language.”*

Similarly, Mario also advised that examiners should seek assistance from ESRI South Africa on how to structure GIS questions. Mario also viewed guidance from examiners to geography teachers as crucial with regards to how the GIS questions are going to be structured. Mario also revealed that marks allocated for GIS questions are not adequate: Marion (semi-structured interview) laments:

*“The questions are not asking learners more. When the map work papers are set, in March, GIS only covers 5 marks, 15 marks in June, 15 marks in September, and 15 marks in the final examination. I am also not happy with the structuring of questions because what we teach in class is not normally asked*

*in question papers. They ask very little from what we taught learners in class. Maybe if the examiner could ask for guidance from ESRI South Africa on how to structure questions, it could assist.”*

From the above extracts, we are learning that these teachers need proper guidance from examiners regarding the way paper-based GIS questions are going to be set. According to the participants, this is because examiners tend to be more practical, whereas geography teachers in rural learning ecologies rely mainly on the textbook in teaching GIS. Breetzke et al. (2011), Eksteen et al. (2012), and Mzuza and Westhuizen (2019) confirm that one of the problems identified in South Africa relates to inadequate practical experience in the use of GIS by teachers. Also, paper-based GIS is not allocated sufficient marks when tested in question papers. Therefore, Mario advised that the examiner should approach ESRI for assistance as they are experts in the field of GIS. According to Breetzke et al. (2011) and Eksteen et al. (2012), paper-based GIS was introduced by ESRI South Africa for resource-poor schools. For this reason, ESRI South Africa would be in a better position in advising examiners on how to structure questions and to focus more on GIS when setting question papers.

#### **4.4 PAPER-BASED GIS INCLUSION IN THE GEOGRAPHY CURRICULUM**

All participants in this study perceived that including paper-based GIS in the geography curriculum is good. Mario and Gale's responses expressed that geography is more relevant than any other subject when it comes to GIS because the subject focuses on the environment and maps. All participants commented that although paper-based GIS was meant to expose learners to technological skills by learning geography using computers, the problem is the lack of resources. Duncan mentioned that it was good to include GIS in the geography curriculum. However, the problem is with the implementation process due to the lack of resources in rural learning ecologies. Duncan (semi-structured interview) elucidates:

*“It was a good idea to include GIS in the geography curriculum but the problem is with the implementation...Shortages of maps, lack of good resources so that is very discouraging sometimes because you want your learners to be performing at their best and you want to see the succeeding but when you do not have resources especially in GIS because it is more practical than the other sections. GIS practicality must be accommodated with resources.”*

Again, Billy expressed that there is a lack of resources in rural learning ecologies. He further alluded that the main reason for this is because needed resources are expensive to purchase. For the above reasons, he feels that learners are struggling with learning and understanding GIS. Billy (semi-structured interview) explains:

*“It’s ok, it is an enjoyable section but I think they were supposed to have a better introduction of GIS because first thing GIS requires a lot of resources and also these resources are expensive. If you think of a learner in a rural school, they do not have so much of exposure, even the gadget in the school that I am teaching at, learners are not allowed to have cell phones at school where we can make a bit of example from, so those are some of the challenges.”*

Similarly, Mario also stated that it was a good idea to include GIS in the geography curriculum. He justified this by pointing out that Geographic Information System as a concept includes the word geography. He further elaborated that both GIS and geography focus on the environment and GIS serves as a way of coming up with solutions to various environmental problems. Mario (semi-structured interview) elucidates:

*“Including GIS in geography was the best thing that was done because the concept GIS says “Geographic Information System” so by saying geographical it means there is the inclusion of geography which means that there are methods of geography that were used in the collection of information, that is why it is important for GIS to be taught in the geography subject. GIS is geography because geography deals with the natural environment and it talks about people and so does GIS. People affect the environment and GIS is there to ensure that people do not affect the environment negatively.”*

Mario added that GIS can solve environmental problems and geographical problems because of utilising certain strategies to do so. Mario (semi-structured interview) explains:

*“By looking at different strategies, what can we do on the environment that is already affected by the people GIS can also assist people whenever they cannot access a particular area; people can use something like remote sensing to access a particular area. Politically, like in areas where there are political fights, so if the journalist cannot go there, you can use remote sensing to generate data.”*

In the same way as Duncan and Mario, Gale also revealed that GIS is good because learners are familiar with the use of technology. She assumed that the department of basic education viewed geography as a more relevant subject to include GIS since it deals with topographic and orthophoto maps. Gale (semi-structured interview) comments:

*“The inclusion of GIS in the geography curriculum was good because it makes learners familiar with technology such as computers, cell phones and so on. I think the department of education saw geography subject is being more relevant regarding GIS inclusion since geography deals with topographic and orthophoto maps. The department saw that it will be easier to teach GIS in geography since teachers and learners will be able to refer to maps that are already used in geography rather than taking a subject like life science because it does not use maps.”*

All the participants seem to support the DBE when it comes to including paper-based GIS in the geography curriculum. Breetzke et al. (2011) and Tarisayi (2018) attest that the National Curriculum Statement (NCS) for Grades 10 - 12 introduced GIS into South African schools as part of the geography curriculum from 2006 -2008. Kerski et al. (2013) also agreed that GIS is utilised more widely and effectively where geography has a strong place in secondary school education programmes (Kerski et al. 2013). However, according to Akinyemi (2015), in South Africa, problems relate to inadequate theoretical grounding and practical experience in the use of GIS by teachers, the inadequacy of ICT equipment, and poor infrastructure in schools (for example, lack of electricity). From the participants’ responses, we learn that introducing GIS into the geography curriculum was good. However, a lack of resources emerged as an issue disrupting the effective implementation of paper-based GIS.

#### **4.5 DEPARTMENT OF BASIC EDUCATION’S ROLE IN ASSISTING TEACHERS**

The responses by Duncan, Billy, and Mario expressed that the DBE does assist teachers in the implantation of paper-based GIS by coordinating the geography content workshop in which the teachers are shown how to teach the paper-based GIS to their learners. However, Billy revealed that younger teachers end up teaching paper-based GIS to teachers in these workshops meaning that these younger teachers do not benefit since they do learn anything new. Duncan

also pointed out that although DBE is doing something, but it is not enough because DBE relies on the literature for teaching the GIS, because of the lack of technology. According to Duncan the main problem is when teachers try to teach learners only utilising literature without any practical GIS. This is due to the fact that most of the teachers have never been exposed to computers or the GIS program. Duncan (semi-structured interview) points out:

*“The Department of Basic Education is doing something but it is not enough. That is the problem now because they would be taking teachers to workshops where we are taught about GIS and how to interact with GIS but that is not enough because we know GIS but the problem lies on when we trying to teach the learners. I think for the department their hands are also tied because they cannot do anything about technology, it is beyond their scope but they are trying to give us some literature we can study.”*

Again, as stated earlier, Billy attested that DBE is doing something but the problem is that younger teachers are used as facilitators in these workshops because it is believed that they understand paper-based GIS better than old teachers since they were exposed to GIS in secondary schools and at tertiary level. However, younger teachers then do not gain new knowledge from these workshops Billy (semi-structured interview) explains:

*“We have been invited in few content workshops but you find that there is nothing much that you get from these workshops we asked to attend, the younger teachers end up taking over because you find that we have more information than what the department has prepared for us, so those are the challenges. So it is more like we end up not getting developed.”*

In a different way from Billy, Mario advised that DBE should uses novice teachers as facilitators to expose other teachers to strategies they can implement in their classrooms when teaching paper-based GIS since the DBE lacks funds. Billy (semi-structured interview) comments:

*“Since the department of education does not have money, it can use the novice teachers because they were taught GIS at the university. Some of them got it in secondary schools and universities. So, if they can be able to get those teachers and use them, the department can be able to teach all the other teachers that were not exposed to GIS during their time.”*

From the above excerpts, there is evidence that DBE does assist teachers in the implementation of paper-based GIS through geography content workshops. This is consistent with the findings by Fleischmann and Westhuizen (2015), who point out that the GIS training programmes organised by DBE help teachers to learn how to help poorer schools without computers to implement GIS. The DBE used paper-based GIS to target schools with no computers or electricity access (Breetzke et al., 2011; Kerski et al., 2013). According to Wilmot and Dube (2016), workshops on teaching GIS in Grades 10 to 12 geography have been conducted in a piecemeal fashion, targeting curriculum advisers and only a few teachers. There have been some university-driven interventions, for example at the University of Pretoria, to support effective paper-based GIS teaching especially in poorly resourced schools (Breetzke et al., 2011). Therefore, it is clear according to participants and literature that workshops organised by DBE are inadequate due to their failure to fund these GIS programmes to introduce teachers to additional knowledge about the implementation of paper-based GIS in rural learning ecologies.

#### **4.6 NECESSARY RESOURCES FOR PAPER-BASED GIS IMPLEMENTATION**

This study found that geography teachers are unsure about the resources required for the implementation of paper-based GIS. All the participants were hesitant in providing straight answers to this question in their semi-structured interviews. However, it was evident from all the responses that topographic and orthophoto maps were perceived as dominant resources required for implementing a paper-based GIS lesson. Duncan revealed that the required resources include maps, transparencies, and pencils. He further stated that there should be separate maps that can be used to engage learners in classroom activities to help them prepare for the examination. However, Duncan lamented that resources are not always provided in the school he teaches because of the lack of funds. Duncan (semi-structured interview) made the following comment:

*“We should have maps, because you cannot do anything in paper two without maps to practise. Have additional maps where learners can draw and do other tasks when given activities. We also need transparencies, and pencils. At times you find that a teacher is asking for resources in a school only to find out that the school cannot afford to buy them and then as a teacher you end up saying let me just leave it.”*

Likewise, Billy also mentioned the significance of utilising topographic and orthophoto maps in implementing paper-based GIS. He further stated that atlases are also significant in helping to enhance learners' understanding of what is happening around the world. Billy (semi-structured interview) states:

*“Resources would be maps...I am currently using topographical and orthophoto maps...we also need atlases because learners also have this challenge of not understanding what is happening all over the world...”*

Moreover, apart from using maps in teaching paper-based GIS, Billy has also developed a database in which he teaches GIS components through demonstration with pictures to enhance learners' understanding. Billy (semi-structured interview) clarifies:

*...I have also developed a database where I get to expose these learners to see pictures of like a satellite, remote sensing etc., so if they see pictures then I think it works better for them.*

Billy explained that the database he developed was through his effort by communicating with his colleagues who were already employing this method. The DBE did not provide any assistance regarding his database. He pointed out the DBE only provides maps to be utilised in the grade 12 examination session and after the exam is completed, teachers take the same maps and use them to teach map work in Grades 10 to 12. Billy (semi-structured interview) laments:

*“It has to be myself, I have to phone people and also colleagues that I have seen having these gadgets and also having this information on their laptops and cell phones. So we do share information then I take there and there and develop my own that would work better. The Department of Basic Education only provides maps and even those maps we get them from the grade 12 examination which comes as a problem”*

Similar to Duncan and Billy, Mario expressed that the necessary resources for paper-based GIS implementation are transparencies and maps. He added that soft pens and overhead projector are other useful tools in applying paper-based GIS skills during teaching and learning. Mario (semi-structured interview) articulates

*“There must be some transparencies and maps. A school should own an overhead projector so that data overlaying can be done using transparencies*

*and overhead projectors. Soft pens are also required to draw lines, points, and polygon on the transparencies.”*

Mario revealed, however, that in the rural learning ecology he teaches, there is a lack of many paper-based GIS resources such as overhead projector and transparencies. He only employs the topographic and orthophoto maps when teaching. Mario (semi-structured interview) echoes:

*“My school does not have some of the resources like an overhead projector and transparencies. In my school, we teach learners using the orthophoto and topographic maps. I use orthophoto maps to tell my learners that this refers to a raster data then topographic map refers to a vector data. Then I give a reason as to why I am saying so. But, it is hard to teach because our school does not have the necessary resources.”*

Gale responded that computers are an additional resource that is needed for implementing paper-based GIS. Like all the above participants, Gale mentioned maps as an important resource. However, she only stated computers and maps without referring to other resources the way that Duncan, Billy, and Mario did. Gale seemed to struggle the most in stating the necessary resources for implementing paper-based GIS. Gale (semi-structured interview) echoes:

*“I think it is computers and maps; that is all I can think of. Not all learners have the resources I have just mentioned.”*

From the above excerpts, we are learning that topographic and orthophoto maps are dominating resources required for the implementation of paper-based GIS although all participants also mention additional resources. The additional resources mentioned by participants are transparencies, pencils, soft pens, computers, and overhead projectors. This is consistent with the findings by Antwi, Bansah, and Franklin (2018) who point out that a classroom should be furnished with some ICT facilities such as computers, projectors, and smartboards that are needed daily. Furthermore, in the same way as participants, Buabeng-Andoh and Yidana (2015) note that a paper-based GIS task such as involving searching for the best location to evacuate residents in the event of a flood can be completed with the aid of maps, crayons, and tracing paper.

The participants also revealed that the DBE only provides maps to be utilised in the grade 12 examination and after the exam is completed, the teachers take the same maps and utilise them to teach map work in Grades 10 to 12. This means that there can be a shortage of maps since they only accommodate the total number of learners who write the geography examination without taking into account that the same maps are going to be used for teaching map work to other learners. Therefore, this means that the school must buy additional maps should there be any shortages. According to Amosun (2016), the inequality of educational materials and resources, including the shortage of maps, textbooks, computers and other information technologies in schools is one of the major educational problems in South Africa. This is a challenge when teachers have to implement paper-based GIS in rural learning ecologies.

#### **4.7 SECONDARY SCHOOL EDUCATION ON PAPER-BASED GIS**

All the participants' responses expressed that these teachers were never taught paper-based GIS at secondary school, except for Billy. Duncan and Gale matriculated long before paper-based GIS was included in the curriculum and thus they did not learn about GIS at secondary school. Mario matriculated in 2007 and at that time paper-based GIS had already been included in Grade 10 and 11, but its introduction in matric was only done in 2008 when Mario was already at the tertiary institution. However, Billy, being the youngest of the four participants, was amongst the first group to be taught GIS at secondary school in 2006. Billy (semi-structured interview) explains:

*“...fortunately for me when GIS was introduced in 2006 I think that is when I was in grade 10, so I was amongst the first group but also if you think of it, being taught by someone that has never been exposed to GIS. So, when I look at it now from a teacher's perspective, I can also now say that even my teachers were also not confident enough to teach us that new section of GIS until we got to grade 12.”*

Contrary to this, Duncan stated that he matriculated in 2004 while the DBE was deliberating on the issue of including GIS in school. Thus, he was never introduced to paper-based GIS. Duncan (semi-structured interview) explains:

*...I am a very old man. Back then when I was still in school there was no GIS. So, I was never taught GIS. I only heard about GIS when I started working*

*here...I completed my matric in 2004 and the department of education was still pregnant with GIS.*

In the same way as Duncan, Mario and Gale stated that they were also not taught GIS at secondary school. Gale matriculated in 2002 long before GIS was introduced in the schools. Mario revealed that when he matriculated in 2007 paper-based GIS was already included in the lower grades but not in matric. Mario (semi-structured interview) clarifies:

*“I was not taught GIS at secondary school. I matriculated in 2007 and GIS was not there in matric by this time. I think it arrived in 2008.”*

Gale (semi-structured interview) elucidates:

*“I completed my matric in 2002 and I was not taught GIS in school.”*

From the extracts above, we learn that some of the challenges that geography teachers are faced with in implementing paper-based GIS in rural learning ecologies are made worse by the fact that they were not introduced to paper-based GIS during their school years. We also learn that learners are at times taught by teachers who lack a proper understanding of paper-based GIS. As a result, this affects those learners when they enrol at a tertiary institution and when they become teachers having to implement paper-based GIS. Mzuza and Westhuizen (2019) share the same sentiments by pointing out that if learners had been introduced to GIS at the secondary or primary school level, they might find the GIS much easier to learn and teach. In conclusion, learning the basics of GIS at school is paramount for learners to be able to cope at the tertiary level and in teaching it.

#### **4.8 TERTIARY INSTITUTION EDUCATION ON PAPER-BASED GIS**

All the participants' responses indicated that they were taught GIS at the tertiary institution except for Gale. Gale chose not to study the GIS module since it was not compulsory and had financial implications. Although Duncan and Mario studied GIS at the university, it was not specifically GIS in education and this made it very different from the type of GIS one would get in secondary schools. Billy is the only participant whose response showed that he was taught GIS in one of the modules he did at university when he was studying for his Bachelor of Education degree. Billy (semi-structured interview) explains:

*“Then in university, there was a module where we did part of GIS even though it was so far away from what we actually get to do in schools with learners.”*

Duncan was also introduced to GIS, but it was different as he was studying BSC. Unlike Billy, he was never introduced to GIS that was specifically for education. Duncan (semi-structured interview) points out:

*“At the tertiary level I only did GIS in BSC but it is very different from this GIS.”*

Similar to Duncan, Mario was introduced to GIS, but it was not in education. Mario studied Environmental Planning and Development, and he felt that he studied GIS in detail which assisted him as a teacher in the long run. Mario (semi-structured interview) expounds:

*“The time I was exposed to GIS it is when I went to university. During my second year at the university, when I was doing my second year at the university, I did an introduction to GIS and it was taught in detail. The course that I was doing at the university that led to me to be introduced to GIS was Environmental Planning and Development at the university.... This course has modules that include GIS.”*

Differently from Billy, Duncan, and Mario, Gale chose not to take up a module that incorporated GIS because of the financial implications. Gale (semi-structured interview) clarifies:

*“GIS was there at tertiary when I was studying even though I chose not to do it because it was not compulsory to do it. If I were to do it at tertiary it had financial implication, so I ended up deciding not to do it.”*

From the extracts above, we learn that some of the challenges that geography teachers are faced with in implementing paper-based GIS in rural learning ecologies are made worse by the fact that they were not introduced to paper-based GIS at tertiary institutions. It is also evident from the responses that although many teachers might have been introduced to GIS at the tertiary level, it was different from the GIS that was taught in school and this created challenges for the teachers. It is clear from the data that many teachers got exposed to GIS at university without being taught at a secondary school which created more difficulties for them. This is consistent with the findings of Mzuzza and Westhuizen (2019) who point out that university students

struggle to learn and master GIS content when their first exposure to GIS occurs at the tertiary level, and this often results in wide dislike of the course. Therefore, teachers who were never taught paper-based GIS in secondary school are not only likely to dislike GIS at university but and when they have to implement it in their schools as teachers.

#### **4.9 TEACHERS' UNDERSTANDING OF PAPER-BASED GIS**

The participants understand the intention of DBE for including paper-based GIS in schools. Billy and Gale are of the same view that paper-based GIS introduction in learning ecologies is due to the improvement in technology. Therefore, DBE is trying to introduce learners to computer skills. Mario's perception of paper-based GIS is closely linked to Billy and Gale because he also refers to improvements in technology. However, Mario expanded that paper-based GIS is implemented in schools as a way of preparing learners for the outside world as well as for the university level as GIS is also taught there. Duncan pointed out that DBE is trying to expose learners to an in-depth knowledge of maps. Duncan (semi-structured interview) articulates:

*“The Department of Basic Education tried to make learners have an in depth knowledge of maps. So, the Department of Basic Education is trying to use paper-based GIS as a way for better understanding maps, how they come about and all those processes involved in creating maps. So that when learners look at maps they don't just look at papers but must they have background information.”*

As stated earlier, Billy and Gale expressed that DBE introduced paper-based GIS because of global technological advancements. Gale further pointed out that learners are being exposed to skills of dealing with geography content utilising computers.

Billy (semi-structured interview) explains:

*“This section is being taught because of the improvement of technology.”*

In a similar fashion as Billy, Gale (semi-structured interview) echoes:

*“I think paper-based GIS is trying to introduce learners to computer skills and they are trying to relate geography content to the real world.”*

Similar to Billy and Gale, Mario attested that GIS is part of technology. Mario viewed paper-based GIS as a way DBE is preparing learners for university and the outside world. Mario perceives GIS as part of our daily lives in many ways. Therefore, he echoed that we cannot ignore the existence of GIS in our lives. Mario (semi-structured interview) elucidates:

*“Goal by the Department of Basic Education is that learners must be exposed to GIS at the school level because GIS is there at the universities and GIS is driving the world. So, without GIS in the world, we can go nowhere. Everywhere you go you need a navigator, navigation and technology is part of GIS. Even before the airplane moves it needs GIS. That is why the department felt that it is important to include GIS in schools.”*

Again, Mario stressed that whether or not teachers understand and teach paper-based GIS, it will always be there in the real world irrespective of the challenges they face. Thus, instead of ending the paper-based GIS curriculum under the notion that it is difficult, DBE should invest more money in ensuring that teachers grasp GIS content for the benefit of learners. Mario (semi-structured interview) clarifies:

*“...GIS will always be there in the outside world irrespective of whether teachers are failing to teach it or not. The Department of Basic Education must do something about this by opening more workshops, and use the money allocated to do more workshops and do other practical work done in geography. Even paper two as a whole, some teachers are failing to teach paper two.”*

From the extracts above, we learn that paper-based GIS was introduced in the geography subject in rural learning ecologies due to the increasing global trend to use technology for work with maps. Alibrandi and Palmer-Moloney (2001) state that most government agencies, utilities, industries with distribution networks, real estate, and travel agencies use GIS daily. Therefore, DBE felt that by introducing GIS in learning ecologies learners would be prepared for the outside world Tarisayi (2018) also points out the importance of preparing learners with paper-based GIS at the secondary school level for them to be able to cope with the topic at university.

#### **4.10 TEACHERS' ACCEPTANCE AND USE OF PAPER-BASED GIS IN THE RURAL LEARNING ECOLOGIES**

Teachers' experience and age as moderating effects in the acceptance and use of technology in the UTAUT model were analysed. The moderating effect of experience and age were employed to investigate whether geography teachers' experience and age influence the acceptance and implementation of paper-based GIS in rural learning ecologies (Muhsin et al., 2016). Experience and age moderating effects are dependent on self-efficacy, anxiety, and attitude in the acceptance and use of paper-based GIS. Therefore, the moderating effects were analysed focusing on the teachers' self-efficacy, anxiety, and attitude towards the acceptance and use of paper-based GIS.

##### **4.10.1 MODERATING EFFECT OF TEACHING EXPERIENCE IN IMPLEMENTING PAPER-BASED GIS**

All the participants' responses demonstrated that they struggled with paper-based GIS at the beginning because of being inexperienced. However, Billy, Mario, and Duncan commented that they had improved a lot in implementing paper-based GIS throughout their experience. Duncan commented that he was anxious because of being exposed to this GIS for the first time at a rural learning ecology. Through gaining experience in teaching paper-based GIS, his nervousness towards the acceptance and use of paper-based GIS faded away as he had mastered the section over time. Duncan (semi-structured interview) expounds:

*“At first it was very difficult to teach GIS I wouldn't lie. When I came to this school and saw this GIS I was shocked and I was like “what the heck is this now?” “what is GIS?”. I didn't know it. Luckily when I came in the first term I was teaching grade 10, at least I used to go home and study and realised that grade 10 GIS was not complex. But years went by and started having experience, I started improving and I mastered it. I learnt quickly.”*

On the other hand, Duncan explained that he now experiences difficulties because he views exam questions for the GIS section to be out of the range of learners. He further explained that although he teaches to the best of his ability to try and meet the exam standards, the level of questioning by examiners always increases. Duncan (semi-structured interview) expounds:

*“It is not the best experience to teach paper-based GIS in schools because you would find that when teaching learners, you try by all means to explain to*

*learners but in an exam, you find that questions would be on another level. I try catching up with the level of questioning in preparing my learners for the examination but it like the level of questioning always changes and goes up.”*

Similar to Duncan, but not based on the level of questioning in the examination, Gale is still experiencing difficulties in teaching GIS to the extent that she developed a negative attitude towards the GIS. Gale further elaborated that she prefers if someone else teaches the section for her. Gale at times invites Mario, who teaches in another learning ecology, to teach paper-based GIS for her. Gale (semi-structured interview) comments:

*“It was not easy to teach GIS in such a way that I ended up disliking it, but I managed to gain more knowledge through researching and learning textbooks within my journey of teaching GIS. Even now, I do not like GIS. If I had another way, I would give it to someone else to teach it while I deal with something else.”*

Similarly, Billy mentioned that he felt uneasy about paper-based GIS because of uncertainty about its implementation caused by his lack of experience. Billy was of the view that geography teachers that were already in the field teaching had a better view and understanding of paper-based GIS implementation. To his surprise, Billy discovered that although he was a novice teacher, he was more knowledgeable in certain paper-based GIS sections than other teachers’ although they have long been teaching in the field longer than him. This might have been caused by his experience of being taught GIS both at a secondary school and at a tertiary institution. Billy (semi-structured interview) articulates:

*“When I started teaching GIS I also did not have confidence as much as I do have now because you will always think that those ahead of you know a lot more than you but you will find that when you teaching there are sections you be stronger compared to your colleagues that have been there long before you.”*

Billy further elaborated that although he was a novice teacher, he was expected by other teachers in his rural learning ecology to teach paper-based GIS for them in their classrooms, yet they were more experienced (in how many years they had been teaching), than he was. Through his assistance, other teachers began to gain confidence in teaching paper-based GIS themselves. Billy (semi-structured interview) explains:

*“...I was that one teacher who was expected to move around in classes to teach paper-based GIS that was not even mine. Like grade 10 teacher, the GIS section was taught by myself until I assisted my colleagues then they started teaching that section. So I can say that I have actually improved.”*

In the same way as the other participants, Mario also found GIS challenging at the beginning of his teaching career because of lacking experience. However, because he was exposed to an in-depth introduction of GIS at the university, it assisted him in teaching paper-based GIS and he emphasised that even geography subject advisors noted that he is good in GIS. In addition, Mario emphasised that he had improved tremendously in teaching the paper-based GIS section. Mario (semi-structured interview) expounds:

*“At the beginning when I started teaching geography at a secondary school coming from the university, I was very surprised to discover that GIS was there because I was not taught GIS at a school level. So, it was a bit hard for me to teach GIS, but as time went by, the knowledge I obtained from the university assisted me a lot because at the university we were taught at a high standard about GIS. We were even taught how to draw maps and how to produce good maps. So, that assisted me in teaching GIS. So, over the years I have grown in teaching GIS. Even geography subject advisors noted that I am actually good at teaching GIS then they asked me to go and assist in other schools and I assisted. So, I have grown in GIS a lot.”*

Again, Mario pointed out that throughout his experience of teaching paper-based GIS, he had met teachers who display a negative attitude towards acceptance and use of paper-based GIS. He further stated that this is because they believe that it is challenging because they are inexperienced in teaching and learning paper-based GIS. However, Mario had a different view from his colleagues with regards to his acceptance and use of paper-based GIS. He has a positive attitude towards paper-based GIS implementation. Mario revealed that this might have been because of his exposure to the GIS section long before he became a geography teacher. Mario (semi-structured interview) comments:

*“Teachers I have met, have a negative attitude towards GIS. They do not want the teaching and learning of GIS because they believe that it is difficult. But I believe otherwise because of my exposure to GIS.”*

From the above extracts, it was evident that teachers were faced with challenges when they started implementing paper-based GIS in the rural learning ecologies. According to the participants, this was because paper-based GIS was new and they lacked experience, although some of them were exposed to GIS at the university. Along with the same sentiments, Wilmot and Dube (2016) note that many teachers are not well-versed in GIS. This is apparent from the fact that all, or many, candidates from an examination centre do not attempt to answer questions on GIS (DBE, 2015; DBE, 2016; DBE, 2018). Wilmot and Dube (2016) believe that this is because the fundamental knowledge of GIS is still lacking. This is consistent with the UTAUT model which explains that inexperienced geography teachers are more likely to face challenges towards accepting and using paper-based GIS in rural learning ecologies (Chiemeké & Ewwiekpaefe, 2011). This is because these teachers become anxious, and develop a negative attitude towards paper-based GIS implementation.

It is also evident that certain geography teachers gained confidence because of the long experiences of teaching GIS and through socialisation with their peer-teachers. We also learn that teachers at times requested assistance from others in teaching paper-based GIS. This is consistent with the findings of Wilmot and Dube (2016) who state that teachers use other geography teachers from other schools or university students from outside of school to teach GIS to their learners as they fail to do it themselves. This is because there is a lack of time to properly train geography teachers about paper-based GIS. Therefore, these teachers rely on their peers and textbooks for the implementation of paper-based GIS.

#### **4.10.2 MODERATING EFFECT OF TEACHERS' AGE IN IMPLEMENTING PAPER-BASED GIS**

Billy and Mario's responses expressed the age moderating effect in the acceptance and use of technology affects teachers' acceptance and use of paper-based GIS in the rural learning ecologies. Both Billy and Mario's responses revealed that younger teachers seem to understand paper-based GIS better than their counterparts. Billy further argued that in geography content workshops the younger teachers end up teaching paper-based GIS to other teachers. Billy (semi-structured interview) commented:

*“...the younger teachers in workshop end up taking over because you find that we have more information than what the department has prepared for us.”*

Again, Billy also put it that even though he was young when he first started teaching, he still used to teach paper-based GIS to classrooms that were supposed to be taught by other teachers who were older than him and had been in the field of teaching longer than him. The older teachers ended up observing Billy's paper-based GIS lessons while he taught as a way of boosting their knowledge. As a result, of observing his lessons and asking questions from him, they also gained confidence in implementing paper-based GIS. Billy (semi-structured interview) expounds:

*“The problem of the older teacher was that they didn't have the confidence to go stand in class and teach the GIS section. They didn't have enough resources...I used to ask them to sit in class while I teach then again they will come to me and we sat down and they asked questions where they did not understand in class then I explained where possible and also referred them to textbooks we have in our school and other reading material that I have developed...”*

Similar to Billy, Mario was also young when he started teaching geography. However, geography subject advisors realised that he was quite good in paper-based GIS. For this reason, the advisors asked him to assist in teaching and learning of paper-based GIS in other rural learning ecologies. Mario (semi-structured interview) clarifies:

*“Even Geography subject advisors noted that I am actually good in teaching GIS then they asked me to go and assist in other schools and I assisted....”*

From the extracts above, we learn that younger geography teachers often seem to understand and accept paper-based GIS more than their older counterparts. This might have been because these younger teachers had been exposed to GIS at secondary school and tertiary levels. This is consistent with the findings of Mzuza & Westhuizen (2019) who point out that university students get exposure to GIS at the tertiary level. Therefore, when younger teachers get into the field of teaching paper-based GIS in rural learning ecologies, they may develop positive attitudes and self-efficacy in accepting and implementing paper-based GIS without having uncertainties. The self-efficacy in the UTAUT model is defined by psychologist Albert Bandura (1995) as a person's belief in their ability to succeed in a specific situation or accomplishing a task. In turn, learners' performance in paper-based GIS in rural learning ecologies might improve.

#### 4.11 PAPER-BASED GIS IN EQUIPPING LEARNERS WITH GIS SKILLS

All participants' responses reflected that paper-based GIS is not sufficient in equipping learners with GIS skills. Mario lamented that learners are only taught a summary of the actual GIS. Duncan, Billy, and Gale also expressed that paper-based GIS is not what GIS is all about since it does not use computers. Duncan stated that learners may experience challenges when they use a computer to apply skills they have learnt in the paper-based GIS. Duncan (focus-group interview) comments:

*...paper-based GIS is providing some GIS skills but they are not enough. If you were to place a learner in front of the computer and say apply the skills you learnt in paper-based GIS, the learner will struggle. If learners were to do data layering on a computer, they will suffer and perform much worse."*

Like Duncan, Billy highlighted that paper-based GIS does not teach adequate skills for computer-based GIS. Billy added that learners can use their cellphones to implement GIS but this calls for the learners to have the correct mindset or else they will be distracted and use their cellphones to do other non-school related things. Billy (focus-group interview) articulates:

*...we try push learners as far as we can but we see that paper-based GIS is not what GIS is all about. Even if we were to teach them computer-based GIS it will still not be enough because as developing country learners are not exposed to computers even their mindset is not there. You would find that a learner has a cell phone that works almost equal to what a computer would do but you find that a learner is not interested on doing school work using their cell phones...The mindset of a learner is also something that we would have to work on.*

Again, Mario's indicated that not enough time is dedicated to paper-based GIS in the geography curriculum. Mario further indicated that too few marks are allocated for paper-based GIS in the exams. Therefore, according to Mario, paper-based GIS implementation in the rural learning ecologies is just a summary of the actual GIS. Mario (focus-group interview) laments:

*"If you look at the way GIS is done in schools, they are not providing learners with the necessary skills needed in the GIS field. The learners are only given an introduction or a summary of what is there in the actual GIS...Even when the map work papers are set, in March exam GIS only covers 5 marks, 15 marks in*

*June, 15 marks in September, and 15 marks in the final examination. So, it is not given that much time...*”

Similar to the others, Gale also did not perceive paper-based GIS as providing learners with enough skills for GIS. She revealed that if learners are taught GIS with computers, they may acquire skills of operating the GIS system because they would have done it practically. Gale (focus-group interview) echoes:

*“paper-based GIS does not provide learners with sufficient GIS skills because in schools we use topographic and orthophoto maps to teach about GIS while in developed countries GIS is computer-based. Therefore, a learner who had been taught paper-based GIS might not be able to use a computer to apply skills that he/she learnt through maps. If learners can be taught practically using a computer, they may understand GIS better because of referring to something they have seen a teacher doing and ended up doing it themselves.”*

Again, Gale added that due to a lack of resources, it is difficult for learners to use their imagination in understanding how a GIS programme will operate using a computer. For this reason, learners’ understanding may be distorted. As a result, they fail to acquire a GIS skill that is supposed to be learnt. Gale (focus-group interview) laments:

*“If learners are taught using paper-based GIS, it is just a theory of what is done in computer-based GIS. So, when a teacher uses theory in trying to explain what a learner would have done practically in GIS, some learners might end up not understanding what a teacher is trying to explain. This is because it is not easy to use our imagination in trying to understand something unless it is explained in such a way that paints a clear picture in the learners’ mind.”*

It is clear from the above extracts that paper-based GIS implementation in rural learning ecologies provides insufficient GIS skills to learners. The lack of resources is one issue that affects learners from acquiring GIS skills because of being limited to paper-based GIS. Learners are forced to use their imagination to picture how a particular concept would work in the GIS programme utilising computers, which is inadequate and difficult. The facilitating condition deals with the issue of the lack of resources that hinder the effective implementation of paper-based GIS in rural learning ecologies (based on the UTAUT theory). Drawing from the literature, Mzuza and Westhuizen (2019) elucidates all the necessities required to

implement GIS in schools, which includes such resources as computers, software, hardware, internet access, and maps. Thus, the absence of such resources creates problems for both teachers and learners in the implementation of paper-based GIS to acquire actual and needed GIS skills.

It was also evident from the extracts that paper-based GIS implementation is not given adequate time in the rural learning ecologies. Teachers provide learners with a summary of paper-based GIS without engaging in any in-depth knowledge. This, in turn negatively, affects learners and stops them from acquiring real-world skills in GIS. based on the literature, Tarisayi (2018) explains that time constraints in the teaching of GIS in South Africa stem from the CAPS allocation of only four hours per week to teaching geography. The teaching of GIS becomes theoretical due to inadequate time allocation which limits exposure to the technical and practical aspects of GIS. For the above reasons, teaching and learning of paper-based GIS is not enough in rural learning ecologies.

#### **4.12 LEARNERS' PERFORMANCE IN PAPER-BASED GIS**

Mario's remarked that his learners perform exceptionally well in the paper-based GIS section. However, Gale lamented that her learners perform poorly in the paper-based GIS section. Duncan and Billy revealed that their learners' performance in paper-based GIS is satisfactory but there is still room for improvement. Duncan articulated that his learners may perform better if there is increased availability of resources to support the implementation of the paper-based GIS. Duncan (focus group interview) echoes:

*“GIS performance for my learners is not that bad but I wouldn't say it is where I want it to be. They are performing however I feel they are not in the level they could be in if they were more resources.”*

Similarly, Billy revealed that there are still areas that require improvement in the teaching and learning of paper-based GIS to improve his learners' performance in the section. He also stated that when he started teaching, there were learners who never attempted the paper-based GIS section in the exam but over the years he has witnessed improvement in how learners do the section. Billy (focus group interview) articulates:

*“It improved but there is a gap. GIS is 15 marks, so most of them would score more than 7 marks but I remember when I started teaching in this school, most*

*of them were not even attempting that section of GIS but now most of them do score above 50% of 15 marks. So I can say that they have improved.”*

Billy also provided reasons he perceives as hindrances to his learners’ performance. He believed that learners lack confidence when answering questions in the examination because they are not taught paper-based GIS in detail. Billy also alluded to the issue of learners focusing more on learning map work calculations at the expense of other sections. As a result, learners’ performance in paper-based GIS suffers. Billy (focus group interview) expounds:

*“Because even though they were taught but they were taught the minors of the subject. So I think they also did not have the confidence. You find that when you take a previous exam question paper that learners have written and asked them the same questions in class that is where I realise that learners would have been able to answer the questions during the exam because they don’t have the confidence. Our learners were also back then used to focus on calculations. In a map work question paper of 75 marks, there are only 20 marks of calculations so their focus was a lot on calculations. So, most learners went to the examination room knowing how to calculate even if you told them that you can still make it even if you didn’t know how to calculate.”*

In comparison, Mario’s response revealed that he was satisfied with his learners’ performance. He believes that the reason for the exceptional performance of his learners is because he is good at teaching paper-based GIS. He further argued that he teaches learners from lower grades and moves with them to the upper grades. He even teaches for other teachers in his school. Mario (focus group interview) elucidates:

*“My learners are performing extremely well in GIS because I teach them from grades 10 up to grade 12. I am the one who assists other teachers to teach GIS in my school. So, learners move from grade to grade with the GIS content I have taught them and as a result, they perform better.”*

Different from the above participants, Gale revealed that her learners perform poorly in paper-based GIS and that this is caused by a lack of resources in the rural learning ecologies. As a result, she ends up having to make learners visualise by utilising their imagination to understand certain paper-based GIS concepts. Therefore, this creates challenges for learners. Gale (focus group interview) articulates:

*“They are not performing well. I think the reason why my learners are not performing well is that I say things that will make my learners imagine and think deeply about something they have never seen before. We are also using terms that learners have never used before or heard about before. Learners have to imagine, if they fail it means that they will not know what we are actually talking about. It is difficult to imagine something that does not even exist in your mind...To imagine GIS it is very challenging for learners and this leads to poor performance.”*

From the extracts above, it is evident that the majority of the participants are unhappy with learner performance in GIS. For two participants, although learners produced satisfactory performance in paper-based GIS the teachers felt that the results might have improved if learners were provided with resources and in-depth knowledge about paper-based GIS. This is consistent with 2015, 2016, and 2017 diagnostic reports for NSC examination which revealed that geography learners’ performance in GIS indicates that they lack fundamental GIS knowledge (DBE, 2015; DBE, 2016). This is also in line with Liebenberg et al. (2018) who refer to performance expectancy in the UTAUT model. From the performance expectancy’s view as a determinant of intention, learners’ poor performance may be a result of teachers lacking belief that paper-based GIS might enhance the way they deliver the GIS content to learners. For this reason, geography teachers may develop a negative attitude and lack of acceptance towards paper-based GIS as a strategy that can improve learners’ performance.

It is also evident from one participant’s response that her learners were performing poorly in the GIS section. It was clear that she perceived the lack of resources as the main problem to her learners’ poor performance. This is also in line with Liebenberg et al. (2018) who refer to facilitating conditions in the UTAUT model. From the facilitating condition’s perspective as a determinant of intention, learners’ poor performance may be a result of a lack of relevant resources to implement paper-based GIS. The lack of resources in the rural learning ecologies meant that teachers may develop negative attitudes and lack of acceptance towards the implementation of paper-based GIS, and thus., learners’ performance is negatively affected. However, it was clear from one participant’s response that there are teachers who achieve great learner performance in paper-based GIS in the rural learning ecologies. This is consistent with

Gupta et al. (2008), Liebenberg et al. (2018), and Mutlu and Der (2017,) who referred to effort expectancy in the UTAUT model. From the effort expectancy's perspective as a determinant of intention, learners' exceptional performance may be as a result of a geography teacher who feels at ease in implementing paper-based GIS.

#### **4.13 PAPER-BASED GIS IMPLEMENTATION IN A RURAL LEARNING ECOLOGY**

All the participants' revealed that topographic and orthophoto maps are the main resources required to implement paper-based GIS in the rural learning ecologies. All participants also revealed how other schools implement paper-based GIS. Gale and Mario never utilise a computer in the implementation of GIS. However, Duncan and Billy main utilise maps but also use their personal computers to teach. Duncan further stated that he makes learners visualise about certain GIS concepts and it is not easy to make a learner visualise with understanding. Duncan (focus-group interview) echoes:

*“I make sure that I bring my maps to the classroom and use the chalkboard. I give learners notes about GIS that consists of all the components of GIS. I try by all means necessary to create pictures in their minds. However, it is not easy when you are having a large number of learners in the classroom and having to create because the level of understanding is not the same for learners.”*

Moreover, Duncan also indicated that when he is implementing paper-based GIS, he tries to be practical by utilising his computer to demonstrate certain features to learners. He stated that this is because certain learners understand better when a teacher becomes practical in implementing paper-based GIS. Therefore, he refers to notes in the textbook and infuses them with practical examples for learners to understand. Duncan (focus-group interview) elucidates:

*“Some learners need a teacher to be more practical. For that reason, I also bring my laptop and I will teach them by saying in this computer there is software. Then I inform learners that a computer without software is just a dead tool. So, how I will be interacting with them, trying to explain and giving them more examples like Facebook and other apps that operate in a similar fashion to a GIS. refer to notes infusing them with practical examples in order to try to*

*make learners understand GIS better. For learners having learnt notes and then I ask them which layers they can identify on the maps and then they give me answers...*”

Again, Duncan also revealed that he knows of a well-resourced school that implements GIS using computers. He explained that a former model C school he knows implements paper-based GIS using maps and thereafter, learners would be taken to the computer lab to practice what they had learnt in textbooks and maps. Duncan (focus-group interview) point out:

*“...especially the former model C’s, they are teaching it using computers. For them, they even go to computer room, I heard one teacher say once in a while she takes her learners to the computer room to show them GIS practically using computers because they have GIS software.”*

Duncan also added that all schools in his district were given the software, and given workshops on the GIS software. This is where the same model school obtained the software from; they only had to install it on the computer for learners to be able to use it. However, since Duncan’s school was a rural learning ecology, his learners never got to utilise this software although he once operated it on his laptop. Duncan (focus-group interview) explains:

*“We were given...software in workshops but the problem is computers. So, we were in the same workshop with teachers from former model C schools and they were given software and we were also given. So, for them is beneficial because they already have computers. For them is only to say let us install this. I think It was 2013 where we went to one of the schools for a workshop that lasted for two days where we were given ArcView software I even installed those on my laptop and they were working very nicely, I was excited to do certain things on the GIS programme. But the problem is that it is not for me, it is for the learners to know because they do not have computers. So, GIS can work in schools provided that IT is already in place in schools.”*

Similarly, to Duncan, Billy also utilises maps and his laptop at times in the implementation of paper-based GIS in his rural learning ecology. This is because he wants to expose his learners to the application of GIS in the real world. It is also evident that Billy does not rely too much on his laptop because when learners get tested in exams they are tested utilising topographic and orthophoto maps. Billy (focus-group interview) indicates:

*“I bring maps, my database that have a lot of slides so there is also GIS I do expose them to that infuse application of GIS. Grade 11 and 12 are a lot more exposed to the GIS application when you doing map work. But I do not take them away from what they will get tested on because what they get tested on would be paper maps which are your orthophoto maps and topographic maps. So, I cannot take them too far into knowing about computers and GIS away from what they will get tested on.”*

Furthermore, Billy’s response also emphasised the importance of integrating paper-based GIS into other geography sections. This is because, according to Billy, paper-based GIS can be a tool used to solve geographic problems that may be found in other geography topics. Billy (focus-group interview) expounds:

*“When we teach GIS, we should integrate or it can be infused in all chapters of geography from as early as grade 10. But the problem that we have is how GIS is assessed even when you get a provincial and national exam paper, they assess it separately. For example, you teach a learner about flooding then you say an insurance company would make use of GIS to see how much they going to charge you if you develop a settlement over a floodplain. Learners would be able to understand that ...ok if we say this is a floodplain, this means that this place is prone to flooding or chances are that you going to be charged a very high premium compared to someone over a dry point settlement. So now you have infused a topic of another chapter into another chapter.”*

Differently, Billy pointed out that some teachers in other learning ecologies implement paper-based GIS by utilising question papers from previous years. Billy stated that although using question papers to learn for the exam is important, what is more significant is making learners understand paper-based GIS for future use in the real world. Billy (focus-group interview) comments:

*“...Some teachers will teach learners for learners to just pass the exam. They used to call it ‘drilling learners with question papers’. For myself, even though I do drill them with question papers exposing them to past year papers but I also believe in a holistic understanding of a chapter. Because it is of no use to just know the content without knowing its use and effects in the real life of the people and the environment. So, I always remind my learners that they must*

*remember that this geography is about the lives of the people and the environment. So, it always best for them even to cope when they get to the university”*

Mario, on the other hand, expressed the importance of providing learners with many examples when implementing paper-based GIS. According to Mario, he creates a learning atmosphere that enables learners to see themselves as future GIS specialists. He does this by informing learners that the maps they see were created by people who went along the same path as them in learning paper-based GIS. In this way they also begin seeing themselves as part of the map-making process Mario (focus-group interview) elucidates:

*“To make learners love and understand GIS better, I make use of more examples. Also when I teach about orthophoto and topographic maps, I always tell learners that these maps were made by us. I even include myself when I am referring to the word “us” and also the GIS specialists so that learners will love it. I even include learners by telling them that as they are learning GIS from me, I am actually producing a new GIS specialist after the session. So, they will try to understand what I am teaching.”*

Again, Mario emphasised that in making examples during his lessons, he utilises components such as a cell phone which is something that learners are familiar with and use almost every day. In this way, he believes that learners may be able to grasp and accept paper-based GIS easily. Mario (focus-group interview) explains:

*“I make use of the things they use every day as examples in teaching GIS. For example, I say if you look at the word orthophoto it has the word photo at the end, and a photo is made up of pixels which is part of raster data in GIS. Even the example of a cell phone that they have is a system, and when you talking about GIS you are talking about a system that you use to store information, in that way they easily catch up with GIS.”*

Mario pointed out that teachers of other schools at times invite him to teach paper-based GIS for them. Before he teaches their learners, he first checks how far teachers have taught paper-based GIS to their learners by referring them to their notebooks. Mario had discovered that some teachers leave out other paper-based GIS topics when teaching learners. Mario had also discovered through teaching other teachers that it is the older teachers who lack understanding

of paper-based GIS implementation in rural learning ecologies. Mario (focus-group interview) comments:

*“...in my teaching career I have moved to a number of schools, more than seven schools I went to teach them GIS. So, before I teach learners in those schools I first look at the notes that the learners have to see what teachers had taught learners, then I teach what teachers have not covered according to the learner's notes and then I do the summary of the whole topic...I have discovered that old teachers do not understand and don't teach GIS the way young teachers do. Old teachers just do a small summary and pass without allowing more time for learners' understanding.”*

Differently from Billy and Duncan, Gale revealed that when teaching paper-based GIS, she only uses textbooks and maps. She also added that learners rely on their minds to visualise certain information because of the lack of resources. Gale (focus-group interview) clarifies:

*“I teach GIS as a theory by using textbooks and maps; there is nothing that we do practically. It is just theory and I make learners use their imagination of something they do not even see.”*

From the above extracts, we are learning that teachers in rural learning ecologies utilise topographic and orthophoto maps in the implementation of paper-based GIS. This finding resonates with the sentiment of Breetzke et al. (2011) when they point out that paper-based GIS was developed for rural learning ecologies as a strategy to address the lack of computers. It was also evident that there are geography teachers who do not teach certain paper-based GIS sections because they lack understanding. Ayorekire and Twinomuhangi (2012) and Musakwa (2017) corroborate this finding since they point out that the unavailability of experienced teachers to teach GIS is a common problem in Africa. However, it was also discovered that there are teachers who do utilise computers in teaching paper-based GIS. This is in agreement with the UTAUT model which stresses the significance of facilitating conditions in implementing GIS (Venkatesh et al, 2003). Therefore, learners' performance may improve due to exposing learners to the infusion of both theory and practise.

#### 4.14 ADVANTAGES OF PAPER-BASED GIS IMPLEMENTATION

All participants had differing perceptions about the benefits of paper-based GIS in rural learning ecologies. Billy expressed that learners get exposed to technology because of paper-based implementation. On the other hand, Gale's response revealed that learners obtain knowledge from paper-based GIS they can apply in the real world. However, Duncan and Mario held a similar view that due to lack of facilitating conditions in the rural learning ecologies, paper-based GIS is advantageous as teaching and learning are mainly done utilising maps. Duncan (focus-group interview) articulates:

*“In these rural areas, there is no electricity. There is poor infrastructure. The rural areas technology-wise are not advance. So, in a way, it is an advantage for people in rural areas to use this paper-based GIS. If they were to be given computers, they wouldn't have electricity to operate those computers. So, for them it a step in the right direction. Especially for schools that are situated in deep rural areas because in some rural areas there is electricity.”*

Again, Mario explained that paper-based GIS is a solution for the teaching about GIS since there is a lack of computers in rural learning ecologies. Mario further stated that GIS requires someone who is already equipped with computer skills, so if learners from rural learning ecologies were to be taught computers, it would consume a lot of time. Mario (focus-group interview) explains:

*“It is because learners are not exposed to computers. So, it is the advantage to learn GIS using papers, and transparencies to do data layering. It is an advantage to them because they will be using what they always use and it is what is available to them. But if you were to use a computer, it may take time because GIS requires someone who already has computer skills so it might take time for them.”*

In contrast, Billy noted that paper-based GIS exposes learners to computers. However, according to Billy, in rural learning ecologies, there is a lack of computers and he thus resorts to using learners' cell phones when implementing paper-based GIS because the phones operate similarly as a GIS programme platform. Billy (focus-group interview) clarifies:

*“Learners get exposed to computers...but in a rural area, you will find that a computer is available for drafting curriculum vitae and recommendation letters. Learners don't get exposure to computer-based GIS. But when we teach*

*them then we tell them that know when you use your cell phone, you will find that there will be coordinates when someone sends you a location even on your social platform. You will see that there will be coordinates. Those are the same coordinates we will be talking of when we are here in class doing map work and GIS. So, now learners know that they can make use of what they have been taught in school and implement it at home... ”*

Gale’s response indicated that although paper-based GIS equips learners with skills they may utilise in the real world but they are few. Gale (focus-group interview) echoes:

*“Paper-based GIS does have benefits even though there are few, but learners can understand certain information in paper-based GIS that they can apply in the real world.”*

From the extracts above, we learn about the usefulness of paper-based GIS in rural learning ecologies. It is evident that paper-based GIS is viewed as a solution for implementing GIS in rural learning ecologies where computers are scarce. This is because paper-based GIS utilises maps and tracing paper instead of a computer being the main resource (Buabeng-Andoh & Yidana, 2015). Therefore, by using paper-based GIS, teachers and learners may be able to engage in tasks such as searching for the best location to evacuate residents in the event of a flood (by using maps). Buabeng-Andoh and Yidana (2015) also add that paper GIS proved very important for teaching conceptual issues of GIS before moving to the computer. Thus, when learners get experience with paper-based GIS they do also engage in concepts that are used in the GIS programme.

#### **4.15 DISADVANTAGES OF PAPER-BASED GIS IMPLEMENTATION**

Duncan and Mario stated that the disadvantages are linked to the lack of resources in rural learning ecologies. This creates difficulties when teachers have to explain paper-based GIS content to learners. The consequence of this is poor learner performance in the GIS section. The resources Duncan is referring to are the shortage of topographic and orthophoto maps. Duncan also complained that some learners in his rural learning ecology are not familiar with computers, which worsens the level of understanding that learners gain even when doing paper-based GIS. Duncan (focus-group interview) laments:

*“The level of thinking abilities in rural schools is not in the level some learners would be in. At times I try to explain some GIS concepts to a 16-year-old learner and he or she gets confused. I end up having to lay a foundation in learners by providing a background about computers. Shortages of maps, lack of good resources so that is very discouraging sometimes because you want your learners to be performing at their best and you want to see the succeeding but when you do not have resources especially in GIS because it is more practical than the other sections. GIS practicality must be accommodated with resources.”*

Similarly, Mario’s response revealed that the paucity of resources such as transparencies to implement paper-based GIS is disadvantageous because paper-based GIS requires transparencies for data layering. If the school principal does not purchase them in time, it means that learners may be delayed in learning the section. Therefore, y teachers might have to come up with other means for learners to learn. Mario (focus-group interview) laments:

*“Teachers have to provide transparencies because learners do not have them. So, when we request our principals for transparencies, we have to go down on our knee begging for transparencies to be bought for learners. Only to find out that the transparencies will come to school during the time you no longer need them. This forces the teachers to use their own money to buy transparencies for learners.”*

Gale’s response expresses that although paper-based GIS equips learners with some GIS skills, many learners may still not be able to operate a GIS system because it requires someone familiar with computer skills. Gale (focus-group interview) indicates:

*“Since GIS is paper-based, learners may not be able to apply skills in computer-based GIS even though they might have information. This is because learners have not been exposed to the practicality of computer-based GIS.”*

From the extracts above, we learn that there is a scarcity of resources to implement paper-based GIS in rural learning ecologies. It is evident that teachers struggle with the availability of resources to teach and this is discouraging since teachers may then develop a negative attitude towards the implementation and acceptance of paper-based GIS. Along the same line Fleischmann and Westhuizen (2017), put it that GIS implementation in rural schools is

discouraged by the absence of needed resources. In turn, this affects learner performance in the GIS section because learners are not taught well (Gould, 2018). It is also evident that although learners acquire the GIS skill through learning paper-based GIS, this is not sufficient for a learner to be able to operate a GIS system on a computer. This is consistent with the findings of Breetzke et al. (2011) who point out that in paper-based GIS, learners are learning about GIS and not learning with GIS. This means that learners in rural learning ecologies are not utilising GIS in learning GIS and this may be disadvantageous when they are required to use a computer for GIS.

#### **4.16 CHAPTER SUMMARY**

In this chapter, the data was presented, analysed, and discussed. The data presented the participants' perceptions of implementing paper-based GIS in rural learning ecologies. The findings were organised through deducting from the UTAUT model that framed this study and also inducting findings that emerged from participants' responses. The researcher examined and analysed responses of participants and identified themes that were common and unique. The next chapter brings the study to a conclusion. In doing this, the chapter following summarises the study and presents the conclusions and recommendations based on the findings. Furthermore, the implications of the study are discussed in the chapter that follows.

## **CHAPTER FIVE**

### **CONCLUSIONS AND RECOMMENDATIONS**

#### **5.1 INTRODUCTION**

The previous chapter presented the findings of the study, which were linked to the literature and the theoretical model of the study. Thus, the perceptions of geography teachers of paper-based GIS implementation in a rural learning ecology were discussed. This is the final chapter which aims to conclude the study. The chapter presents five aspects, namely, aim and research questions, a summary of the study, conclusions drawn from the findings, recommendations from the study and the implications of the study.

#### **5.2 AIM AND PURPOSE OF THE STUDY**

The study was aimed at understanding geography teachers' experiences of implementing paper-based GIS in the rural learning ecologies of basic education in UGU district, KwaZulu-Natal. The main purpose of this study was to allow these teachers to voice the way they received paper-based GIS ever since it was introduced to them. Therefore, geography teachers that were participants for the study were either from rural learning ecology A or rural learning ecology B. Therefore, the study sought to answer the following critical research questions:

1. What are geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology?
2. How do geography teachers implement paper-based Geographic Information Systems in a rural learning ecology?
3. Why do teachers implement paper-based GIS in a rural learning ecology in the way that they do?

#### **5.3 SUMMARY OF THE STUDY**

Chapter one presented an overview and orientation to this study. The researcher presented issues related to the geography teachers' perceptions of paper-based GIS implementation in a rural learning ecology. This chapter presented the background, statement of the problem, rationale and motivation, and significance of the study. The researcher also discussed the aim and purpose as well as outlined the research questions that are addressed in the study. The

chapter was concluded by discussing a brief overview of the research design and methodology as well as the outline of the study.

Chapter two was divided into sections. The first section presented the understanding and links between geography education and Geographic Information Systems (GIS). The second section presented a review of international literature relating to the implementation of GIS in schools. The third section presented a review of national literature relating to the implementation of paper-based GIS in rural learning ecologies. The last section presented the theoretical framework of the study, named The Unified Theory of Acceptance and Use of Technology (UTAUT).

Chapter three presented the research design and methodology adopted in the study. The chapter gave special attention to the interpretive paradigm, qualitative research and the phenomenological case study methodology. The chapter then discussed the research setting, selection of participants, profile of participants, and data generation methods namely: semi-structured interviews and focus group interviews. Lastly, the data analysis was explained, as well as the ways of ensuring trustworthiness, the ethical considerations taken, and the limitations of the study.

Chapter four presented and discussed data generated from semi-structured interviews and the focus-group interview. These findings were then analysed relative to the research questions and discussed using thematic analysis.

Chapter five was the final chapter which presented the conclusions that were derived from the findings of the study and subsequently provided a summary of the study. Furthermore, recommendations to the Department of Basic Education and geography teachers were also presented in this chapter.

#### **5.4 CONCLUSIONS DRAWN FROM FINDINGS**

This study established that implementation of paper-based GIS in a rural learning ecology is affected by inadequate teacher training, lack of information, resources and financial constraints, and complex paper-based GIS concepts. This subsequently presents a challenge for geography teachers in the implementation of paper-based GIS in a rural learning ecology.

This study also concluded that geography teachers had inadequate teaching time and poor facilitating conditions for effective teaching of paper-based GIS. The study, therefore, recommends that the Department of Basic Education provides support to geography teachers by reviewing the time allocated in the Annual Teaching Plan (ATP) for teaching paper-based GIS in schools.

The study revealed that the main resources required to effectively implement paper-based GIS in a rural learning ecology include topographic and orthophoto maps. However, the main concern was that geography teachers struggled to apply paper-based GIS concepts practically using topographic and orthophoto maps. The teachers often taught paper-based GIS concepts without applying them onto maps. Teachers also found it difficult to explain paper-based GIS concepts. As a result, some learners struggled to understand and apply paper-based GIS concepts using both the topographic and orthophoto maps.

The study also highlighted that geography teachers are not pleased with the way paper-based GIS is assessed in paper two. These teachers revealed that examiners do not provide them with proper guidance as to how paper-based GIS will be assessed. As a result, teachers are unable to provide assessment guidelines to learners when they teach GIS. This, in turn, disadvantages learners when they write external examinations.

#### **5.5 RECOMMENDATIONS**

The study recommends that the Department of Basic Education, in association with universities, should provide formal training to geography teachers and provide them with the necessary resources across all schools to ensure the effective teaching of paper-based GIS. The

training may be rendered in the form of prolonged workshops that focus on paper-based GIS implementation in schools. The Department of Basic Education (DBE) may also allocate funds in schools for resources required for paper-based GIS implementation. The DBE workshops aiming at supporting teachers with paper-based GIS implementation should include strategies that would enable geography teachers to simplify the complexity of GIS concepts taught to learners in a rural learning ecology.

The researcher recommends that the DBE should also attend to the issue of poor facilitating conditions. The DBE should support rural learning ecologies with information communication technology (ICT) to support the implementation of GIS. The improved technical support may lead geography teachers to more readily accept and therefore, implement paper-based GIS in a rural learning ecology.

It is also recommended that the DBE should pay attention to the application part of paper-based GIS implementation, and the DBE should find alternative approaches that they can teach geography teachers to use in explaining the paper-based GIS concepts.

It is also recommended that paper-based GIS examiners should provide workshops for geography teachers in which they provide guidance on the approach that must be used when teaching paper-based GIS that will correspond with the way questions are going to be asked in the examination.

## **5.6 IMPLICATIONS FOR FURTHER RESEARCH**

This was a small-scale study that explored the perceptions of four geography teachers about paper-based GIS implementation in two rural secondary schools in the UGU district. The findings of this study do not reflect the overall views of Kwa Zulu-Natal schools. Therefore, the experiences of geography teachers about paper-based GIS implementation in these two rural secondary schools cannot be generalised to all rural schools in Kwa Zulu-Natal. Therefore, other researchers can interrogate the perceptions of geography teachers on paper-

based GIS using bigger samples and different research approaches such as quantitative and mixed methods research.

## **5.7 CHAPTER SUMMARY**

This chapter presented and discussed data generated from semi-structured interviews as well as the focus-group interview. The analysis of data was then completed and thematic analysis was done. The chapter has presented some of the key insights from the study on geography teachers' perceptions of paper-based GIS implementation in a rural learning ecology and the reasons for such experiences. The chapter also discussed a few areas for further research.

In this study, geography teachers were given an opportunity to share their experiences of paper-based GIS implementation in a rural learning ecology. The researcher believes that it is important for the Department of Basic Education to be made aware of geography teachers' perceptions of paper-based GIS implementation in a rural learning ecology so that the challenges they face can be addressed. Since teachers are employees of the Department of Basic Education, they have a right to reflect on how they perceive their implementation of paper-based GIS that was introduced by the Department in 2006 to South African schools. The teachers' views on the implementation of the GIS has consequences for the learners' performance in the section. The paper-based GIS implementation feedback from geography teachers would help the Department of Basic Education to identify areas for improvements.

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**Geography teachers' perceptions of implementing Paper-based Geographic Information Systems in a rural learning ecology**

**Semi-structured interview Schedule**

1. How long have you been teaching Geography in the FET phase?
2. Which grades are you currently teaching?
3. Which section(s) of the Geography curriculum do you enjoy teaching? Why?
4. Which sections of the Geography curriculum do you find challenging? Why?
5. What are your views pertaining the inclusion of GIS in the Geography curriculum?
6. What are the necessary resources that you think a school should have in order to implement paper-based GIS properly? Does your school have such resources?
7. Were you taught GIS at secondary school and in tertiary education?
8. What have been your experiences of teaching GIS?
9. What have been your experiences of teaching paper-based GIS?
10. What is your understanding of paper-based GIS?
11. Do you think that paper-based GIS provide learners with sufficient GIS skills?

**Geography teachers' perceptions of implementing Paper-based Geographic Information Systems in a rural learning ecology**

**Focus group interview Schedule**

1. How do you teach GIS in the classroom?
2. Do you perhaps have an idea of how other schools teach GIS in a classroom?
3. How is your learners' performance in the GIS section?
4. What do you perceive as the advantage of implementing paper-based GIS in a rural context?
5. What are the barriers of implementing paper-based GIS in a rural context?

**CONSENT TO CONDUCT RESEARCH IN A SCHOOL**

**UNIVERSITY OF KWAZULU-NATAL**

**SCHOOL OF EDUCATION**

**MASTERS OF EDUCATION (MEd)**

Geography teachers' perceptions of implementing Paper-based Geographic Information Systems in a rural learning ecology

**To the School Principal**

I am Thulasizwe Fredrick Mkhize, currently studying towards the Masters in Social Science Education. To obtain my Masters qualification, 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 in the UGU district. I would like to request your permission for Geography Further Education and Training teachers at your school to partake in this study by answering questions related to the teaching of 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 Geography teachers' perceptions of implementing paper-based GIS in a rural learning ecology.

✓ **PROCEDURES**

The teachers will be informed that their participation in this study is voluntary and that there are requested to share their understanding of paper-based GIS implementation in a rural learning ecology during interview sessions.

✓ **POTENTIAL RISKS AND DISCOMFORTS**

As the researcher, I foresee no risks and discomfort in this research, as I will be conducting research that seeks to understand the teaching of paper-based 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' permission.

✓ **PARTICIPATION AND WITHDRAWAL**

The teachers will be given a choice to decide whether they will like to partake in this study or not. Those that choose to participate in the study may withdraw at any time without consequences. Furthermore, the teachers may also refuse to answer any questions they do not want to answer.

I can be contacted at:

Email: I can be contacted at:

Email: [thulasizwemkhize1989@gmail.com](mailto:thulasizwemkhize1989@gmail.com)

Cell: 0659987241

My supervisor is Ms. Zondi who is located at the School of Education, Edgewood campus of the University of KwaZulu-Natal.

Contact details: email: [Zondit2@ukzn.ac.za](mailto:Zondit2@ukzn.ac.za)

Phone number: 031 260 1379

You may also contact the Research Office through:

P. Mohun

HSSREC Research Office,

Tel: 031 260 4557 E-mail: [mohunp@ukzn.ac.za](mailto:mohunp@ukzn.ac.za)

Thank you for your contribution to this research study.

## DECLARATION

I understand the procedures described above. All questions or concerns relating to this consent form have been answered to my satisfaction, and I agree to allow the FET Geography teachers to participate in this study. A copy of this form has been given to me to retain.

\_\_\_\_\_  
Principal (Surname and initials)

\_\_\_\_\_  
Date

\_\_\_\_\_  
Signature

School stamp

University of Kwa Zulu-Natal  
College of Humanities  
School of Education  
Geography

Dear Geography Teacher

### **INFORMED CONSENT LETTER**

My name is Thulasizwe Fredrick Mkhize. I am a Masters candidate studying at the University of KwaZulu-Natal, School of Education. I intend to do a research study which aims at understanding the teaching of paper-based Geographic Information Systems (GIS) in a rural learning ecology. With this letter, I would like to request your permission to participate in the research study. Should you agree, your participation in the study will take an hour or less for each session. You are kindly requested to partake in a semi-structured interview in which you will be an interviewee as well as to avail yourself for a focus group interview. The times and dates of the meetings are negotiable 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 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 be interviewed, please indicate (by ticking as applicable) whether or not you are willing to allow the interview to be recorded by the following equipment:

	willing	Not willing
Audio equipment		

I can be contacted at:

Email: [thulasizwemkhize1989@gmail.com](mailto:thulasizwemkhize1989@gmail.com)

Cell: 065 998 7241

My supervisor is Ms Zondi who is located at the School of Education,  
Edgewood Campus of the University of KwaZulu-Natal

Tel: 031 260 1379      E-mail: [Zondit2@ukzn.ac.za](mailto:Zondit2@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](mailto: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.

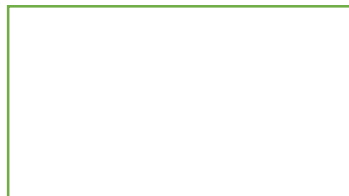
I understand that I am at liberty to withdraw from the study at any time, should I wish to do so. A copy of this document has been given to me to retain.

**Signature of participant**

**Date**

\_\_\_\_\_

\_\_\_\_\_



11 February 2019

**Mr Thulasizwe Fredrick Mkhize 209516862**  
**School of Education**  
**Edgewood Campus**

**Dear Mr Mkhize**

**Protocol reference number: HSS/0019/019H**

**Project title: Geography teachers' perceptions of implementing paper-based Geographic Information Systems in a rural learning ecology**

**Full Approval — Expedited Application**

In response to your application received 6 December 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL**.

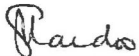
**Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment [modification prior to its implementation. In case you have 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



.....  
Dr Shamila Naidoo (Deputy Chair)  
Humanities & Social Sciences Research Ethics Committee

/pm

cc Supervisor: Thabile Zondi  
cc Academic Leader Research: Dr SB Khoza  
cc School Administrator: Ms Sheryl Jeenaarain

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Humanities & Social Sciences Research Ethics Committee  
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# Masters thesis

*by* Thulasizwe Mkhize

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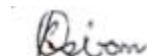
# CERTIFICATE OF ENGLISH EDITING

This certificate confirms that the thesis entitled below has been edited by an English expert with a Ph.D. who has professional review and editing experience. The following errors were checked for and corrected: grammar, punctuation, spelling, word choice, sentence structure, and clarity.

**Thesis title:** GEOGRAPHY TEACHERS' PERCEPTIONS OF IMPLEMENTING PAPER-BASED GEOGRAPHIC INFORMATION SYSTEMS IN A RURAL LEARNING ECOLOGY

**Author:** Sizwe Mkhize

**Date issued:** 6 January, 2020



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(A.A.S., A.A.S., B.Sc., B.Sc. (Hons), M.Sc., Ph.D.)