

**Exploring Opportunities and Challenges for Integrating Geographical  
Information System (GIS) into Geography Teaching and Learning at  
Secondary Schools in Lesotho**

By

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DISSERTATION

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Certification

This is to certify that this dissertation has been read and approved as having met the requirements of the Faculty of Education, National University of Lesotho, for the award of Master of Arts in Education.

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## Abstract

GIS is regarded as one of the most powerful teaching resources for geography education, and has been integrated into geography curriculum at schools in many countries. However, GIS is not yet part of geography curriculum in Lesotho. Instead, there is advocacy for GIS integration because several policies and official documents call for integration of ICT in education. The objective of the study was to explore the opportunities and challenges for integrating GIS into the teaching and learning of geography in Lesotho. To achieve this objective, the study posed four research questions, focusing on the teachers' understanding and benefits of GIS for geography education as well as factors influencing and measures taken to promote integration of GIS at schools.

The methodological procedures for the study were premised on the quantitative approach, thereby adopting a descriptive survey to explore teachers' perspectives regarding GIS integration at schools. Besides, the data were gathered through a questionnaire, transcribed and analysed through descriptive statistics. The findings of the study, therefore, revealed that there are both opportunities and challenges for integrating GIS into the teaching and learning of geography in Lesotho. In particular, schools have proper infrastructure such as electricity, internet connectivity, and computer laboratories geared towards enhancing integration of GIS. Also found is teachers' willingness to integrate GIS into their lessons, coupled with geography content which can be taught through GIS as well as ICT teaching at schools. The study also revealed that challenges such as teachers' limited skills to use GIS, limited access to computer laboratories, high student-computer ratio and lack of GIS software are likely to impede the integration of GIS into geography education at schools.

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## **List of acronyms/abbreviations**

ArcIMS- Arc Internet Map Server

CGIS- Canada Geographic Information System

CAPS-Curriculum Assessment Policy Statement

DIME- Dual Independent Map Encoding

Ecol- Examination Council of Lesotho

ESRI- Environmental Systems Research Institute

ETSIP- Education and Training Sector Improvement Plan

GESP- Geography Education Standards Project

GIS- Geographic Information System

GoB- Government of Botswana

GoL- Government of Lesotho

GoN- Government of Namibia

GPS- Global Positioning System

GUI- Graphical User Interface

ICT- Information and Communication Technology

IGU- International Geography Union

LATE- Looking at the Environment

LIDAR- Light Detection and Ranging

MAP-Map Analysis Package

MBESC- Ministry of Basic Education, Sport and Culture

MoET- Ministry of Education and Training

NCS-National curriculum statement

NRC- National Research Council

SA-South Africa

UK- United Kingdom

USA- United States of America

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# CHAPTER ONE

## INTRODUCTION AND BACKGROUND TO THE STUDY

### 1.1 Introduction

Technology has become an imperative part of life so much that it has transformed the way organisations, companies, or people work and communicate (Sigafos & Green, 2007; Yang, Yang, Wiu, & Liu, 2014). Research reveals that digital technology is ubiquitous in everyday life, and has affected the way in which education is viewed across the world (Biddulph, Lambert, & Balderstone, 2015; Karvankova, Popjakova, Vancura, & Mladek, 2017; Sigafos & Green, 2007; Yang et al., 2014). Furthermore, Xing and Ng (2016) specify that technology provides very useful teaching resources for classroom teaching and learning. In fact, previous research conducted by Lemberg and Stoltman (1999) observes that technology has revolutionised geography and influenced pedagogical approaches to teaching geography. This study is, therefore, intended to explore the opportunities and challenges for integrating GIS in the teaching and learning of geography in Lesotho.

### 1.2 Background to the study

Geospatial technology refers to all the technologies which are used to acquire, manipulate and store geographical data. These include GIS, remote sensing, Global Positioning System (GPS), and virtual globes (Solari, Demirci, & Van der Schee, 2015). These technologies have been adopted and used in different companies, organisations or agencies, and even by individuals, including, military personnel, healthcare services, mining management, and national parks (Hoalst-Pullen & Patterson, 2010; Singh, P, Singh, A, Singh, A, Kumbhakar, & Ray, 2017). The education sector is no exception in this regard, since these technological tools are used to enhance teaching and learning at schools (Stevenson, Brody, Dillon, & Wals, 2013).

The engagement of geospatial technologies in school geography, according to Wiegand (2001) and the International Geography Union (IGU) (2016), is motivated by the fact that geography is competing with other subjects for space and survival in the curriculum. Furthermore, discussing challenges facing school geography, Rawling (2004) stressed the need for integration of

technologies into geography education. The issue is taken up by Akoreda (2010), who reports that students experience difficulty in acquiring geographical knowledge and skills because of the abstract manner in which the subject is taught. Therefore, geospatial technology can help to resolve these challenges facing geography education. Similarly, Biddulph et al. (2015) point out that technology is crucial for geography education because geography is viewed as a 'spatial science'. Although the afore-stated views advocate geospatial technology in geography, special emphasis is on the application of GIS with the understanding that the tool has greater potential to contribute significantly to geography teaching and learning (Biddulph et al., 2015; Lidstone & Williams, 2006).

According to Burrough (1986), GIS is a system that is meant to develop a powerful set of tools for collecting, storing, retrieving, transforming and displaying spatial data from real world for a particular purpose. In the same manner, Zhu (2016) defines GIS as a computer-based system intended to capture, manage, manipulate, integrate, analyse, visualise, and disseminate spatial data. The notion is echoed by Dueker (1979) noting that GIS allows its users to observe spatially distributed features presented by the points, lines, and areas. In other words, GIS is a tool employed for dealing with real-world data. As Davidson and Payne (2000) observe, GIS facilitates the work with information by organising it together with the exact location.

Although GIS was not originally designed for teaching and learning, research shows that it is a powerful tool for geography education (Fargher, 2006; Kerski, 2003; Solemn, 2001). For this reason, many countries have implemented GIS as part of geography curriculum. For example, GIS is part of geography curriculum in the United States of America (USA) (Kerski, 2003), Turkey (Aladag, 2010) and the United Kingdom (UK) respectively (Bednarz, 2004). Nonetheless, developing countries are not immune to the integration of GIS into geography education. For Kerski, Dermici, and Milson (2013), South Africa is amongst the countries which have implemented GIS in geography curriculum. Besides, the majority of developing countries in Southern Africa have official documents and policies that advocate the use of information and communication technology (ICT) in general, albeit without any specific reference to the use of GIS. For example, Botswana has developed the ICT policy, which provides for the ICT application at schools (Chisholm, Dhunpath, & Paterson, 2004).

Similarly, Lesotho as part of the developing countries has embraced the idea of integrating technologies into education. Kalandla and De Villies (2008) trace the introduction of computers in education to the early 1990s in Lesotho from private donors, for the purpose of equipping learners with computer literacy skills. Later in 1999, non-government organisations such as the School Net donated laboratories, computers, software and intranet connectivity to schools, seeking to assist teachers in instructional practices by using computers (the Government of Lesotho ICT Policy, 2005; Nepad Action Plan, 2006, cited in Isaacs, 2007). Besides these initiatives, integration of ICT is advocated in several policies and official documents in the country.

As pointed out by the Government of Lesotho (GoL) (2004) in *the Lesotho Vision 2020*, quality education is the key to addressing national needs and producing highly skilled manpower and future leaders. As such, it is the intent of the GoL that by 2020, Lesotho shall have advanced technological research and development. In the same document the GoL shows commitment to revisiting school curricula so as to integrate technology, thus ushering in development of technological skills and creating the opportunities for high enrolment of learners for technology-related careers (ibid, 2004).

Similarly, the GoL (2005) stated in *the Education Sector Strategic Plan* that its vision is that “Basotho shall be a functionally literate society with well-grounded moral and ethical values; adequate social, scientific and technological knowledge and skills by the year 2020” (p.1). This view is also shared by the goals set in *the Lesotho Vision 2020*. Furthermore, this shows that it is crucial to develop learners with technological skills necessary to become responsible citizen. With the same view, the Ministry of Communications, Science and Technology developed an ICT policy with the purpose of providing well-established strategy through which the nation can fit into the information society (Lesotho ICT Policy, 2005). This policy is regarded as the stepping stone towards achieving the national goals as stated in *the Lesotho Vision 2020* document (ibid, 2005). One of the strategies of achieving these standards is through the commitment of the GoL to investing in ICT education and human resource development. Examples include providing ICT literacy skills geared towards such target groups as learners, in-service training personnel in the both public and private sectors (ibid, 2005). The implication is

that once equipped with ICT skills, in-service-teacher trainees will apply them to their teaching environment.

Moreover, the Ministry of Education and Training (MoET) (2009) developed a curriculum and assessment policy in order to provide comprehensive guidelines for teaching and learning at both basic and secondary education levels. The policy specifies the need for education to cater for national needs and globalisation, including advanced technology and communication. With the policy, the MoET also aims to “promote scientific and technological skills in responding to socio-economic challenges” facing the nation (p. 12). This policy was probably designed for inculcating educational skills, attitudes and values that are central to learners’ personal development, socio-economic developments of the country, as well as creating opportunities for learners’ participation in globalisation (ibid, 2009). In fact, MoET views development of technological skills as imperative for high-quality life on the part of learners (ibid, 2009).

In addition, within this policy is the body of knowledge and skills selected for secondary education. These are categorised into five learning areas: linguistic and literacy; numerical and mathematical; personal, spiritual, and social; scientific and technological; and creativity and entrepreneurial, with geography being offered under scientific and technological learning area as a core but not necessarily a compulsory subject (MoET, 2009). By offering geography in a scientific and technological learning area, apparently indicates geography as playing a major role in promoting technological skills amongst learners. This, therefore, provides an opportunity for integrating GIS into geography as an appropriate vehicle to achieving stipulated technological skills. However, as Raselimo (2016) pointed out, geography education in Lesotho is far behind international trends such as integration of GIS technology.

Furthermore, GoL (2012) in *the National Strategic Development Plan* affirms that the skills developed at schools are not congruent with the market-required skills, with learners, however, developing technological skills on a small scale. As such, the GoL considers reforming education to improve, amongst other things, the quality of education by integrating technology into teaching and learning. Besides, the school curriculum has geography content with topics that can be taught and learnt through the help of GIS (Raselimo, 2016). For instance, the author observed that the topic on a map-work has content which provides for the use of GIS with the following objectives:

- (a) Interpret information in photographs, maps, and diagrams, text and statistical forms;
- (b) Describe and explain landforms, natural vegetation, land use and settlement shown on photographs or in sketches (ibid, 2016, p.8).

Raselimo (2016) further sees these objectives as providing a platform through which learners can develop photographic interpretation skills and acquisition of computer literacy pertaining to remote-sensing. Other related topics in geography which can promote technological skills include population and settlement. For example, an objective under rural settlement specifies that learners should “describe the patterns of rural settlements in Lesotho” (the ECoL, 2015). To acquire this knowledge, GIS which uses real-world data, can provide learners with different settlements across the country, and learners can describe patterns based on their observation of information provided by the GIS. Learners also can study population distribution over a set of regions, and give reasons for such distributions. This view has been taken up by Smith (2002), who states that GIS allows learners to observe patterns and features in the environment and to establish relationships between humankind and the environment.

### **1.3 Statement of the problem**

The foregoing discussion has shown that education is expected to promote development of technological competences amongst learners. However, technologies such as GIS are not yet part of the geography curriculum in Lesotho. This raises a concern because GIS is a noticeable global trend in school geography (Wiegand, 2001). Hence, it is fundamental to recognise and allocate a place for GIS in geography education. Besides, many studies have examined the integration of technologies at schools in Lesotho. However, none of them focused solely on integration of GIS into geography teaching and learning. For instance, Chere (2011) focused generally on the integration of technology into classroom practices, while Lisene (2017) focused on the integration of ICT into the teaching of Physical Science. This study was intended to explore the opportunities and challenges for integrating GIS in geography education in secondary schools. The study further explored the perspectives of geography teachers on the role of GIS in geography teaching and learning.

### **1.4 Research questions**

This study sought to answer the following key questions:

- (a) What do Geography teachers understand by GIS?
- (b) What are the benefits of using GIS in geography teaching as perceived by Geography teachers?
- (c) What factors are likely to influence the integration of GIS at secondary schools in Lesotho?
- (d) What measures may be taken to enhance application of GIS to geography teaching and learning?

### **1.5 Rationale for the study**

The study is vital for the education system in Lesotho. In the first place, it raises awareness amongst educational stakeholders, particularly curriculum policy makers, curriculum developers of geography and teachers about the importance of integrating GIS into geography education. Specifically, the study hopes to inform the curriculum policy-making body about the significance of GIS for attaining national standards set for geography education at secondary schools. This is because GIS is viewed as an appropriate means through which learners effectively develop geographical skills and knowledge (Ticker, 1992). Therefore, the findings of the study will hopefully enable the researcher to persuade the policy-making body to facilitate the integration of GIS into geography education by developing the policy framework, which will provide clear guidelines for geography teachers when implementing GIS in the teaching. It is further anticipated that the study will benefit curriculum developers of geography by highlighting areas of geography content which can be taught or learnt through GIS. On this basis, the curriculum developers could revise geography syllabus so as to integrate GIS.

Furthermore, the study is fundamental to geography teachers in that it will enrich their knowledge about some of the latest developments in school geography. In addition, the study will equip teachers of the significance of GIS in making geography education-orientated and interesting to them as well as to learners. This new approach would, thus, help to offset one of the concerns noted by Akoreda (2010) that learners consider geography a boring subject because of the manner in which it has been taught. Therefore, the researcher hopes that the study will motivate geography teachers to use GIS in their teaching to enhance the quality of teaching.

## **1.6 The Structure of the study**

This study is organised into five chapters. Chapter One introduces the study, presents the background information to the study, problem statement, research questions, as well as the rationale for undertaking the study. Chapter Two discusses the literature related to the opportunities and challenges for integrating GIS at schools, the chapter defines the concept of GIS, thereby discussing different views on, developments and trends of GIS and its role as a geospatial technology, and its role in the integration into geography education. Chapter Three presents the methodological orientation of this study, thus covering the research approach, design, population and sample, methods of collecting and analysing data as well as research ethics and issues of reliability and validity. Chapter Four presents data analysis and interpretation. Chapter Five presents the findings of the study based on the analysis of the questionnaire data. These findings are presented considering research questions in mind, in order to identify whether research questions are answered. The chapter further presents the conclusion that is reached, limitations and recommendations.

## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 Introduction**

This chapter presents literature review on GIS, focusing mainly on the concept of GIS as a member of the geospatial technologies and trends and developments of GIS. The chapter discusses the benefits of GIS for geography teaching together with related factors influencing the integration of GIS into geography education. Finally, the measures taken to ensure an effective implementation of GIS in geography education are discussed.

#### **2.2 Definitions of GIS**

According to Chrisman (1999), defining GIS depends on the context in and purposes for which it is used. As introduced in Chapter One, GIS is often used in various organisations. As such, this suggests that the concept has been examined from different perspectives with scholars giving descriptions with multiple facets of GIS (Longley, Goodchild, Maguire, & Rhind, 2005; Melnick 2002). For Cromley and McLafferty (2012), a lack of standardised definition of GIS is because GIS is an enabling technology. The purpose of this section is to discuss various definitions of GIS.

Put generally as an enabling technology, GIS is defined as a computer system designed to collect, store, retrieve, manipulate, and display spatial data, which is represented by points, lines, and polygons along with the associated attributes (Clarke, 1986; Cole, 2017; Franklin, 1992; Kurlend & Gorr, 2007; Zhu, 2016). For Smith, Menon, Starr, and Estes (1987) GIS is a data-based system, in which most of the data are spatially indexed together with a set of procedures operating in order to answer queries about spatial entities in the database. Davis (2001) defines GIS as the integration of three elements: geography, information and system. In this view, GIS is a computer-based technology and methodology used for collecting, managing, analysing, modeling, and presenting geographical data for different purposes. Besides, Incekara (2012) construes GIS as a comprehensive mapping system intended to capture, store, analyse, synthesise, edit, retrieve, manipulate, and display spatial data collected or derived from earth's surface in the form of charts, tables or images. The implication of these definitions is that GIS is

a computer-oriented tool, which is used to gather, process, store and present real-world data into manageable forms used for different purposes. For this study, GIS refers to a computer-based teaching resource which is capable of collecting, storing, manipulating, analysing, retrieving and presenting real world data, which is valuable for teaching and learning of geography.

In general, it is noted that central to these definitions is that GIS collects, stores, manipulates, retrieves, and presents spatially referenced data, for organisational purposes. As for this study, the purpose of the spatial data will be for teaching and learning geography at secondary schools. Furthermore, these definitions are an important lens through which GIS can be defined in this study, the feature which helped the researcher to develop data collection techniques to discover how teachers understand the concept of GIS and its integration into teaching geography at schools.

## **2.3 Components of GIS**

In order for GIS to work, a series of components such as hardware, software, data, people and procedures are crucial. These components are discussed in turn below.

### ***2.3.1 Hardware***

Hardware is defined as the computer system on which GIS operates, and it involves computers, printers, plotters, digitisers and other important equipment (Davis, 2001; Gopi, Sathikumar, & Madhu, 2007; Heywood, Cornelius, & Carver, 1998). Similarly, Worboys and Duckham (2004) define hardware as the physical components of the computer system such as computer chips and keyboards. Based on the discussion, it can be noted that hardware acts as a backbone of GIS operations as it provides the platform on which GIS activities can be carried out.

### ***2.3.2 Software***

According to Worboys and Duckham (2004), software is comprised of all computer programs executed by a computer system. Phakde (2006) views GIS software package as having five technical modules: data input and verification; data storage and database management; data output and presentation; data transformation; and interaction with the users. Similarly, GIS software is entrusted with the responsibility to generate, store, analyse, edit, manipulate and display geographic information (Gopi et al., 2007; Kerimi & Akinci, 2009). Examples of GIS software include Esri's ArcMap, ArcExplorer Java Edition for Education (EEJEE), or Open

layers (Napoleon & Brook, 2008; Tamaszewski, 2015). For instance, Napoleon and Brook (2008) observe that EEJEE software has the ability to display and visualise data, analyse data, and create map layouts for printing. In other words, software comprises the programs which are necessary to perform desired activities.

### ***2.3.3 Organisation and people***

Organisations and people are regarded as an important element of the GIS infrastructure, for they put GIS into work to produce desired information (Davis, 2001; Montello & Sutton, 2013). Exploring the possibilities of operating the GIS, people are responsible for ensuring that GIS perform its functions as intended and search for ways in which GIS can be used effectively and efficiently to achieve the desired goals of any organisation (Shonts & Murray, 2007). Here, people can be categorised into three groups: viewers, general users and GIS specialists (Lo & Yeung, 2007; Montello & Sutton, 2013). Hence, it can be argued that people play an important role in the operation of GIS.

### ***2.3.4 Data***

Data is regarded as the core component of the GIS operations (Davis, 2001; Gopi et al., 2007; Tamaszewski, 2015). Data is the representation of the features of the earth (Davis, 2001). As Matthews and Herbert (2008) put it, these features may include landforms, field boundaries, vegetation types, and buildings. In addition, Kerimi and Akinci (2009) indicate that data represents certain geographical areas, objects or phenomena intended to serve certain purposes. This means that the features of the earth are collected using GIS for organisational purposes.

### ***2.3.5 Methodology***

The methodological component of the GIS encompasses all techniques and procedures which are followed when using both GIS and its data to achieve desired goals, whether individual or organisational (Davis, 2001). In Gopi et al.'s (2007) opinion, each organisation has its own unique ways of using GIS depending on different organisational purposes. Furthermore, Kerimi and Akinci (2009) stress the importance of the methodology of a GIS, more especially in its operation to facilitate attainment of the needs of the organisation. In general, the complexity of GIS, with each component being available and appropriate, is such that it can enable an individual or an organisation to achieve the set goals.

## **2.4 GIS as a member of geospatial technology**

GIS forms an important part of technologies which are classified as geospatial technologies. The notion of geospatial technologies can be described, with reference to the forms of technology which belong to geospatial technology. The concept is thus discussed specifically by justifying prioritisation of GIS amongst these technologies.

### ***2.4.1 Geospatial technology***

According to Zektser, Dzhamalor, and Everett (2007), geospatial technology refers to a group of technologies that are used to collect, process and classify data into digital format. Sui (2008) describes geospatial technology as a “suite of technologies that deals with where, what, when and how information can be obtained explicitly covering a particular locale, increasingly on multiple scales” (p.1). Solari et al. (2015) define geospatial technology as a tool associated with observing, measuring and analysing features of the earth. Central to these definitions is that geospatial technologies are used to gather information from a particular area of interest in the world. Actually, Makinster, Trautmann and Barnett (2014) aver that geospatial technology offers special ways to view, explore and understand the world. In other words, this technology provides a computer-based methodology through which people can study the world.

Many geospatial technologies, including GIS, Global positioning System (GPS), remote sensing, digital globes such as Google Earth, laser instrumentation, light detection and ranging (LIDAR), 3-and 4-dimensional visualisation, and Internet-based mapping (web mapping) have been indentified (Scholten, Velde, & Manen, 2009; Solari et al., 2015; Thurston, Poiker, & Moore, 2003; Zektser et al., 2007). As Thurston et al. (2003) and Zektser et al. (2007) stated, integration of these technologies revolves around GIS. Thurston et al. (2003) take a notion further, regarding GIS and GPS as more valuable tools for their unique ability to navigate, locate and analyse human-environmental relations. This implies that GIS and GPS help people to study relationships between people as well as between people and their environment in ways that facilitate better understanding. As a result, these technologies have been found to be resourceful thereby being incorporated into geography education. For instance, GIS, GPS, Internet-based mapping, and virtual globes have been integrated in K-12 classrooms in the USA (Alibrandi, 2003; Bednarz & Bednarz, 2008; the National Research Council, 2006). This view concurs with Solari et al.’s (2015) perspective who opine that digital technologies provide more opportunities

for learners to study the earth. As such, these particular technologies are important for helping learners to study the environment.

#### ***2.4.2 Justification for prioritising GIS among other geospatial technologies***

Although research shows that geospatial technologies are integrated into geography teaching, GIS is prioritised over all these technologies (Gerber, 2003). According to Gerber (2003), unlike other geospatial technologies, GIS is able to analyse complex phenomena from local to global scale; it provides more advanced ways of visualising and analysing data; it also unpacks relationships, patterns and trends, which are difficult to recognise with other technologies. Furthermore, Wang (2006) sees GIS as uniquely managing geographically referenced data, and having the capacity of spatial query, which locates information based on location relationship between features from different layers. Maantay and McLafferty (2011) report the main strength of GIS as lying in its power to incorporate many types of data with a known spatial component, thus visualising and processing these data quickly and efficiently. From Maantay and McLafferty's perspective, Anthamatte and Hazen (2011) affirm that by integrating several layers of data, GIS allows for discovery and exploration of spatial patterns in different phenomena. On the whole, these views suggest that GIS provides advanced strategies for dealing with spatially referenced data, which are unfeasible to execute with other forms of geospatial technologies.

#### ***2.4.3 GIS softwares for geography education***

There are different GIS softwares that geography teachers use for teaching. For instance, Keiper (1999) studied the use of ArcView GIS software in a Grade Five classroom. The use of ArcView software for teaching is corroborated by Shekhar and Xiong (2008), who expound that ArcView software is employed in the education system by an administration body, researchers, and teachers at primary, secondary and tertiary levels. Baker and White (2005) note that Internet-based online GIS have also been used for teaching purposes.

Generally, geospatial technology comprises a set of technologies which deal specifically with spatial data. However, as observed, these tools differ in terms of capabilities, with GIS as the leading technology amongst them.

## **2.5 Trends and developments of GIS**

GIS is not a new technology as it has long been adopted in many governmental as well as private agencies across the globe. Noted below are the trends and developments of GIS from the 1940s to the early 2000s.

According to Bracken, Higgs, Martin, and Webster (1989), an overview of GIS application in the UK, the USA and Canada provides useful insights into the trends and developments of GIS. Elangovan (2006) affirms that GIS emerged in the 1940s and 1950s, and its widespread was motivated by the successful implementation of computer-based graphical data processing at Massachusetts Institute of Technology and Database Management System by General Electric in 1965. Furthermore, research reveals that the first incarnation of GIS was developed in the form of Canada Geographic Information System (CGIS) in the field of GIScience (Brooks, Butt, & Fargher, 2017; Elangovan, 2006; Fazal, 2008; Kerimi & Akinci, 2009). That is to say, Elangovan (2006) and Fazal (2008) in their respective studies aver that CGIS was used in Canadian government agencies for land and resource management. This aligns with the Tomlinson (1987) view that GIS was initially used for environmental management, in particular, land-based resource management such as forests. The afore-stated views imply that GIS emerged as a new tool that was used for management purposes in the 1960s.

Besides the development of CGIS, the Bureau of the Census contributed to GIS developments in the late 1960s amidst some challenges facing developments of tools for conducting the 1970 population census (Fazal, 2008). Hence, the Bureau of Census developed the DIME (Dual Independent Map Encoding) program and used it to create digital records of all the US streets. As a result, the similarity between DIME program and CGIS was established, leading to the introduction of a GIS-related program at the Harvard University Laboratory for computer graphics and spatial analysis, and in turn resulted in the production of ODYSSEY GIS in the late 1970s (Longley et al., 2005; Peuquet & Marble, 1990).

Amongst the first users of GIS, Coppock and Rhind (1991) note the public or quasi-public institutions concerned with large spatial datasets in the form of maps. Adding to the discussion, Cromley and McLafferty (2012) state that in the US, local government employed GIS to create and manage cadastral databases, digital land parcel or property databases, while Longley et al. (2005) found the GIS software as comprised of computer routines which were easier to operate.

This means that GIS has been used to deal with very large data that was challenging to manage prior to GIS introduction. This also shows that GIS was becoming popular amongst organisations and agencies, especially those dealing with spatial data.

Longley et al. (2005) assert that as the GIS market grew, there was a high demand for advanced software with a standard user interface from the 1970s to 1980s. Kerimi and Akinici (2009) further stated that GIS industry experienced rapid growth, which, in turn, led to the development of world-leading companies in GIS software such as the Environmental Systems Research Institute (ESRI) and Intergraph. As a result, the end of the 1970s and beginning of 1980s saw the standard means of communicating with a GIS type in the command lines. However, Cromley and McLafferty (2012) contend that command-based or query-based user interfaces were difficult to operate since they required the users with advanced technical skills. This implies that users experienced challenges using GIS, resulting in further developments of GIS. This resonates with Peuquet and Marble's (1990) assertion that the late 1970s marked the end of the "local hand-crafted GIS" and the advent of new advanced systems.

In addition, Dangermond and Movehouse (1987) note that hardware developments such as larger memories for lower cost, desktop computers with high levels of graphics performance and low cost, reliable output devices such as inkjet printer were developed, thus having a greater impact on GIS from the 1980s to the early 1990s. In an attempt to address software issues experienced in the 1970s, two key developments were made in the 1980s: command line interfaces were first supplemented and later replaced by graphical user interfaces (GUIs), which simplified the way users operate GIS and a customisation capacity was introduced in order to create specific-purpose applications in the generic toolboxes (Longley et al., 2005). Similarly, in the 1980s, GIS was considered crucial for the state and municipal planning agencies, leading to the development of low-cost GIS system such as Map Analysis Package (MAP), (Ehrgott, Figueira, & Greco (2010). This suggests that GIS has been growing over the decades, resulting in development of various GIS softwares with differing capabilities.

By the same token, during the 1990s, widespread of GIS was motivated by the application of GIS by the local government in the UK (Campbell & Masser, 1995). For Stillwell, Greertman, and Openshow (1999), in the mid-1990s, desktop mapping packages such as Arcview were developed which were used as presentation tools by the businesses. Such developments were

soon followed by the introduction of powerful personal computer-based GIS software (Ehrgott et al., 2010). This is corroborated by Sugumaran and Degroote (2011), who claim that in the 1990s, there was a shift from workstation-based GIS to systems based on personal computer. The authors further observe the second half of the 1990s as marked by commercial systems such as ESRI's ArcMS (Arc Internet Map Server), thereby attributing such developments in GIS to the growth of the Web. As a result, GIS shifted from desktop-based system to more Web-enabled GIS (Abdul-Rahman, & Pilouk, 2008; Sugumaran & Degroote, 2011). This view has been shared by Li, Dragicevic, and Veenendaal (2011) and Schreibman, Siemens and Unsworth (2016), who indicate that Web-mapping platforms such as ESRI' ArcIMS emerged in the 1990s and continued growing into the early 2000s.

Most importantly, the above discussion has detailed the development of GIS over time. It has also shown GIS softwares that were developed during the period. Based on the discussion, it can be argued that GIS is increasingly growing since coupled with its fast developing market. This growth coincides with the need for more advanced GIS softwares, the feature which probably heralds a highly improved GIS development in the future.

## **2.6 The status of GIS in school geography**

Integration of GIS into secondary geography education amongst different countries has been carried out in different periods. However, Scholten et al. (2009) report that GIS integration shows both similarities and differences amongst countries. It is the purpose of this section to discuss the status of GIS in school geography.

According to Johansson and Pellika (2006) and Scholten et al. (2009), in the US and Canada, GIS was allotted space in the geography curriculum in the 1990s. Scholten et al. (2009) take it further, stating that Nellis (1994) and Sui (1995) were amongst the first people to instil motivation and interest in GIS application to geography in the US. In addition, Kerski (2001) reported on the widespread of GIS as an important learning tool in the US. However, less than 1% of the high schools were using GIS in teaching. In his subsequent study, Kerski (2003) discovered that amongst 20, 000 high schools in the US, GIS was available in less than 1, 600 schools, with only half of the teachers having used GIS more than once in their teaching. This implies that although GIS is part of the geography curriculum in US, its application to geography is low.

According to Longley and Clarke (1995), geography is fundamental to the curriculum in the UK. In fact, research indicates that geography education offered in the UK is more advanced than that offered in the US (Department of Education and Science, 1991; Rawling, 2002). Just like in the US and Canada, GIS was introduced in geography in the UK in the 1990s where it became an integral part of geography curriculum (Bednarz, 2004; Wiegand, 2001). This suggests that GIS is viewed as an imperative teaching resource in the teaching of geography in the UK. Hence, Scholten et al.'s (2009) emphasis on the central role of GIS in geography teaching points to the value of the subject in the curriculum of the UK. However, this alone does not prove GIS as used effectively. Ordnance Survey (2004) reports that GIS is not often used by teachers during instructions in the UK. As such, the case of GIS in the UK implies that GIS is not frequently used in schools, despite being an integral part of the geography curriculum.

Besides Canada, the USA and the UK, GIS has been found to be part of geography education in many more countries: Germany introduced GIS in the 1990s (Scholten et al., 2009) and Turkey in 2005 (Aladag, 2010). Demirci (2008) also notes that Austria, Belgium, Europe, France, Finland, and Sweden have integrated GIS into the geography teaching. Included amongst these countries is China, which implemented GIS in its education system (Kerski et al., 2013). It is, therefore, worth noting that many developed countries have integrated GIS into geography curriculum.

In developing countries, particularly in Southern African region, only South Africa and Zimbabwe have integrated GIS into geography education. As discussed earlier, South Africa integrated GIS into geography curriculum in 2006 as part of the National Curriculum Statement (NCS) for Grades 10, 11 and 12 (Scheepers, 2009). Although GIS was implemented in 2006, Breetzke, Eksteen and Pretorious (2011) argue that the interest in GIS was evidenced in the NCS of 2003, thus prescribing GIS as a skill to be acquired by learners. Fleming (2016) added that GIS was later incorporated into the Curriculum Assessment Policy Statements (CAPS) in 2013. Regarding the implementation of GIS, Breetzke et al. (2011) report that Grade 10 students are taught the general concepts of GIS and geographical concepts. According to this view, Grade 11 learners are taught about functional components of GIS, while the Grade 12 are taught additional functional components of GIS (ibid, 2011). As noted above, with strong support by the NCS and CAPS, GIS is integrated into senior secondary education in South Africa. Despite such support,

some teachers are unaware of the potential of GIS in teaching. As Scheepers (2009) put it, “the level of GIS awareness is not yet very high in South Africa” (p.44). In Zimbabwe, the geography syllabus has a clear objective that states that learners should be able to “demonstrate basic knowledge of Geographic Information System (GIS) in resource management” (Ministry of Primary and Secondary Education, 2015, pg.1). In this syllabus, GIS is integrated as a standalone topic-map work and geographic information systems (ibid, 2015). This means that learners are only taught the basics of this software.

Likewise, other Southern African countries have policies and official documents advocating the integration of ICT, in general. Botswana is a typical example, having developed several documents with guidelines for the integration of ICT into education: the 1994 Revised National Policy on Education; the Vision 2016; and the Botswana’s ICT policy of 2004, known as Maitlamo (Mafuraga & Moremi, 2017). In *the Vision 2016*, the Government of Botswana (GoB) communicated its economic goals and strategies in order to achieve the goals. Central here the ICT document geared towards achieving a highly competent nation (GoB, 1999). In addition, the *Botswana’s ICT Policy* put forward a need for the government to integrate ICT into formal education, both as a subject and as a teaching resource (GoB, 2004). Furthermore, Isaacs (2007) reports on the GoB’s commitment to implementing ICT in education, highlighting PC laboratories provided at both junior and senior secondary schools. At tertiary level, the Faculty of Education at the University of Botswana offers a course which trains teachers to develop and use educational resources, including technology-based resources (Dimane, 2016). These views show that efforts are made to foster integration of ICT at schools in Botswana. Although these policies and documents provide the basis for integrating GIS, they are silent about implementing GIS as a resource for geography education.

In Namibia, the Ministry of Basic Education, Sport & culture (MBESC) developed a policy called *the Policy for Information and Communication Technology in Education* intended to cohere with progress in other countries as well as equip to learners with suitable skills for the information society (MBESC, 1995). One objective stated in this document was to ensure that all learners at school develop basic computer literacy skills. Equally significant is the Government of Namibia (GoN) (2004) which developed *the Vision 2030*, the national plan of which has been to improve the quality of life amongst the Namibians, with reference to the developed

counterparts. The GoN, amongst others, strategically improved the quality of education, introducing technology at schools and making it accessible to all (ibid, 2004). In addition, the GoN (2007) developed another document, entitled *the Education and Training Sector Improvement Plan* (ETSIP), which was meant, amongst others, to improve access to ICTs at schools. The government then introduced ICT as a subject, and trained teachers to use it in their classrooms. However, Chisholm, Dhunpath and Paterson (2004) discovered that while both the University of Namibia and the Polytechnic have resources, including skilled personnel to train teachers in ICT, stakeholders in education are silent about demanding the university to equip teachers with ICT skills. Besides, Ngololo, Howie and Plomp, (2012) report that while management aspects of the ICT policy showed high-to-medium levels of implementation, teachers in various subjects showed low levels of subject-specific ICT resources. In other words, the use of relevant ICT resources for each subject was limited. In summary, Namibia has made several attempts to improve the integration of ICT at schools. However, just like Botswana, Namibia is quiet about integrating GIS into geography education. As discussed in the previous chapter, Lesotho has policies and official documents, recommending the integration of ICT into education, although all of these documents overlook ways of integrating GIS into geography education.

On the whole, the discussion has shown that GIS is more often adopted in the developed countries than in the developing countries. However, the level of integration at schools in developed countries is low. Furthermore, the majority of developing countries advocate the use of ICT in teaching and learning. As noted earlier, only SA emphasised the integration of GIS into geography education. This suggests that the majority of Southern African countries lag behind in terms of subject-specific technology-based resources such as GIS. Moreover, in the study conducted to analyse the status on GIS in thirty-three countries, Kerski et al (2013) concluded that the current global landscape of GIS is small for secondary education. By the same token, Tan and Chen (2015) reported that the levels of integration of GIS in both developed and developing countries is low. It can, therefore, be concluded that the status of GIS in school geography is low. This observation thus calls for more efforts to ensure full implementation of GIS at schools.

## **2.7 Benefits of integrating GIS in the teaching and learning of geography**

GIS is integrated into geography curriculum in many countries because it is deemed to be a paramount teaching and learning tool. As such, GIS is the area of study which should be adopted by learners and teachers for attaining national standards. In this section, the benefits of using GIS in geography education are discussed.

### ***2.7.1 Development of spatial thinking skills through GIS***

The study conducted in the USA found the manner in which GIS helped learners to develop spatial thinking skills (Audet & Abegg, 1996; Bednarz, 2004; Houtsonen, 2006; Johansson, 2006; Palladino, 1994). To elaborate, Brooks et al. (2017) identified three elements of spatial thinking such as spatial visualisation, spatial orientation and spatial relations. This suggests that learners develop visualisation skills which enable them to establish relationships between any given phenomena. Concurring with these views, Bednarz (2001) reports that geographers' strong argument for integrating GIS into geography curriculum is its purported ability to enhance learners' spatial thinking skills. It is for this reason that GIS is incorporated into geography curriculum in the US (Gerber, 2003). Similarly, in Australia, Kidman and Palmer (2006) discovered that GIS promotes development of spatial thinking abilities, involving concepts of space, visualisation and reasoning. This implies that GIS offers learners an opportunity to unravel a phenomenon and its causal relations.

In addition, in the UK, Fargher (2004) took a GIS sample lesson in geography, studying the extent to which Titanic disaster in 1912 was natural. Thus, the author examined the ship's course, location, ocean currents, sea depth and the influence of the continental shelf, and concluded that GIS enhanced spatial skills of learners, particularly noting visualisation, locational understanding, map projection, and understanding of scale. Besides that, Perkins, Hazelton, Erickson, and Allan (2010) in their study communicate that during the three-day GIS curriculum; they noticed an increase in the learners' spatial awareness in K-12 education. Nevertheless, some scholars have raised concerns whether GIS promotes spatial thinking. For instance, in his foregoing study, Bednarz (2004) declared lack of or inadequate research, proving GIS as enhancing learners' spatial thinking skills. This, therefore, implicates that more research is needed so as to substantiate whether and the extent to which GIS is a tool for spatial thinking skills.

### ***2.7.2 GIS as a tool for promoting geographical skills***

Besides development of spatial thinking skills, GIS is an efficacious tool for promoting other geographical skills such as thinking, analysing, synthesising spatial data, map-reading and interpreting (Audet & Abegg, 1996; Lemberg & Stoltman, 1999; Palladino, 1994; Pottle, 2001; Shin, 2006). Taking the point further, Shin (2006) claims that through GIS, learners are able to analyse and infer about spatial data, while Keiper's (1999) study examined the cognitive implications of integrating GIS in K-12 education. The study discovered that by using GIS, learners changed their learning style from memorising information to practising geographic skills. For West (2003) GIS is a support tool for learners to develop higher-order thinking and provide learners with varying strategies through which to solve environmental problems. Furthermore, in the UK, Fargher (2006) maintains the role of GIS in assisting learners to develop critical thinking and creativity skills, which form an important part of geographical skills. In other words, learners are able to study environmental issues around them and think about how such issues have occurred. In the process, learners develop critical thinking abilities.

Moreover, the Geography Education Standards Project (GESP) (1994) postulates that application of GIS to geography teaching and learning allows learners to develop numerous geographical skills, including the capability to organise and analyse geographic data, ask critical questions as well as to provide reasonable answers to the questions under study. Correspondingly, Wanner and Kerski (1994) assert that American learners developed the ability to analyse and display geographical data when GIS was used. In spite of the above findings, Kerski (2003) argues that in the inquiry-based lessons with GIS, there were no signs showing that learners developed geographical skills. Nonetheless, recent studies support the ability of GIS to develop geographical skills amongst learners. For instance, Liu, Bui, Chang, and Lossman's (2010) study in Singapore evaluated a problem-based learning in an experimental group and a control group respectively, and used GIS only in an experimental group. They report that while students in the control group memorised teaching material, students in the experimental group engaged in higher-order thinking skills, more especially analytic and evaluative skills. This suggests that through interaction with GIS, learners are able to develop various geographical skills. As such, learners have been found to be able to think, analyse and evaluate geographical information as presented to them.

### ***2.7.3 GIS and deeper understanding of geography content***

In addition to geographic skills, GIS helps learners to understand geography content better. That is, through employing GIS in geography lessons, Solemn (2001) and Shin (2006) reveal that learners were able to respond to questions and perform well on tests. Furthermore, Smith (2002) affirms how GIS offers learners' opportunities to explore and understand many issues in the geography curriculum. When exemplifying, she notes that students can scrutinise patterns and features in physical and human environments, and determine relationships between them. In the same way, Hall-Wallace and McAullife (2002), cited in Stevenson, Brody, and Dillon (2013) used GIS-based activities to equip learners with plate tectonics, and thus observed students' demonstrable improved understanding of content. Kerski (2003) observed the role of GIS in increasing students' ability to synthesise, identify and evaluate reasons for human activities on the environment. Corroborating Kerski, the NRC (2006) expounds that GIS allows learners to solve local problems with real data. This is because GIS presents learners with real-world socio-economic and environmental issues, and makes them suggest suitable strategies for solving such issues basing themselves on the observation of these issues through GIS. Ida et al. (2014) take it further, indicating that GIS' ability to manipulate data and manage large datasets promotes learners' understanding of geographical information which would otherwise be difficult to access.

### ***2.7.4 GIS' impact on learners' academic performance***

Several studies have highlighted positive impact of GIS on students' academic achievement (Habibah & Arumugam, 2005; Othman, 2007; Vasugiammai, 2005). For instance, Vasugiammai (2005) found that Malaysian learners were excited when learning with GIS and understood the conceptual patterns and population distribution. Moreover, GIS was noted for facilitating spatial understanding among learners Biebrach (2005), thereby helping learners to visualise and analyse spatial information and ultimately making them develop a better understanding of geography content. According to Patterson, Reeve and Page (2003), GIS training conducted by a high school and a university alleviated students' understanding of geography. On completion of high school, these students participated in a field-based hands-on experience, using GIS and performed higher on test scores than university students who had not used GIS before (ibid, 2003).

### ***2.7.5 GIS and learners' motivation***

GIS also motivates learners to learn geography. Many studies report that GIS has the potential to motivate students to learn geography (Biebrach, 2007; Kepier, 1999; Kerski, 2000; Linn, 1997; Milson & Earle, 2008). This is supported by West (2003), who studied the levels of motivation on students using GIS and concluded that students were more focused when involved in GIS-related activities. Hence, Roberts (2003) proposes that a key element of inquiry learning is creating a 'need to know' in that, if GIS increases motivation, the 'need to know' element can have a positive impact on geographical inquiry. In other words, if GIS motivates learners, learners should be placed in a position where they will be willing to learn even more, for in-depth understanding. Added is the Turkish study on GIS and students' motivation, where Aladag (2010) found that students using GIS demonstrated higher levels of motivation than those who did not use GIS. It can, therefore, be stated that GIS creates an interesting and enjoyable classroom learning environment, which stimulates learners' curiosity to learn more.

### ***2.7.6 GIS as a tool for inquiry-based learning***

GIS helps facilitate inquiry-based learning. For instance, Fisher and Binns (2000) exemplified that geography learners can employ GIS in a geographical enquiry to investigate the potential customer base for alternative locations for a new supermarket. Contributing to the discussion, NRC (2006) expounds that GIS creates a rich, generative, inviting and challenging problem-solving environment. Besides, Kinniburgh (2009) views GIS as engaging learners in an inquiry-based learning, the aspect which is an integral to geography education. For instance, in Lesotho's geography syllabus, there is a section dealing with inquiry and presentation skills (Ecol, 2015). Therefore, GIS is imperative for inquiry-based learning.

Overall, this section has discussed the benefits of using GIS in geography education. Based on the discussion, it could be argued that GIS promotes development of skills and acquisition of geography knowledge, which are central to the teaching of geography. Literature, thus, shows GIS as not only having the potential to motivate learners, but also as an essential tool for geography lessons.

## **2.8 Factors constraining the use of GIS in geography teaching and learning**

Although the potential benefits of GIS for teaching and learning have been widely documented in the literature, its integration into secondary school education faces a number of impediments. The purpose of this section is to discuss the barriers to using GIS in geography education.

### ***2.8.1 Lack of teachers' understanding of GIS technology***

Research indicates that teaching with GIS has been challenging for teachers, more especially as a selection of appropriate teaching methods. However, it is noted that GIS, used together with appropriate teaching methods can effectively facilitate instructional processes and allow learners to acquire knowledge and skills as intended (Bednarz, 2004; Johansson, 2003; King, 1991; Singh, Singh, Weeman & Bergen, 2012; Wanner & Kerski, 1999). This is substantiated by the literature in that GIS software is 'educationally inappropriate' and requires advanced skills on the part of teachers (Bednarz and Van der Schee, 2006; the National Council for Geographic Education, 2006). Hence, teachers are unable to use it in their teaching. For instance, GIS requires the ability of the teacher to acquire and import data and convert them into suitable formats and size for use in the classroom. As a result, some teachers may not be able to perform these tasks (ibid, 2006). In the same way, Scheepers (2009) asserts that despite teaching learners about GIS, South African teachers found it difficult to incorporate GIS into their classroom teaching. In their respective studies, Biebrach, (2007), Ruas (2011) and Scholten et al. (2009) observe the difficulty of using GIS as due to the complexity of the GIS software. In other words, teachers are unable to apply GIS in their classrooms because it is demanding and requires sacrifices on the part of the teachers in order to understand and use it properly to achieve the instructional goals. These observations imply that the majority of teachers may not use GIS in their instructions because of its complexity.

Concurring with the discussion, Yap, Tan, Zhu and Wettasinghe (2008) posit that factors contributing to the difficulty in using GIS include lack of GIS training and exposure, insufficient peer support and inadequate lesson demonstrations by experienced GIS teachers. Contributing to the afore-stated views, Ruas (2011) and Bednarz and Audet (1999) state without comprehensive guidelines when planning for lessons with GIS and teaching models for using GIS, teachers experience difficulties when using GIS. This implies that if teachers are to effectively implement GIS in schools, there is a need to provide them with clear strategies or procedures through which

they can adopt GIS. Facing such challenges, Gonzalez and Donert (2014) teachers cannot easily establish an effective use of GIS as a tool for teaching and learning of geography.

### ***2.8.2 Inadequate training of teachers***

Teachers are often given short training sessions on the use of GIS. This, according to Gatrell (2004), is because teacher training institutions in the US do not provide teachers with training on the use of GIS. This means that teachers are expected to learn to use GIS on their own. Consequently, lacking in relevant skills to operate the tool, teachers may not use GIS even if it is essential tool for teaching. For example, in the survey to determine the knowledge and skills teachers have about GIS, Dermici (2009) discovered that 66% of teachers had no accurate knowledge regarding GIS and its role for geography teaching and learning and 82% of teachers stated that they do not have the skills to use GIS in geography lessons. This shows that when teachers are not introduced to and trained on using GIS, they may not integrate it into their lessons. This view is supported by Baker, Palmer and Kerski (2009), who assert that teachers who receive little training in GIS tend to teach without it.

In cases where GIS training is offered, it often focuses on equipping teachers with knowledge about GIS, rather than develop them with pertinent skills to providing models and strategies for integrating GIS into geography education. With limited teacher training on GIS, teachers return to work with fewer GIS skills (Gatrell, 2001). As a result, Baker (2005) recommends that training in GIS should at least take forty-hour duration or more, so that teachers can develop ample skills for operating GIS. On the contrary, Baker et al. (2009) argue that lack of training results from low levels of interest in GIS by educational stakeholders. This means that overlooking GIS as a valuable tool for teaching, the educational authorities may not invest on training geography teachers.

### ***2.8.3 High work load***

Besides inadequate training, increased workload of teachers acts as a barrier to the use of GIS. As postulated by Mehren and Uphues (2010), teachers are already overloaded at schools and the introduction of GIS has worsened the situation. For example, Hohnle, Schubert, and Uphues (2011) claim that teachers are expected to include more competence-orientated teaching and to incorporate the features of global education into their lessons. Furthermore, Neyland (2011) echoes this observation, seeing teachers as faced with an overloaded curriculum, so much that

the innovations such as GIS integration tend to lower chances of fruitful implementation. Besides, Abuhmaid (2011) explains that teachers are overloaded to learn, prepare and practise what they learnt. This means that teachers may not have time to practise GIS because of limited time they have. As a result, Fullan (2003) suggests that for teachers to realise or implement the aims of any educational system, it is crucial to have their workload reduced.

#### ***2.8.4 Lack of time***

Lack of time is a barrier to the integration of GIS in the classroom. As stated by Honhle et al. (2011) and Gonzalez and Donert (2014), teachers complain that GIS training consumes time set for teaching and preparing learners for examinations. Therefore, lack of time to attend training sessions may hinder the use of GIS in geography education. Furthermore, Neyland (2011) points out that many teachers have limited time to prepare lessons and units designed for both real-world data and geography content and skills. In other words, teachers require enough time for instructional planning so as to find ways of developing desired GIS knowledge and skills. Similarly, Baker et al. (2009) express a concern over limited time for teaching about GIS: what it is, how important it is for geography, or how it could help them to learn geography. Therefore, GIS may not be integrated at schools.

#### ***2.8.5 Financial problems and lack of GIS-related infrastructure***

Access to the information and communication technology (ICT) infrastructure is necessary for the integration of ICT into education (Plomp, Anderson, Law, & Quale, 2009). However, for the schools to provide such infrastructure as the GIS's hardware, software and data is expensive (Gonzalez & Donert, 2014; Olsen, 2002). In addition, Steve (1994) acknowledges that rudimentary computer infrastructure at many schools limits GIS use. For example, lack of electricity increases the costs for making GIS available at schools. Hence, financial constraints may slow down the provision and adoption of GIS. According to Addy and Olsen (2011), hiring GIS specialists for training teachers has been costly to governments. The case in point is Japan, where geography teachers have limited access to computers as a result of prioritising subjects such as Information for Computer Use, and that the cost of computer equipment and software poses affordability issues (Koseki, 2008; Ida et al., 2014; Minamino, 2003). As a result, this hinders the use of GIS at schools.

Based on the discussion it is noted that implementation of GIS is a challenging process, coupled with many obstacles to the GIS implementation. However, many of these problems can be overcome with proper measures to which we turn in the following section.

## **2.9 Measures which can enhance integration of GIS into geography education**

As discussed in the previous section, implementation of GIS is associated with a number of obstacles. This suggests that education stakeholders, including teachers, involved in implementing GIS should be well prepared for any challenges that may rise during the implementation process. As noted above, the following section discusses the measures which may be taken to overcome barriers to integrating GIS into geography teaching.

### ***2.9.1 Professional development of geography teachers***

In the first place, there is a need for professional development for teaching with GIS. According to GESP (1994), every computer system that teachers are entitled to use requires particular skills on the part of teachers. Should teachers use GIS effectively, they need exhaustive training. This notion is taken up by Kerski (2001), who puts as follows about GIS, “the tool itself has no answers; these come from human investigator” (p.131). This supposes that teachers should be skilled in order to use GIS to obtain the desired results for classroom learning. He also proposes one condition on GIS training: teachers from the same school should be trained together. This is fundamental to helping teachers to share the skills developed during and after training sessions. In addition, Smith (2002) states that there are websites dedicated to helping teachers in proper implementation of GIS, in that these websites comprise introductory materials outlining the principles and applications of GIS. This implies that through the websites, geography teachers can enrich their knowledge and skills about GIS. Also, when concluding his study, Kerski (2003) recommends that the approach to GIS should shift from ‘how can we get GIS into the curriculum’ to ‘how can GIS help meet curricular goals’. This implies that teachers should be given relevant training in GIS so that they can work towards attaining the curricular standards. Furthermore, Wallace (2004) states that teachers are the gatekeepers of educational changes and educational innovations. Hence, it is paramount to devote time to training them in innovations such as GIS. As key implementers of GIS, teachers should be given an ample time for training sessions so that they can develop the necessary skills.

However, Schleicher and Lawrence (2005) discovered that in numerous teacher-training institutions, GIS education is not offered to pre-service teachers. For instance, they discovered that in German's teacher-training institutions, GIS was not included as a basic competence for geography teachers. Similarly, in Lesotho, teacher-training institutions such as National University of Lesotho and Lesotho College of Education do not provide GIS education to teachers. Besides pre-service training, the NRC (2006) suggests that teachers should be provided with in-service training. However, while it is important for teachers to know what GIS entails, it is imperative to allocate a larger proportion of training duration to equip teachers with GIS-integration skills into teaching. One of the measures suggested is that training teachers should be embraced by structured infrastructure and continual professional support since GIS software requires continual upgrade (Ruas, 2011). In brief, GIS training should focus closely on developing teachers with relatable skills to give instructions on and with GIS. However, one observation from the afore-stated views is lack of clear, in-depth details about a teacher-training programme, including strategies adopted for teaching with GIS.

### ***2.9.2 Increased access to resources***

Also noteworthy is the increasing access to relevant resources in order to boost integration of GIS. All resources necessary for teachers to execute GIS in their teaching should be made available. Craig, Harris, & Weiner (2002) identify, as one of the most important resources, the GIS hardware and software. They point out that nowadays GIS tools are cheap and available since they are developed by many companies. This means that countries can easily access these companies to buy GIS tools for their schools. Added to the GIS hardware and software, are several books, published to provide teachers with relevant information regarding integration of GIS at schools. Malone, Palmer, and Voigt's (2003) title *Community geography: GIS in action*, intended to guide teachers on integrating GIS into their classroom practices is a typical example in the USA.

Furthermore, the NRC (2006) report that some GIS companies provide pertinent information packages to schools to enhance the use of GIS to achieve the educational objectives such as packaged information for teaching and learning about cyclones, dynamic earth and hurricanes. Similarly, in Turkey, a textbook, *GIS for teachers* was published to help Turkish teachers to understand and implement GIS at schools (Demirci, 2011). A similar case was found in Japan,

where Ito (2010), cited in Ida et al. (2014), introduced the concept of virtually free textbook-based lesson plans scheduled for fifty-minutes to be used as GIS teaching materials, with every lesson plan built on the previous one. The discussion suggests that as GIS tools and related books are available from diverse companies nowadays, education authorities including schools are responsible for supplying teachers with them so as to acquire more knowledge and skills applicable to teaching.

### ***2.9.3 Equipping learners with GIS skills***

Similarly, teaching learners about GIS is invaluable. As Gilbert (2004) stipulates, teachers should equip their students with relevant GIS skills applicable to real-life contexts. On the contrary, Lidstone and Stoltman (2006) argue that it is unclear how much GIS students should know, how they can use it to acquire geographic knowledge, and how long they will keep these skills in mind. As such, there should be clear guidelines on the strategies through which teachers can teach GIS to learners. For instance, at upper schools in the US, the Digital Quest's SPACESTARS program and the Looking at the Environment (LATE) project developed GIS courses geared towards grounding learners on and applying GIS skills (NRC, 2006). In South Africa as discussed earlier, students are taught about GIS applications from Grade 10 to Grade 12 (Scheppers, 2009). Gonzalez and Donert (2014) warn that although it is vital to teach learners about GIS, it is imperative to maintain the relationships and boundaries between GIS and geographical education. These views suggest that in order to develop the proper use of GIS in teaching geography, it is important to first teach learners about GIS as well as equip them with GIS-related skills. There is also a need to specify how much of GIS learners should know before using GIS (ibid, 2014). Based on the discussion, it is apparently important to train learners on the use of GIS. However, literature does not specify what aspects of GIS should be taught to learners. Until there are clear guidelines to that effect, the extent to which learners should be trained will remain vague.

### ***2.9.4 Re-design GIS software***

In the final analysis, it is important to re-design GIS software for educational purposes. As discussed earlier, GIS was not originally designed for teaching (Fargher, 2006; Kerski, 2003; Solemn, 2001). Therefore, GIS software should be redesigned if it were to succeed as a teaching resource in geography education. To do that, the NRC (2006) proposes three models for

redesigning the GIS software for secondary schools: academic, commercial and collaborative. Amongst these models, collaborative model is recommended because of its potential to involve several people from different backgrounds such as curriculum developers, government, academia and the K-12 user community. However, research fails to clearly show how the software should be designed in order to be regarded as an 'educationally appropriate' tool.

In general, the implementation of GIS is indispensable for all the stakeholders involved. That is, if teachers experience any difficulties at the implementation stage, relevant measures should be taken to overcome such obstacles. It is pivotal to having all the parties co-operate so as to successfully implement GIS in education. However, further research is needed to articulate what aspects and how much of GIS both teachers and learners should know before using GIS in teaching and learning. Finally, as discussed above, the need to redesign GIS software for teaching should be accompanied by comprehensive details on how the software should be designed.

## **2.10 Conclusion**

This chapter has discussed the relevant literature on GIS. First, the study has defined the concept of GIS, thus observing a number of definitions of the concept. Besides, the components of GIS as a tool have been provided, be they hardware, software, data, people and procedure. In addition, geospatial technology has been considered in the section. Interestingly, GIS has been found to be central to the use of geospatial technology. In other words, GIS is the superior system to all other aspects in focus. The chapter further examined the trends and developments of GIS, thus reflecting GIS as an increasingly changing technology. This phenomenon could be explained by having teachers continuously attend workshops to learn about the new software once the old one becomes outdated. Furthermore, amongst these trends and developments, one observes lack of software which is developed solely for teaching, yet there is growing demand for integration of GIS into education.

In terms of status of GIS in school geography, it is concluded that GIS is more highly advocated in the developed world than in the developing world, with the level of integration being low in cases where it is integrated. As such, this suggests that both developing and developed countries should work hard to fully implement GIS at schools. As such, education stakeholders should

work together to implement GIS as intended at schools where it has already been introduced. The developing countries, without GIS implementation should integrate GIS into geography curriculum and develop policies suitable for its adoption at schools.

Furthermore, the literature has discussed the benefits of using GIS for teaching. Here, it is noted that GIS not only promotes development of geographical knowledge and skills, it also makes learning interesting, meaningful, and contextually relevant to the learners. By using spatial data, GIS develops environmentally-friendly citizens. However, if not properly used, these benefits may not be harnessed, thereby constraining or hindering the integration of GIS into teaching and learning. Finally, the study has further discussed the measures which may be adopted to overcome the challenges facing the implementation of GIS. As indicated, there is a need to design and develop GIS software for teaching at schools in Lesotho and probably elsewhere.

## **CHAPTER THREE**

### **METHODOLOGY**

#### **3.1 Introduction**

This chapter discusses the procedures which were followed in the fieldwork for the study. The research approaches adopted for the study are presented. Specifically the following methodological areas are discussed in turn: research approach, research design, population and sample, methods of collecting and analysing data, as well as research ethics and reliability and validity issues.

#### **3.2 Research approach**

Researchers conduct studies in order to find relevant answers to questions of interest, using scientific procedures (Kothari, 2004). Three common approaches to research are identified. These include quantitative, qualitative and mixed methods (Williams, 2007). These approaches provide methodological steps through which data are gathered, managed and analysed in a given study (Wolcott, 2009). The choice of the research approach depends on the type of data to be collected (Williams, 2007). In this study, the quantitative approach is employed to allow the researcher to collect massive amounts of data in order to clearly answer the set research questions.

According to Houser (1998), the quantitative approach to research is defined as an approach which draws attention to the measurements and quantification of data. The quantitative research is also described as one which uses numerical data to describe and explain a phenomenon under study (Allen, Titsworth, & Hunt, 2009; Muijs, 2004; Muijs, 2011). Mertler (2016) and Leavy (2017) view quantitative researchers as often seeking to describe any situations, establish relationships that exist between variables of interest, or even to explain such relationships between variables. These definitions suggest that quantitative research deals with numerical data in order to obtain answers regarding the phenomena being studied. For this study, the quantitative approach is adopted to describe the current situations regarding integration of GIS into geography at schools. Mertler (2016) further indicates that quantitative research relies on the use of numbers, particularly statistics in both the collection and analysis of data. With this

approach, the researcher was able to gather data from many participants sampled for this study (Cottrell & McKenzie, 2011). This means that the researcher was able to reach out to as many schools and geography teachers as possible for the purpose of collecting data, which “truly” represented the population being studied. Besides, Boyley and Schmierbach (2015) stated that researchers, who follow quantitative approach, are able to draw conclusion because of the use of statistics. This was thus evident in this study, for it used descriptive statistics.

### **3.3 Research design**

The research design employed for this study is a descriptive survey. According to Simon and Katz (2003), a descriptive survey is a research design which is entrusted to provide descriptions of aspects of people or things under study. Mangal and Mangal (2013) define such a research as one which employs survey techniques to describe the characteristics or variables of a particular group of individuals, institutions or systems under study. These definitions imply that a descriptive survey seeks to give a detailed account of valuable characteristics which are evident in the study and/or about the particular issue being studied. For Wimmer and Dominick (2011), and Harvey and Land (2017), a descriptive survey describes what exists at the moment, thus explaining a current situation of the issue being studied.

On this basis, a descriptive survey was appropriately used, and it allowed the researcher to collect data directly from the respondents about their opinions, knowledge and perceptions of GIS. This is cited in literature as one of the advantages of using descriptive surveys (Houser, 2012). A similar case has been reported by Mangal and Mangal (2013), stating that this particular research design is used to develop a clear picture of a certain group of people regarding their desired characteristics or variables under study. Furthermore, with the descriptive survey, the researcher was able to identify both opportunities and challenges for integrating GIS at schools.

Drawing on the appropriateness of a descriptive survey, and its potential to yield massive data about the present characteristics and conditions of the population being studied (Brink & Wood, 1998), the researcher was able to investigate geography teachers’ perceptions of attitudes towards GIS and its role in geography teaching and learning. The researcher observed available potential as well as possible constraints for integrating GIS into geography as observed by

teachers. In other words, through the descriptive survey, the researcher developed a clear picture of the issue being studied

### **3.4 Population**

The population for the study comprised of twenty secondary schools that offer geography education in the urban area of Maseru, Lesotho.

### **3.5 Sampling**

The convenient sampling technique was used to select schools in the area of research interest. By convenient sampling is meant a sampling procedure which draws the sample in terms of the readily available sampling units (Sim & Wright, 2000). This sampling is often used when the researcher recruits people who are available and willing to participate in the study (Johnson & Christensen, 2011). These schools were chosen because they were convenient for the researcher in that they were accessible and required less transport fees since one travels a short distance between the researcher's and these schools, which are even clustered in one area. As such, all geography teachers in those schools were asked to participate in the study. A total of twenty schools offered geography in the Maseru urban area, and those schools, 75 teachers taught geography. As a result, 75 geography teachers participated each of which was given a questionnaire (75 in all) to complete. Out of 75 geography teachers, only 64 teachers completed and returned the questionnaires, thus giving the return rate of 85%. This shows that there was a high return rate of questionnaires, the aspect which greatly helped the researcher to obtain much information so as to answer the research questions under study. In this way, there have been increased chances for the data to fairly represent the sample, thereby minimising the sample bias (Burns, & Grove, 2011; Monette, Sullivan, & Dejong, 2011). Of all the returned questionnaires, only one was discarded with most of the questions unanswered. This means that only 63 questionnaires were used and analysed in the study.

### **3.6 Methods of data collection**

As has been noted above different ways of collecting data for scientific studies have been noted. This study used a questionnaire to collect data on the opportunities and challenges for integrating GIS into geography education. Research has shown that a questionnaire is a productive method

of collecting data in a descriptive survey (Houser, 2012; McNabb, 2010; Sim & Wright, 2000). This study has therefore used questionnaires to gather data to answer the research questions.

According to Brace (2008), a questionnaire refers to both the set of questions to be answered by the survey participants and to survey instruments to be administered by an interviewer, either in a face-to-face interview or by telephone. Correspondingly, a questionnaire is defined as a printed self-report form that is designed to elicit information through written or verbal responses of the subjects under study (Burns & Grove, 2011). These definitions suggest that a questionnaire is a form of data collection technique which involves planning and setting out questions to be distributed and answered by participants on the topic of interest, being researched either on their own or by being guided. Furthermore, a questionnaire is used in research for different purposes. As stated by Brace (2008), a questionnaire is used to provide a standardised interview across all subjects. This is cited as the key in most survey researches (ibid, 2008). In addition, McNabb (2010) sees a questionnaire as a technique used to generate data to specific questions pertaining to the attitudes, opinions, motivations, knowledge and demographics, to mention a few. Literature also indicates that a questionnaire can be used to generate data from a large number of respondents, either a population or samples (Anderson & Arsenault, 1998; Burns & Grove, 2011; McNabb, 2010).

In addition, a research questionnaire can be developed by open-ended questions and or closed-ended questions (Ary, Jacobs, & Sorensen, 2010; Sim & Wright, 2000). The study has used closed-ended questions. As defined in the literature, a closed-ended question is a question that is accompanied by a set of predetermined, relevant response alternatives, from which the respondents can choose their answers (Ary et al., 2010; Clow & James, 2014; Proffetto-McGrath, Polit, & Beck, 2010; Royse, 2008). Taking the point further, Proffetto-McGrath et al. (2010) indicate that an alternative list may comprise simple answers such as yes or no, or extend to complex expressions of opinion.

Closed-ended questions are used because they require limited time for tabulating and coding data for computer analysis (Royse, 2008). This is because the response choices are available, and the researcher is not required to decipher lengthy responses from the respondents. By the same token, Ary et al. (2010) attest that although constructing closed-ended questions is time-consuming, this form of a questionnaire permits the researcher to easily tabulate the respondents'

responses. The authors continue to show that respondents can answer the questions without any difficulty (ibid, 2010). As a result, this likely increased chances for the respondents to complete and return questionnaires. The researcher used the literature review to design a questionnaire, which constituted more closed-ended questions than open-ended questions. The questionnaire items included biographical details and computer skills, integration of ICT into education, GIS questions, school facilities and measures that can be used to improve integration of GIS. It should be noted that some of the questionnaire items, especially computer skills and use, as well as technology use were extracted from Chere's (2011) thesis. The questionnaire has, therefore, been vital for this study as it helped the researcher to gather rich data on the perspectives of teachers regarding integration of GIS.

### **3.7 Data analysis**

The preceding section discussed the instrument that was used to collect data in answer to the research questions. Once gathered, the data should be analysed using relevant methods in a research. Data analysis is a procedure followed to reduce, organise and give meaning to data (Offredy & Vickers, 2010). However, Conradi and Wang (2003) assert that these methods should be chosen based on the type of survey and the data collected. As such, this study used descriptive statistics to analyse the data gathered through questionnaires.

As discussed in the literature, descriptive statistics are techniques which are used in research to describe or summarise large amounts of data from large samples in an abbreviated form for better understanding (Aldrich & Cunningham, 2015; Lodico, Spaulding, & Voegtler, 2010; Macfie & Nufrio 2006; Malici & Smith, 2013; Vercruyssen & Hendrick, 2012). Moreover, describing numerical data in a comprehensible order, descriptive statistics use mathematical techniques, thus making the data understandable to readers (Ingleby & Oliver, 2008; Reviere, Berkowitz, Carter, & Ferguson, 1996; Sim & Wright, 2000). Reviere et al. (1996) further see statistics as useful techniques used to summarise, describe, examine, and explain the survey findings in a succinct ways (ibid, 1996). Therefore, in this study, the researcher was able to identify contributing factors to the integration of GIS as shared by the research participants.

There are different ways through the researchers can analyse data using descriptive statistics. In this study, the researcher used frequency tables as well as bar charts. This usage was motivated by the fact that tables and charts help to summarise large amounts of data in a simple form, and

can convey much information effectively (Chiang, 2003). Frequency tables also show how variables are distributed in the population under study (Mathur, Muralidharan, Parthasarathy, Batugal, & Bonnot, 2008). Through descriptive statistics, simplified by frequency tables and bar charts, the researcher was able to clearly analyse and interpret the data. As a result, the researcher was able to identify key findings from the collected and analysed questionnaire data.

### **3.8 Research ethics**

The way researchers approach, interact, and treat human participants raises ethical concerns (Wallimman, 2011). Like in any other studies research ethics in this study were based on the three principles developed by Belmont (1978) such as beneficence, respect and justice for persons. Beneficence is defined as a principle of doing no harm to the participants (ibid, 1978). This principle is explained by Leathard and McLaren (2007) as a situation in which the researcher should protect the wellness of the participants. This was maintained by the use of appropriate words when talking to the respondents, with the researcher also avoiding putting the respondents' lives at risk, but ensuring their voluntary participation in the research.

The principle of respect encompasses both the right to self-determination and the right to full disclosure (Stommel & Wills, 2004). This suggests that the researcher is expected to obtain an informed consent from the participants by providing them with detailed information regarding the research, including the description of and rationale for the research, thus assuring the participants of their right to withdraw and confidentiality (Buchanan, 2004). This ethical consideration was ensured in this study by asking the permission from each school principal to allow the researcher to ask for assistance from his or her geography teachers. The researcher also introduced herself to geography teachers and explained the study, its importance to them, and asked them for participation by completing the questionnaire. Regarding confidentiality, the researcher informed the respondents that the information was to be used for only this study and allowed them a right to remain anonymous; the participants were further assured of their right to participate in and withdraw from the study if they wanted to. Indeed, in some schools, teachers stated that they were not going to complete the questionnaire, and the researcher respected their decisions.

In terms of the principle of justice, the researcher should ensure that the right to privacy of the participant is protected in that too personal information is not required in the study (Tietze,

2012). This was evident in the study because the researcher only asked the respondents to complete the questionnaire, without interfering with their personal matters.

### **3.9 Reliability and validity**

In research, the researchers should consider issues of reliability and validity of the instrument because the weakness of either of the two can threaten the findings of the study as well as the conclusions drawn about the study (Klenke, 2008). According to Woodrow (2014), reliability refers to the consistency of the results (Kumar, 2011; Woodrow, 2014). This means that if researchers were to conduct a study again with similar subjects, they should obtain similar results to those obtained previously. On the contrary, validity is defined as the extent to which an instrument measures what it is intended to measure (Kumar, 2011; Woodrow, 2014). In other words, validity is concerned with the relevance of an instrument to addressing the purpose of any study (Hancock & Mueller, 2010).

Premised on the above principles, the researcher ensured reliability and validity in this study by tailoring all the questions to the main research questions and addressing research questions completely (Thomas, 2004). Ramlaul and Hogg (2010) shared the same notion, emphasising researchers' recourse to consider reliability and validity of the tool when developing and using a questionnaire. Taking the point further, Stangor (2011) suggests that researchers ensure that content of the measurement technique represents the literature on the topic accurately. Hence, in this study, the researcher reviewed the literature as in Chapter Two as the basis for setting questions related to the literature per se.

Besides, the researcher used pilot testing as a means to validate the instrument and data for the study. From the Fink's (2013) perspective, pilot testing strengthens validity and reliability in that it helps the researcher to see that all topics are included coupled with a variety of the responses to the questions. Pilot testing was, therefore, administered with three schools, in which case 10 questionnaires were distributed, only seven of which were collected from geography teachers at the selected schools. Noted here is that the results were useful because the researcher was able to edit the questionnaire, thereby ensuring relevance and clarity of the questions asked.

### **3.10 Conclusion**

This chapter has discussed the methods and all procedures used to conduct the research. The researcher considers these methodological practices useful in the study because she was able to collect, analyse data as well as discuss the findings of the study from which conclusion have been drawn.

## CHAPTER FOUR

### DATA ANALYSIS AND INTERPRETATION

#### 4.1 Introduction

This chapter presents the analysis and interpretation of the questionnaire data. Data are analysed using descriptive statistics because they help to provide meaningful summaries about the sample (Trochim, Donnelly, & Arora, 2015). In other words, these statistics help the researcher to clearly describe and summarise the basic features of the data as discussed in Chapter Three. Besides, for logical purposes, the data are analysed in answer to the main research questions of the study as stated in Chapter One. The analysis starts with biographical details, and it is followed by analysis of the data starting with research question one to research question four. Conclusions from the analysis are finally drawn.

#### 4.2 Biographic details of respondents

Demographic information of participants is vital in data analysis because it can enable researchers to compare views of different respondents on the issue under study (Gatewood, Field, & Barrick, 2011). Therefore, this part of the analysis provides biographical details of respondents, focusing on their gender, age groups, qualifications, areas of subject specialisation and a length of teaching experience. Personal details of the respondents are also anticipated to help the researcher to contextualise the findings and make relevant recommendations about the phenomenon being studied.

**Table 4.1 Personal information of respondents**

Variable	Biographical group	Count	Percentage
Gender	Female	42	69%
	Male	19	31%
Age portion	20-30	12	19%
	31-40	24	38%

	41-50	16	25%
	51-60	10	16%
	61+	1	2%
Qualification	Diploma	6	10%
	Degree	41	65%
	Honors	11	18%
	Master's degree	5	8%
	Others	0	0%
Areas of specialisations	Geography & Sesotho	12	19%
	Geography & DS	12	19%
	Geography&Mathematics	2	3%
	Geography and History	4	6%
	Geography & Economics	1	2%
	Geography and English	18	29%
	Geography and Religion	2	3%
	Geography & Literature	1	2%
	Geography and Science	9	14%
	Geography & Special Ed	1	2%
Teaching experience	0-5 years	14	22%

	6-10 years	12	19%
	11-15 years	11	17%
	16-20 years	13	21%
	20+ years	8	13%

**(a) Gender:** of all the teachers contacted, 69% are female, and 31% are male. It is clear that both males and females are represented in this study although there are more female respondents than their male counterparts.

**(b) Age portion:** As shown in Table 4.1, age groups of respondents range from 20-30 to 61 and above, whereby most respondents (38%) are between 31-40 years old; of these only 1 (2%) respondent is over 61 years of age. One would, therefore, assume that teachers in the lower-age groups are likely to know better about technologies such as GIS because they are young and interested in using technology.

**(c) Qualification:** Table 4.1 shows that 41 (65%) respondents are bachelor's degree holders, while 6 (10%) respondents have diplomas. This implies that most respondents have degree as their qualification, the qualification which can enable respondents to understand geography and appreciate the need to use technological resources in the teaching and learning of the subject.

**(d) Areas of specialisation:** the results show that 29% constitutes qualified geography and English language teachers. In fact, 62 respondents are qualified geography, who had taken geography as one of their areas of specialisation. In other words, they have knowledge and skills relevant to teaching geography.

**(e) Length of teaching experience:** based on the percentages for age groups: 6-10 (19%), 11-15 (19%), 16-20 (21%), and 20 and above (8%), it is noted that a large number of respondents have long teaching experience. This shows that most respondents are experienced geography teachers. It can be expected that these groups of respondents have mastered f teaching methods, so much that they can incorporate technology into their teaching.

### 4.3 Teachers' understanding and knowledge of GIS

This section presents the understanding and knowledge of respondents about GIS. The data analysed in this section are significant for the study because teachers' understanding and knowledge about GIS are key to the integration of GIS into school geography.

#### 4.3.1 Knowledge about GIS

This research question was to know whether respondents have ever heard of GIS. This question will help to establish whether teachers know anything about GIS.

**Table 4.2: Teachers' awareness of GIS**

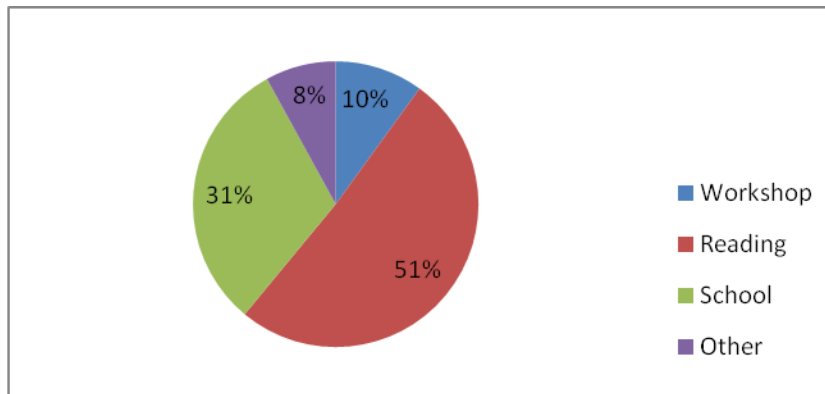
Variables	Frequencies	Percentages
Yes	41	67%
No	20	33%
Total	61	100

Missing=2

As shown above, 67% of the respondents have heard of GIS, while 33% have not. This implies that the majority of respondents have an idea about GIS.

#### 4.3.2 Teachers' Sources of GIS knowledge

The respondents, who have heard of GIS, were requested to identify their sources of information about GIS. A total of 39 respondents attempted this question, and the results are shown in Figure 4.1 below.



**Figure 4.1 Respondents' source of knowledge about GIS**

Looking at the results, the highest percentage of respondents (51%) is noted as having heard of GIS from reading, with the lowest percentage of respondents (8%) having heard from ‘other’. This means that for most respondents, knowledge about GIS is derived from reading. Those, who have heard from elsewhere, were required to specify. They have been found to have heard of GIS from colleagues, the media and teachers. Besides, 31% of the participants have heard of GIS from school, whereas 10% have heard from workshops. This suggests that some teachers were introduced to GIS while at schools.

**4.3.3 Teachers’ basic knowledge of GIS**

To examine the teachers’ basic knowledge about GIS, three knowledge items were used. Table 4.3 presents the data on the degree to which teachers agree or disagree with the statements.

Table 4.3: Respondents’ level of agreement or disagreement with GIS knowledge statements

<b>Statements</b>	<b>Agree</b>	<b>Strongly agree</b>	<b>Disagree</b>	<b>Strongly disagree</b>	<b>Not Sure</b>
<b>(a)</b> GIS is a computer system used to collect, store, retrieve, manipulate, and present spatial data	50%	17%	5%	0%	28%
<b>(b)</b> GIS is a member of the geospatial technology	42%	22%	0%	0%	36%
<b>(c)</b> Geospatial technology refers to a group of technology that is used to explore, view, or study the environment.	58%	11%	2%	0%	30%

The data presented in Table 4.3 show that of the 58 teachers who responded to the question, 50% “agreed” with the provided definition of GIS. This could mean that they not only knew the definition, but they also considered it suitable for GIS. Another group of respondents (17%) “strongly agreed” with the GIS definition. This is an indication that they understand GIS. Besides that, 5% responded that they “disagreed” and none of the respondents strongly disagreed with the statement, while 28% were not sure about GIS. Hence, it can be argued that 67% of respondents understand GIS, as 50% agreed and 17% strongly agreed with the definition of GIS respectively.

The results further show that 42% of respondents agreed that GIS is a member of geospatial technology. In other words, most respondents understand that GIS is a geospatial technology. Therefore, these results suggest that respondents not only accept the GIS definition, but they also associated it with geospatial technologies. However, 36% of the respondents are not sure of the statement about GIS.

Regarding teachers’ knowledge of geospatial technologies, the data illustrate 58% of the respondents as agreeing with the given definition of geospatial technology, with 30% of the respondents being uncertain. This indicates that while most respondents understand geospatial technology, few respondents lack knowledge about the technologies which are associated with the teaching of their subject, particularly geospatial technology. Moreover, considering the percentages of respondents who are not sure about the definition of GIS (28%), GIS as a member of geospatial technology (36%), and definition of geospatial technology (30%), it is possible that some respondents do not understand anything about GIS.

#### **4.4. Perspectives of geography teachers on the benefits of GIS for geography education**

This part of the analysis is intended to examine the role of GIS in teaching and learning geography as perceived by geography teachers. The respondents were given a list of options from which to choose. The questionnaire items for this section were designed in such a way as to require the extent to which GIS can benefit geography teaching and learning. The data on their perspectives are presented in Table 4.4:

Table 4.4 Views about the benefits of GIS for teaching and learning of geography

<b>Benefits</b>	<b>Very</b>	<b>Quite</b>	<b>Somewhat</b>	<b>Not at all</b>
GIS is an important teaching resource	69%	22%	5%	4%
GIS can help learners develop spatial thinking skills	71%	18%	9%	2%
GIS can help learners develop other geographic skills	76%	15%	9%	0%
GIS can help learners develop map reading and interpretation skills	71%	18%	9%	2%
GIS can help learners understand geography better	59%	21%	16%	4%
GIS can help motivate learners	71%	23%	5%	0%

As shown on Table 4.4 above, 69% of respondents regard GIS as a very important teaching resource, whereas only 4% of respondents do “not at all”. These results imply that although most teachers have only learnt of GIS from reading, they consider it important for geography education. It is observed from Table 4.4 that the highest percentage of the respondents (71%) believes that GIS can be “very” helpful in equipping learners with spatial thinking skills. This score is higher than that recorded in Table 4.3, whereby 50% of the respondents agreed with the given definition of GIS. This suggests that while few respondents understand GIS, the majority believe that GIS has the potential to help learners to develop spatial thinking skills.

The data presented in Table 4.4 further show that the majority of respondents (76%) are aware that GIS can be “very” helpful regarding learners’ development of geographical skills. In addition, 15% of the respondents view GIS as ‘quite’ helpful to learners on these skills. However, only 9% believe that GIS can “somewhat” help learners. The results, therefore, report most respondents as positively associating GIS with instilling geographic skills amongst learners.

Of the 58 respondents, 71% indicated that GIS can be “very” helpful in developing learners with map-reading and interpreting skills; and 18% indicated that it can be “quite” helpful; 9% stated that it can be “somewhat” helpful; and 2% stated that it can “not at all” be helpful. This probably means that while there are mixed feelings about this question, most respondents view GIS as a resource, helping learners to develop map-reading and interpreting skills.

Moreover, the percentages in Table 4.4 further show that out of the 58 respondents, 59% believe that GIS can be “very” helpful regarding learners’ ability to understand geography content, and 21% believe that it can be “quite” helpful. Some respondents (16%) think that GIS “somewhat” helps learners to understand geography, while only 4% think that it “cannot at all”. Overall, the data suggest that the majority of respondents are positive about the benefits of GIS which is reflected in learners’ understanding of the content.

From the Table 4.4, one realises that for the majority of the respondents (71%), GIS can be very helpful and motivational to learners. In addition, 23% believe that GIS quite motivates learners. This means that most respondents view GIS as a tool, capable of motivating learners. Nonetheless, only 5% of the respondents saw GIS as “somewhat” motivational to learners. Apparently, most respondents trust the motivational value of GIS amongst the learners.

#### **4.4 Factors that are likely to enable and/or constrain integration of GIS in geography education**

In order to explore the potential for integration of GIS into geography teaching and learning, some questionnaire items examined whether the teachers have computer skills, their level of confidence about using computers, the available GIS-related infrastructure and whether the schools offer ICT as a subject.

##### ***4.4.1 Computer skills and use***

Computer skills and use focus on the level of competence for using computer and confidence that respondents have about several computer functions. These data will be useful in determining whether respondents can utilise GIS when teaching, and how much training may be required.

#### ***4.4.1.1 Computer skills of respondents***

As shown in Chapter Two, GIS is a computer-based system, meaning that teachers should be computer-literate so as use GIS. Table 4.5 presents the results for the analysis of the respondents' computer literacy skills.

**Table 4.5 Computer skills of respondents**

<b>Skills</b>	<b>Frequency</b>	<b>Percentage</b>
Very little/no skill	14	22%
Beginner	7	11%
Intermediate	36	57%
Advanced	6	10%
<b>Total</b>	<b>63</b>	<b>100%</b>

Table 4.5 illustrates that 57% have rated their computer skills as intermediate, 22% as very little or no skills at all, 11% as beginner skills, and 10% as advanced skills. Given the percentages for both intermediate (57%) and advanced (10%) computer skills, it can be stated that most respondents have basic computer skills, which offer opportunities for integration of GIS into geography teaching and learning.

#### ***4.4.1.2 Computer education/training***

Respondents were asked whether they have taken a computer course, and Table 4.6 shows the responses to this question.

**Table 4.6 Computer training**

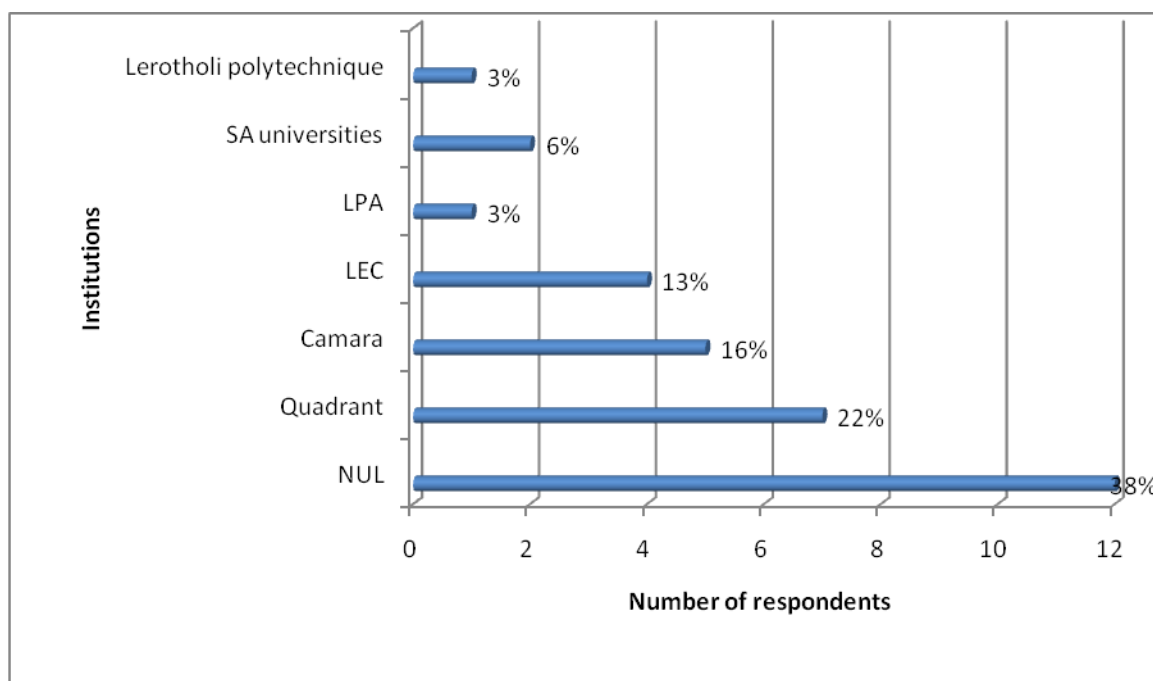
	Frequency	Percentage
Yes	39	67%

No	19	33%
<b>Total</b>	58	100

From the table above, one notes the majority (67%) of the respondents as having had computer training, while 33% of them have not. The highest percentage of respondents with computer training suggests that there is potential for integration of GIS because many teachers can use a computer.

#### 4.4.1.3 Computer training institutions

The respondents indicated that they have knowledge and skills to operate a computer from the sources specified in Figure 4.2.



**Figure 4.2 Institutions providing computer course**

As presented in Figure 4.2, various institutions and organizations have trained the respondents on computer literacy. However, most respondents (38%) had received training from the National University of Lesotho (NUL). This means that as a teacher-training institution, the NUL makes

efforts to equip respondents with technological skills necessary for teaching as well as for their personal use.

#### ***4.4.1.4 Duration of computer course***

This question required respondents, who received computer training to specify the time they had spent on computer studies. Table 4.7 shows the duration of the computer courses that respondents had taken.

**Table 4.7 Duration of a computer course**

<b>Period</b>	<b>Frequency</b>	<b>Percentage</b>
Less than 6 months	17	63%
7 to 12 months	8	30%
Above 1 year	2	7%
<b>Total</b>	27	100%

Missing=5

Although respondents received computer training, the results in Table 4.7 reveal that 17 (63%) respondents received training for the duration of less than six months. This implies that they have developed only basic computer skills. Some respondents (30%) took a computer course for seven to 12-months. Only 7% of the respondents spent more than a year in computer training. With these results, it is observed that most respondents with intermediate computer skills had the duration of less than six-month computer training.

#### ***4.5.1.5 Impressions about the computer course***

The analysis of the qualitative data on the responses of the teachers on their impressions about the computer course they received point to the fact that the computer training was limited to computer appreciation. For instance, one respondent stated, “It was an introduction to typing and saving as well as creating folders”. Similarly, another respondent stated, “it equipped one with the basics of computer”. In spite of the findings that the focus of the computer course was on the development of basic skills, the respondents affirmed that a computer course was very helpful

and interesting. In other words, they had enjoyed learning, and benefited a lot from the course. Thus, the respondents found this course helpful.

However, the respondents considered the course too short, and challenging. Their explanation is that they had failed to understand what was taught. For example, one respondent declared that the course did not cover everything that was planned. As discussed earlier in Table 4.7, most respondents had attended the computer course for less than six months, thus showing why they encountered problems in computer course.

**4.4.1.6 Respondents’ level of confidence in using computer**

Table 4.8 presents the respondents’ level of confidence in using a computer for different computer activities (n=60)

**Table 4.8 Confidence in using computer**

Computer function	Very	Quite	Somewhat	Not at all
Use office application	38%	38%	17%	7%
Store and retrieve information	38%	37%	15%	10%
Internet to access information	52%	36%	7%	5%
Email	52%	31%	11%	6%
Produce multimedia files	18%	38%	28%	15%
Work with databases	14%	34%	24%	29%

The table illustrates that equal percentages of respondents (38%) are ‘very’ and ‘quite’ confident at using office applications, while only 7% of respondents can not at all do the task. It is obvious that most respondents are confident in using office applications. Most respondents (38%) as shown above are very confident about storing and retrieving information. Respondents are not

only very confident about using office applications, but they are also very confident about storing and retrieving information. However, 10% of respondents are not at all confident about doing this task. The results further show that the largest percentage of respondents (52%) is very confident in surfing the internet to access information, which suggests that they can download teaching materials for teaching and learning geography.

From the teachers' responses (see Table 4.8), many teachers (52%) are very confident about using computer for emails. This percentage is similar to that of the respondents, who are confident in using the internet to access information, an indication that the respondents can perform different activities using a computer. In addition, most respondents (38%) are quite confident about producing multimedia files. This means that teachers can copy and transfer information from the computer files to the compact disk. Surprisingly, 28% of the respondents are "somewhat" confident about this task. Therefore, training can be crucial for this group if teachers were to produce multimedia files with information gathered with GIS. Besides, Table 4.8 shows that 34% of the respondents are quite certain about working with a database. It is, therefore, apparent that most respondents can use a computer for different activities.

#### ***4.5.2 Integration of ICT in schools***

This section analyses data regarding the respondents' knowledge and skills on the integration of information and communication technologies in the teaching of geography. This is especially crucial as it will help the researcher to determine the extent to which respondents are likely to integrate GIS into geography lessons. It also uncovers the extent of the respondents' value for the integration of various technologies into geography education. Thus, the section uncovers some of the contributing factors for integrating GIS into education.

##### ***4.5.2.1 ICT education in schools***

This questionnaire item set out to find out whether the respondents' individual schools offer ICT education to learners. The results are illustrated as follows in Table 4.9:

**Table 4.9 Integration of ICT in schools**

<b>Answer choice</b>	<b>Frequency</b>	<b>Percentage</b>

Yes	35	57%
No	26	43%
<b>Total</b>	61	100%

Missing=2

As demonstrated in Table 4.9 above, 57% of the respondents reported that ICT is taught at their schools, whereas 43% indicated that ICT is not taught. This suggests that some schools understand the need to develop technological skills amongst learners. Furthermore, this condition provides the possibility to integrate GIS at their schools.

#### ***4.4.2.2 Ways in which ICT is taught in schools.***

This question was directed mainly at the respondents (57%), who stated that ICT is taught at their schools. The question required the respondents to recount how ICT has been taught at their schools. Table 4.10 indicates that of the respondents, 33 (94%) responded that ICT has been taught as a separate subject, while 2 (6%) indicated that ICT has been integrated into their subjects as their choice.

**Table 4.10 Ways in which ICT is integrated in schools**

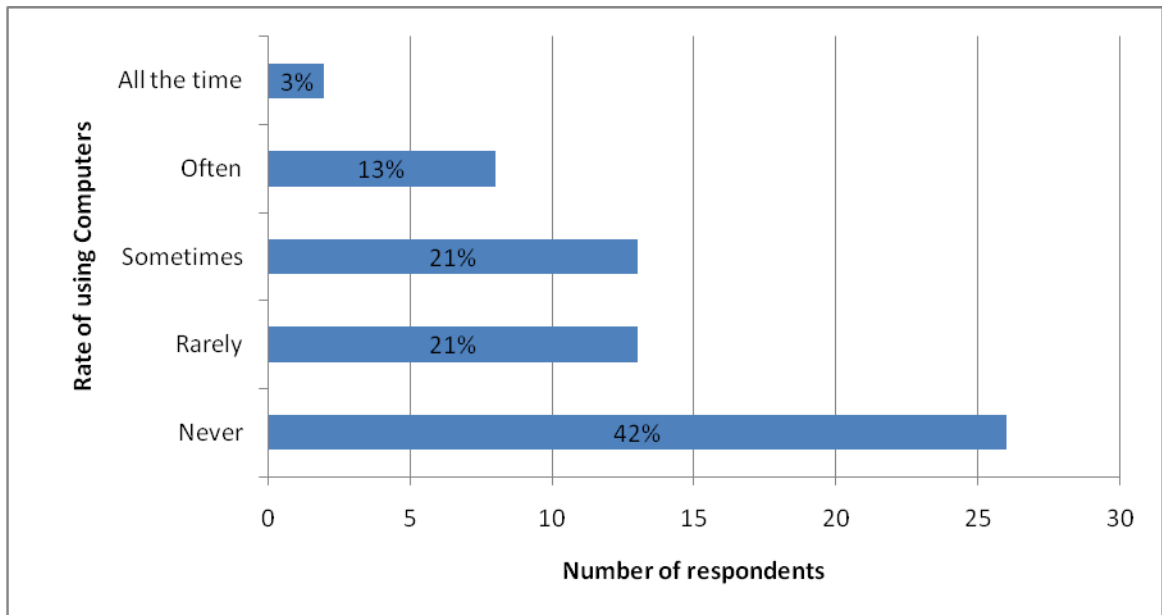
<b>Variable</b>	<b>Frequencies</b>	<b>Percentages</b>
ICT is taught as a separate subject	33	94%
ICT is integrated in my subject because I choose to do so	2	6%
<b>Total</b>	35	100%

From Table 4.6, most respondents have attended a computer course, and have intermediate computer skills as discussed in Table 4.5. However, only 6% of the respondents integrated ICT

into their teaching. As such, the majority of the respondents, being computer-literate, could not encourage them to integrate ICT into classroom teaching.

**4.4.2.3 Extent to which teachers use computer and/or internet in classrooms**

The respondents were asked to state the extent to which they use a computer and the internet in classroom teaching. The responses to the questionnaire are, therefore, shown in Figure 4.3 below.



**Figure 4.3 Respondents use of computer for teaching**

While 67% of the respondents had taken a computer course and 57% of the respondents had intermediate computer skills, the majority (42%) of the respondents had never used a computer or the internet in classrooms. The implication is that teachers might not use GIS in geography teaching, even when they have received GIS training.

**4.4.2.4 Ways in which teachers use computers and/or the internet**

The question inquired about the educational activities done by teachers using a computer or the internet. The respondents had the freedom to select more than one option on this question. According to Table 4.11, most respondents (84%) use computer or the internet for lesson preparations.

**Table 4.11 Educational uses of computer and internet**

Uses	Frequency	Percentages
Lesson preparations	32	84%
Teaching	19	50%
Record keeping	23	61%
Other use	14	37%

The table further shows that 19 (50%) respondents use them for teaching, 23 (61%) use them for record-keeping, and 14 (37%) use them for other uses. Table 4.10 reveals that 84% of the respondents use computer and internet for lesson preparations, correlate with Table 4.8, where 52% of respondents are very confident about using the internet to access information. This could mean that the respondents use computer and the internet to access relevant information for geography lessons. Furthermore, those who chose “other use” were required to specify those uses. Table 4.12 below presents their responses to the question.

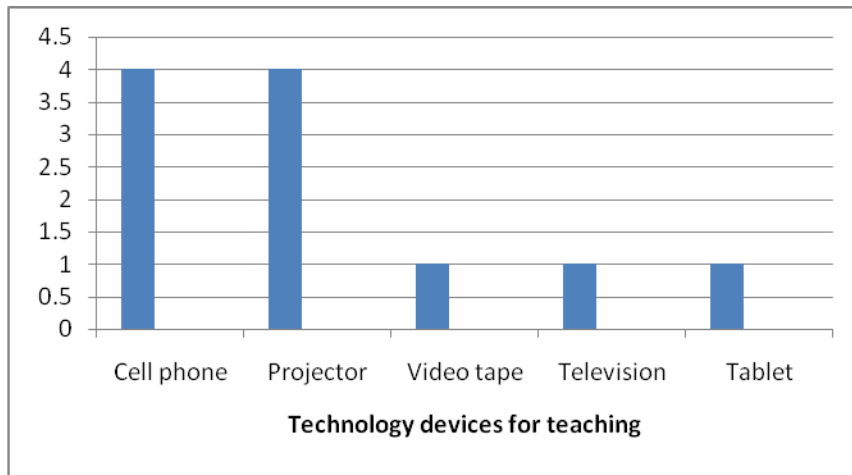
**Table 4.12 Other uses of computer and internet**

Responses	Frequency	Percentage
Search geography information, e.g., concepts definitions	11	79%
Personal uses	1	7%
Emails	2	14%
<b>Total</b>	14	100%

Most teachers (79%) use computer or the internet to search for geography information. This suggests that they use the tools to understand geography concepts better. These results imply that teachers use computer and the internet to prepare for classroom teaching.

**4.5.2.5 Types of technological devices that teachers use for teaching geography**

Given the wide range of technologies applicable to geography teaching, this question sought to find the forms of technologies used for teaching. Figure 4.4 illustrates the devices used by teachers in geography education.



**Figure 4.4 Technological devices used in geography education**

From Figure 4.4, it is observed that very few respondents answered this question. This, in turn, indicates that very few respondents use technology when teaching. As noted, of the respondents who use technology, an equal number of respondents (4) use cell phones and projectors, while other devices used are video tape, television and tablet by each respondent. The implication of these results is that teachers might be reluctant to use GIS if it is implemented, since the majority of respondents are not used to teaching with technology.

**4.4.2.6 GIS training**

The ability to use GIS is one of the requirements for the integration of GIS. As such, the respondents were asked whether they had training on the application of GIS. The results are given in Table 4.13 below.

Table 4.13 Respondents’ training on the application of GIS

<b>Answer choices</b>	<b>Frequencies</b>	<b>Percentages</b>
Yes	3	5%
No	59	95%
<b>Total</b>	62	100

The data show that an overwhelming majority (95%) of the respondents had no training on GIS, while only 5% claimed to have GIS training. The high percentage of the respondents without GIS training was to be expected provided that GIS is not yet part of teacher-training programmes in Lesotho.

#### ***4.4.2.7 Institutions or organisations providing GIS training***

This question was attended to by only three respondents who stated in Table 4.13 that they had training on GIS. The question sought to find the institutions which provided GIS training. Table 4.14 shows the institutions which offered the training.

Table 4.14 Institutions offering GIS training

<b>Respondents</b>	<b>Age group</b>	<b>Teaching experience</b>	<b>Institution</b>
One	31-40	4 years	Tertiary
Two	31-40	18 years	Tertiary
Three	41-50	14 years	Tertiary

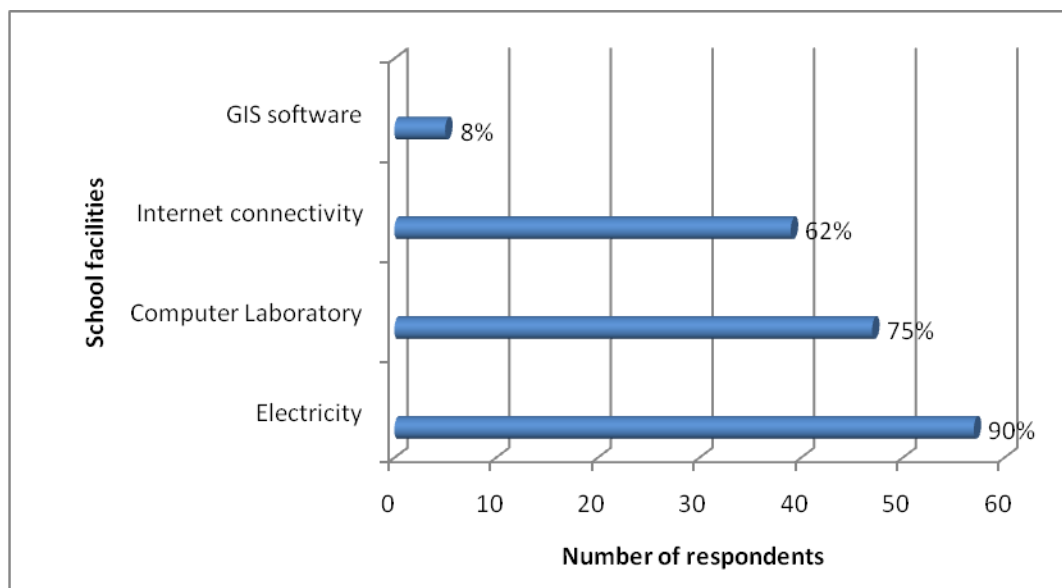
All three respondents had training on GIS at tertiary. However, considering 14- and 18-year teaching experience of the two respondents, it is difficult to believe that they had received GIS training since this is not yet offered in higher education in Lesotho.

### 4.5.3 Schools' infrastructure and classroom environment related to GIS

For GIS to be implemented at schools, certain facilities are considered as well as classroom conditions (Ida et al., 2014). Hence, the questionnaire included some questions to find whether such facilities and conditions are available at schools. The information analysed will highlight some of the factors influencing the integration of GIS at schools.

#### 4.5.3.1 School facilities necessary for integration of GIS

There are four major facilities required in the implementation of GIS. Figure 4.5 gives the respondents' responses about the facilities found at the selected schools.

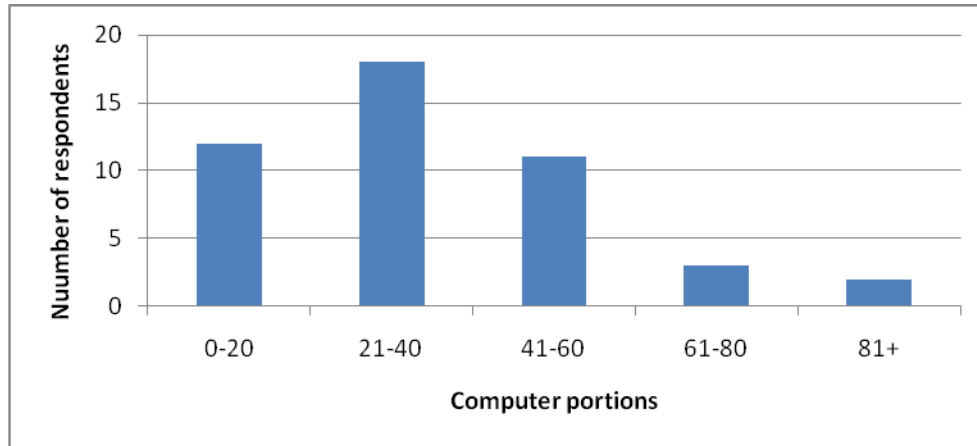


**Figure 4.5 GIS-related facilities at schools**

The figure above reveals that most respondents stated that electricity, computer laboratory and internet connectivity are available to their schools, with electricity being the most selected facility by 90% of the respondents. This implies that these facilities act as enabling factors for the integration of GIS at such schools. In contrast, GIS software is the least available facility to schools as only 8% of the respondents indicated that their schools have it. Nonetheless, of 8% of the respondents, two stated (see Figure 4.1) that they learnt of GIS from reading; one from school; one have not ever heard; and one did not attend this question. Besides, these respondents are from different schools. As such, it is difficult to confirm whether indeed GIS softwares are available at their schools. The implication of these results is that lack of GIS in schools could be a barrier to the integration of GIS.

#### 4.5.3.2 Number of computers in school computer laboratories

The quantitative data presented in Figure 4.6 show that many schools do not have a sufficient number of computers.



**Figure 4.6 Number of school computers**

The data show that the number of computers in the schools ranges from less than 20 to over 81 computers, with most schools having the number of computers ranging from 20-40. As a result, the student-computer ratio is moderate provided that geography classes are comprised of less than 40 students. This is especially important as these computers may be enough for a normal classroom. This is supported by Perkins and Boardwell (2010), who argue that a classroom usually accommodates 22 to 30 students. As such, a computer laboratory with many computers would facilitate integration of GIS.

#### 4.5.3.3 Teachers' access to computer laboratory

In Figure 4.5, 47 respondents indicated that their schools have computer laboratories. As such, this question required such respondents to indicate their level of access to the computer laboratories. As indicated in Table 4.15, most respondents (51%) have limited access to computer laboratories.

Table 4.15 Level of access to computer laboratories

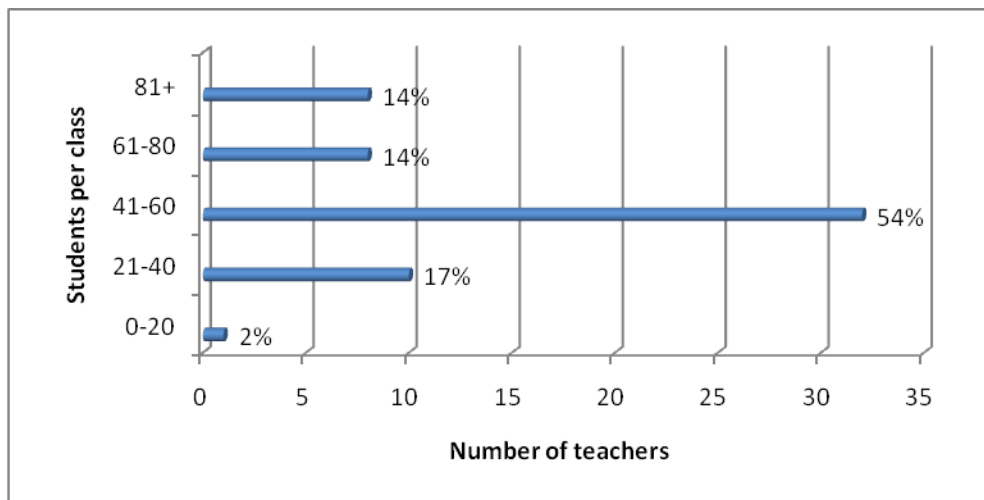
Access	Frequency	Percentage
No access	5	11%

Limited access	24	51%
Average access	10	21%
Full access	8	17%
<b>Total</b>	47	100%

Table 4.15 further shows that a smaller percentage of respondents have an average access to computer laboratories. The limited access to computer laboratories could be the reason why teachers do not use computers in their teaching. Hence, lack of or limited access to computer laboratory is likely to impede the implementation of GIS.

#### 4.5.3.4 Size of geography class

Figure 4.7 below shows the number of geography students, which are taught by respondents. This is useful in that it will help to identify whether classroom size is suitable for integration of GIS.



**Figure 4.7 Number of students per geography class**

Based on the results above, most of geography classes have 41-60 students, as stated by 54% of respondents. Since for most schools, computers range from 21-40 as shown in Figure 4.7, and geography classes have class sizes ranging from 41 to 60 students, student computer ratio is high and computers would not accommodate all learners if GIS was to be integrated at schools.

#### 4.5.3.5 Geography topics that can be taught using GIS

In order to determine whether or not the teachers were aware of the opportunities for integration of GIS in geography, they were asked to identify geography topics that could be taught using the resource. Table 4.16 presents the views of the respondents on whether there are geography topics that can be taught using GIS. According to Table 4.16, a very high percentage of the respondents (96%) believe that there are topics in which GIS can be integrated.

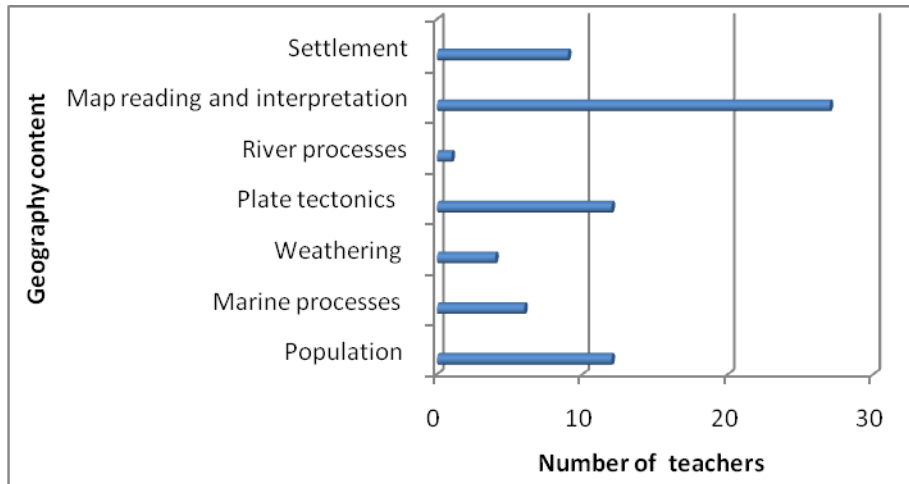
Table 4.16 Integration of GIS in geography topics

Answer choices	Frequency	Percentage
Yes	48	96%
No	2	4%
<b>Total</b>	50	100

The statistics reveal that although most respondents have only heard of GIS as reflected in Table 4.2, and had not received training on the integration of GIS as revealed in Table 4.13, they believe that there are geography topics in which GIS can be integrated. These results also clarify why 69% of respondents in Figure 4.4 indicated that GIS is a very important teaching resource for geography education.

#### 4.5.3.6 Examples of geography topics that can be taught using GIS

This question was addressed to 48 respondents who stated that GIS can be integrated into geography topics. As such, these respondents were required to provide two examples of such topics. The results are illustrated below.

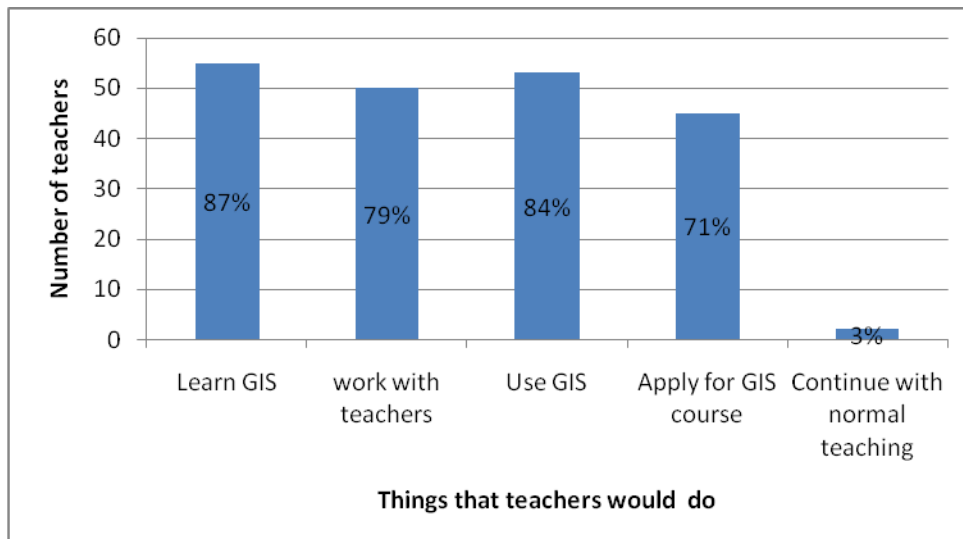


**Figure 4.8 Geography content for integration of GIS**

As shown in Figure 4.8, most respondents (27) believe that GIS is best suited for teaching map-reading and interpretation. This suggests that respondents think that GIS can help learners to acquire knowledge and develop skills about map reading and interpretation, which resonates with the data presented in Table 4.4 where 71% of the teachers agreed that GIS can help students to effectively develop map work skills.

#### 4.5.3.7 What respondents would do if GIS is implemented

This question sought to find out the respondents' willingness to use GIS as a resource when teaching geography.

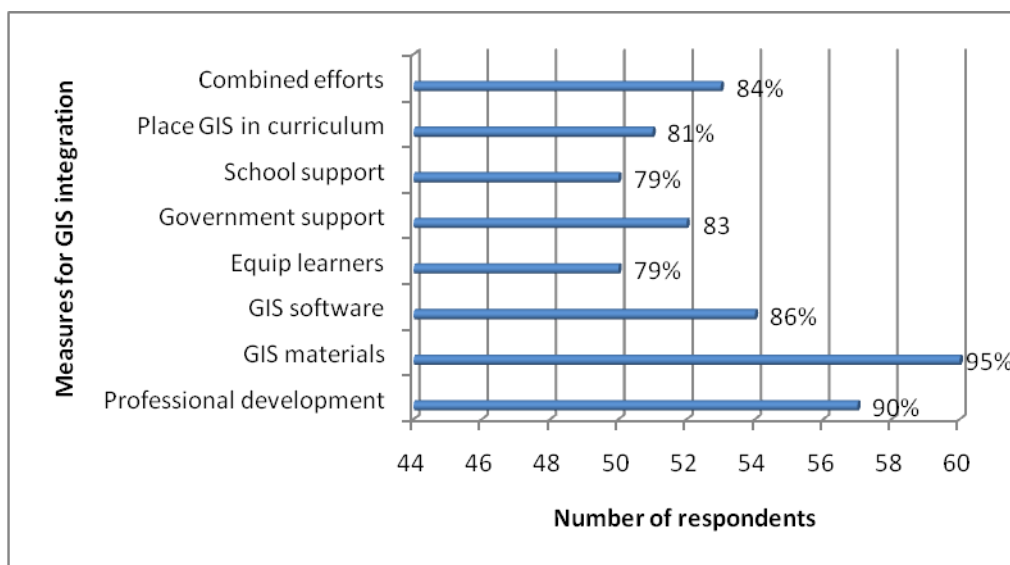


**Figure 4.9 Things teachers would do if GIS is implemented in schools**

Respondents were allowed to select more than one option on this question; hence there are high frequencies on the bar chart. As illustrated, the majority of the respondents indicated that they would learn GIS, work with other teachers, use GIS when teaching, and apply for a specialised GIS. In particular, the overwhelming majority respondents (87%) are willing to learn GIS. This means that the majority of respondents will make some efforts so that GIS is incorporated at schools. The implication, therefore, is that the respondents are willing to integrate GIS as part of their classroom practices. This also shows that they have positive attitudes towards the integration of GIS. Thus, willingness and positive attitude contribute to the integration of GIS.

#### 4.6 Measures which can be taken to enhance effective implementation of GIS in geography education

According to Dooley (1999), cited in Dermici (2009), diffusion of new technologies amongst people follows critical measures. This is the case with GIS because McClurg and Buss (2007) stated that there are several measures that could be taken into consideration for GIS to be successfully implemented in schools. The intention of this section is therefore to examine the measures that may be taken to ensure that GIS is successfully integrated in geography education as viewed by the teachers who filled the questionnaire. These measures are analysed based on the perspectives of the respondents. The data help to set out the strategies used to facilitate implementation of GIS.



### **Figure 4.10 Measures encouraging integration of GIS**

From Figure 4.10 above, it is evident that respondents believe that all these measures are pivotal in the implementation of GIS, with provision of GIS materials ranking the highest with the response rate of 95%. Besides, 90% of the respondents think that professional development is critical for GIS to be effectively implemented. This is probably because most respondents had never received any training of GIS as indicated earlier. With these results, it is observed that successful implementation is based on the measures above.

### **4.7 Conclusion**

The purpose of this chapter was to analyse questionnaire data in order to explore the opportunities and challenges for integrating GIS into geography education. The analysis on biographic information revealed that most respondents are females, ranging from 31 to 40 years of age, qualified geography teachers with a bachelor's degree, and 16-20-year teaching experience. The findings indicate that most participant geography teachers have knowledge, skills, and experience necessary for teaching the subject. Besides, teachers' understanding of GIS was analysed in this chapter. Then it is discovered that most respondents have basic knowledge of GIS, demonstrating familiarity with the concept of GIS. Furthermore, the majority of the respondents consider GIS as an important resource, which can motivate and help learners to develop geographical knowledge and skills.

Analysis also highlighted some factors contributing to the integration of GIS. For instance, the data have revealed that although most teachers have basic computer skills, few of them integrate ICT when teaching. It is reported further that most schools have electricity, internet connectivity, and computer laboratories, with the respondents believing that some geography content can be taught using GIS. However, GIS facilities are much limited at most schools. For instance, it has been found that the student-computer ratio is high for most schools. Most importantly, most teachers have been noted for their will to take an initiative of learning GIS, in order to effectively implement GIS operation at schools. Finally, most respondents indicated that with GIS teaching materials available, the measures outlined in this chapter can facilitate integration of GIS at schools.

## CHAPTER FIVE

### DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Introduction

This chapter summarises and discusses the key findings of the study. The chapter also draws conclusions, and makes recommendations based on the research findings of the study. The findings are discussed in response to the research questions, which were articulated in Chapter One of the study. This approach has helped the researcher to identify the key findings which emerged from each research question, and the extent to which each research question is addressed. As noted earlier, these research questions are as follows:

- (a) What do Geography teachers understand by GIS?
- (b) What are the benefits of using GIS in geography teaching as perceived by Geography teachers?
- (c) What factors are likely to influence the integration of GIS at secondary schools in Lesotho?
- (d) What measures may be taken to enhance application of GIS to geography teaching and learning?

#### 5.2 Geography teachers' understanding and knowledge of GIS

The study sought to find teachers' understanding and knowledge about GIS. The study found that geography teachers know about GIS. This is supported by the fact that most teachers indicated that they have heard and read about GIS. However, it is further observed that teachers have little understanding and knowledge of GIS. This was illustrated by the fact that the majority of teachers 'agreed' with the given definition of GIS. This suggests that since teachers have heard of GIS, they have understood its characteristic features. In other words, for Bednarz and Ludwig (1977) four stages in the adoption of educational innovation can be identified thus marking geography teachers' "awareness" of GIS. In addition, the majority of the teachers have noted a relationship between GIS and geospatial technology. As such, it is clear that geography teachers have knowledge about GIS.

### **5.3 Benefits of integrating GIS into the teaching and learning of geography**

The study also sought to explore the benefits of integrating GIS into the teaching and learning of geography from the perspectives of geography teachers. One of the findings of the study is that GIS is a fundamental technology tool for geography education. A response for most geography teachers was that GIS is a very important teaching resource for geography. In other words, teachers believed that integration of GIS can play a pivotal role in the attainment of geography education standards. Moreover, it is discovered that GIS has the potential to help learners to develop spatial thinking skills. This was shown by a high percentage of teachers, who saw GIS as ‘very’ helping learners to develop spatial thinking skills. These findings are consistent with the previous research, which validates the role of GIS in promoting development of spatial thinking skills amongst learners (Fargher, 2004; Kidman & Palmer, 2006).

Acknowledging the potential of GIS to develop learners’ geographical skills, most teachers indicated that with the use of GIS, learners have the opportunity to develop various geographical skills. Similarly the teachers’ views about GIS echo the findings of previous studies on the subject. For instance, literature shows that through GIS, learners can think, analyse, synthesise data, and infer about data (Fargher, 2006; Shin, 2006; West, 2003). Also noticeable is that GIS can benefit geography by helping learners to develop technical skills as in map-reading and interpreting skills, the aspect which has been confirmed by a high percentage of the participant teachers.

It is also observed that learners can acquire geographical knowledge when GIS is used during instructions. The observation in data analysis indicated that most teachers believe that the application of GIS can greatly help learners to understand geography. This particular finding echoes Smith’s (2002) study which pointed out that through GIS learners are able to understand various geographical issues learnt in geography classes. As stated above, GIS has the potential to motivate geography learners, and this was illustrated by 71% of teachers who stated that GIS can motivate learners very much. This notion of motivation has been reported, amongst others, by the studies conducted by Aladag (2010), Biebrach (2007), and Kerski (2000) respectively.

Nonetheless, it is observed that some teachers are skeptical about the role of GIS in geography. As shown in Chapter Four, some teachers indicated that GIS can “somewhat” help learners to acquire and develop geography skills and knowledge respectively; even for those who indicated

that it is considered an important resource for geography. This suggests that teachers are undecided about the benefits of GIS, possibly because they have limited or no knowledge about GIS. Hence, these teachers may not use GIS even if implemented at their schools.

#### **5.4 Factors contributing to the integration of GIS in the secondary geography education in Lesotho**

The analysis of the questionnaire involved possible factors influencing the implementation of GIS at schools. The findings on these factors are provided in this section.

The findings of the study show that geography teachers have basic computer skills. This was demonstrated by the fact that most teachers have intermediate computer skills, which they developed through a computer training that lasted for a period of less than six months for the majority of them. This means that teachers have necessary skills to operate a computer, most of whom gained the skills from the NUL. Based on the researcher's knowledge, the NUL provides every student with a compulsory computer course at first-year to equip them with basic computer skills. However, the Faculty of Education does not offer any technology-related course for teachers, meaning despite being computer-literate, the teachers are not trained to integrate technology into teaching. In fact, the impressions of teachers about computer course reveal that the course was not intended to equip them with skills for integrating ICT at schools, but it was designed only for imparting basic computer skills. At any rate, teachers have been found to have average confidence in using different computer programs.

Data analysis also reveals that some schools offer ICT as a subject, creating an opportunity for application of GIS to teaching geography. This suggests that learners are equipped with basic skills necessary to operate a computer, a condition which is essential for the integration of GIS at schools. By and large, the findings report that geography teachers do not use a computer and the Internet for teaching purposes. As illustrated by the data, most teachers have never used a computer and the Internet in class for teaching purposes. This is one of the surprising findings, especially in this information technology age where such resources could make geography teaching and learning interesting and effective to both teachers and learners. As reported by Bevainis (2008), teachers in Japan rarely use teaching materials such as the Internet during instructions. Furthermore, limited access to computer and internet use amongst teachers is an

impediment to the integration of GIS into geography. The discussion in Chapter Four revealed that most teachers have restricted access to the computer laboratories.

Although the findings show that the teachers do not use computers and the internet in their lessons, they use these resources to prepare for the lessons. Statistics revealed that most teachers use a computer and the internet to prepare for lessons. Furthermore, teachers use other technological devices such as use of cell phones and projectors. However, only a few teachers use cell phones and projectors during instructions. This would not have been expected given that almost all teachers have smart phones, used to help learners to understand geography content; similarly, some students possibly have smart phones, which they can use to access information on the topic they are learning at the time (Kolb, 2011)

Another key finding of the study is that geography teachers lack skills necessary to integrate GIS into teaching. This was illustrated by the fact that teachers had not received training on GIS. This means that if GIS is to be implemented in geography, one of the critical steps for implementation would be to extensively train teachers on the application of GIS, in order to ensure that they can effectively implement GIS in schools. This is supported by Barker (2005), who specifies that if teachers are to be trained to use GIS, they should be allotted more than 40 hours on training, as discussed in Chapter Two. Also, based on the results, most schools have infrastructure necessary for the integration of GIS, in particular they have electricity, computer laboratory, and internet connectivity. These facilities provide the conditions that would facilitate integration of GIS. Despite the existence of GIS- related infrastructure, it is noted that GIS is lacking at schools. This can be attributed to not only lack of training in GIS, but also to the fact that the GIS technology is not part of geography curriculum as indicated in Chapter One.

The study further noted that most school computer laboratories have computers which are enough for a normal class as noted earlier. In other words, this provides the possibility for integration of GIS because there will be no need for schools to purchase computers. However, due to large class sizes in many schools, the student-computer ratio is high, and this will possibly call for schools to purchase computers that will accommodate all learners. Another barrier noted is that teachers may not integrate GIS when teaching as a result of restrictions towards computer laboratories. It was indicated that most geography teachers have limited access to computer

laboratories. This means that unless teachers are granted full access to computer laboratories, they will not implement GIS during instructions.

Another key finding from the analysis of the survey is that geography teachers believe that GIS is suitable for geography education in Lesotho. This was illustrated by the fact that geography teachers stated that geography has topics; more especially map work which can be taught through the help of GIS. This suggests that geography curriculum serves as one of the main resources for integrating GIS into geography, the feature which can boost teachers' capacity for GIS usage.

The last finding on this research question is that teachers are willing to integrate GIS at schools. Here, teachers indicated that if GIS were to be integrated, they would learn about GIS, and work with other teachers in implementing or teaching GIS, and applying for a specialised GIS course. This implies that teachers understand the significance of GIS in geography teaching and learning, despite having little knowledge about GIS.

### **5.5 Measures which can enhance the integration of GIS at schools**

Since there are many problems experienced in the implementation of educational innovations, some measures should be taken to overcome such problems in an attempt to implement GIS teaching (Wallace, 2004). In this section, findings on the measures considered to enhance integration of GIS are discussed.

The findings indicate the majority of teachers believed that professional development can enhance integration of GIS. Since geography teachers do not have expertise on GIS application in classes, they should be equipped with knowledge and skills, that is, GIS-related resources including textbooks, so that they can use GIS without any difficulties in a classroom. Data analysis further revealed the highest percentage of teachers (95%) as appreciating the value of providing GIS materials, for teachers' use of GIS. Since GIS software is lacking at schools, the results indicate that GIS software should be available for teachers can integrate GIS in their teaching processes. Similarly, learners should be introduced to GIS skills so as to cope with instructional processes and to work at their own spare time. According to teachers, governmental support through the MoET is crucial for enabling teachers to employ GIS. For example, the MoET can provide in-service training to equip teachers with GIS skills.

Equally important finding is that school principals should motivate teachers to use GIS in teaching as well as provide them with relevant resources as in computer laboratories. As such, the joint efforts amongst the government, schools and GIS industry can promote implementation of GIS. As discussed by NRC (2006) some of the GIS companies provide relevant information packages to teachers to help them to use GIS during instructions. Therefore, teachers believe that through combined efforts, they can be in a position to use GIS effectively.

## **5.6 Recommendations**

Based on the findings of the study, the following recommendations are made:

- (a) There is a need for GIS to be integrated into geography curriculum so as to provide teachers with the basis for integrating GIS.
- (b) GIS software should be bought in order for geography teachers to use GIS at their schools.
- (c) Since teachers lack skills to use GIS, teacher-training institutions should provide both pre-service and in-service training GIS-related courses for both geography and other teachers to develop skills required for integrating GIS into their lessons.
- (d) It is also recommended that computers should be increased for teachers' and learners' access because most geography topics can be taught through integration of GIS.
- (e) As most schools offer ICT as a subject, it is recommended that GIS-component should be incorporated to introduce learners to the application of GIS.
- (f) There is also a need to develop policy framework which will guide teachers on the integration of GIS in geography lessons.

## **5.7 Conclusion**

This study was intended to explore the opportunities and challenges for integrating GIS into the teaching and learning of geography from the teachers' perspective. The study revealed that the schools' infrastructure creates the potential for integrating GIS at schools, particularly facilities such as electricity, internet connectivity and computer laboratories. Furthermore, geography curriculum has content which can be taught through the use of GIS. Teachers are also willing to

work hard to ensure effective integration of GIS, and that ICT is taught as a subject at schools. However, challenges, observed included teachers' lack of competence to use GIS, limited computer laboratories and high student-computer ratio, all of which hinder integration of GIS. Therefore, if GIS were to be successfully implemented at schools, critical measures should be followed, in order to overcome the challenges and ensure GIS is implemented accordingly. It can be stated that the study has successfully addressed the research questions outlined in Chapter One of the study. It is, therefore, concluded that there are both opportunities and challenges for integrating GIS at secondary schools in Lesotho.

### **5.8 Limitations of the study**

This study is narrow in scope as it recruited only schools offering geography in the Maseru Urban. Because of a limited timeframe and financial restrictions, the researcher focused only on schools in the Maseru urban areas. Nor could the study include the perspectives of geography curriculum developers as a result of limited time as it was proposed since they play a pivotal role in any curriculum reforms of the country.

### **5.9 Suggestions for further research**

As the study focused solely on Maseru-based geography schools, there is a need for a broader study, which will explore the opportunities and challenges for integrating GIS across the country. Any such a study should find out about the perspectives of the Ministry of Education and Training as one of the main stakeholders in the country. The role of the Ministry of Education and Training through such structures as the national curriculum panel, subject specialists and examination officers is also crucial for integration of GIS. Hence, future research can target these role players to find their views on the integration of GIS. Also, since most modern geography departments now offer GIS in their degree programs, it would be important to explore the perspectives of geography department members in the Faculty of Education at the National University of Lesotho on the integration of GIS-related courses for pre-service teachers. One of the limitations is that the researcher could not observe the school environment to confirm some of the information provided by teachers, for instance, computer facilities as reported by the participants. As such, it would be significant for future studies to consider the issue of school environment.

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## Appendices

Appendix one: questionnaire

### A QUESTIONNAIRE FOR ASSESSMENT OF THE POTENTIAL FOR INTEGRATION OF GIS INTO GEOGRAPHY TEACHING/LEARNING

The survey is intended to gather information from geography teachers on their views or perspectives on the opportunities and challenges for the integration of Geographic Information System (GIS) in the teaching and learning of geography in Lesotho. As such, your participation in this survey is of paramount importance since it will hopefully yield very useful information for the study as well as for the geography curriculum developers. The estimated time for the completion of the questionnaire is 15-25 minutes. Besides, your participation in this survey is voluntary and confidential. The researcher wants to emphasise that information provided in this survey will not be shared with anyone. The information will **only** be used for the study.

Section one: Biographic details and computer skills

This section of the questionnaire seeks your biographic information. Please place a tick against an appropriate response.

About you

Gender: Male [ ] Female [ ]

Age: 20-30 [ ] 31-40 [ ] 41-50 [ ] 51-60 [ ] 61and above [ ]

Qualification: Diploma [ ] Degree [ ] Honors' [ ] Masters degree [ ] Others [ ]

.....

Areas of specialisation (subjects):..... And.....

For how many years have you been teaching Geography? .....

Computer skills and use

How would you describe your computer skills?

Very little/no computer skills [ ]

Beginner [ ]

Intermediate [ ]

Advanced [ ]

Have you ever taken a computer course?

Yes [ ]

No [ ]

c) If yes, which institution or organization provided the course?.....

d) How long was the course.....

e) What were your impressions about the course?

.....  
 .....

f) How confident are you at doing the following with computer technology?

	Very	Quite	Somewhat	Not at all
Using office application (e.g. word processing, Typing documents, )	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Storing and retrieving information (documents, videos)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Using the internet to access information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Using email	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Producing multimedia files (i.e files containing music, videos, photos)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Working with databases	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

SECTION TWO: INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGY (ICT) IN EDUCATION

This section of the questionnaire is about the knowledge, skills and experience regarding the integration of ICT in the teaching and learning process.

Is ICT taught in your school?

Yes

No

If yes, how is ICT taught to classes in your school? Please tick in the box to indicate your response (s).

ICT is taught as a separate subject.

ICT is integrated in my subject because I choose to do so.

3. How often do you use computer and/or the internet in your classes?

a) Never  b) Rarely  c) Sometimes  d) Often  e) All the time

4. Do you use computers and/or the internet for the following? Please tick in the box to indicate your answer (s).

I use computer and/or the internet for preparing for the lessons.

I use computer/or the internet for teaching the students.

I use computer for record keeping.

For any other use  please specify.....

5. Which other forms of technology do you use for teaching geography?.....

## ABOUT GIS

1. Have you ever had training on GIS? Yes  No

2. If yes, where? Tertiary  Computer-training institution  Other  specify.....

3. Have you ever heard of GIS? Yes  No

4. If yes, Where? Workshop  Reading  School  Other  specify.....

5. Indicate the extent to which you agree or disagree with the following statements about GIS:

a) GIS is a computer system used to collect, store, retrieve, manipulate, and present spatial data.

- a) Agree  b) Disagree  c) Strongly agree  d) Strongly disagree  e) Not sure

b) GIS is a member of geospatial technology.

- a) Agree  b) Disagree  c) Strongly agree  d) Strongly disagree  e) Not sure

c) Geospatial technology refers to a group of technology that is used to explore, view, or study the environment. a) Agree  b) Disagree  c) Strongly disagree  d) Strongly disagree  e) Not sure

6. Which of the following best reflects your belief or view on the benefits of GIS for geography teaching and learning? Please tick in the box to indicate your response.

	Very	Quite	Somewhat	Not at all
GIS is an important teaching resource in geography	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GIS can help learners develop spatial thinking skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GIS can promote development of geographic skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GIS can help develop map reading and interpretation Skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Learners can understand geography better through GIS	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GIS has the potential to motivate learners	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Section three:** the purpose of this section is to gather information about the school conditions relating to the integration of GIS as well as your views on the integration of GIS.

1. What facilities are available in your school that could facilitate implementation of GIS? Please tick to indicate your response(s) to the following items:

- a) Electricity

b) Computer laboratory

c) Internet connectivity

d) GIS software

2. If your school owns a computer laboratory, how many computers does it have?

a) 1-20 [ ] b) 21-40 [ ] c) 41-60 [ ] d) 61-80 [ ] e) 81+ [ ]

3. If your school has a computer laboratory, how would you rate your access to it?

a) Full access [ ] b) Average access [ ] c) Limited access [ ] d) No access [ ]

4. What is the average number of students does a geography class have?

a) 1-20 [ ] b) 21-40 [ ] c) 41-60 [ ] d) 61-80 [ ] e) 81+ [ ]

5. In your opinion, does geography have topics that can be taught using GIS? Yes  No

If yes, give two examples of such topics.....

6. What would you do if GIS is implemented in your school?

	Yes	No
I would learn about GIS		
I would work with other teachers		
I would use GIS when teaching		
I would apply for a specialised GIS course		
I would continue teaching like nothing happened		

7. Do you think the following can help ensure effective implementation of GIS in geography teaching and learning? Please tick to indicate your response (s) in the boxes.

- a) Training teachers on GIS
- b) Providing teachers GIS-related materials (e.g books)
- c) Purchasing GIS software
- d) Equipping learners about GIS
- e) Government support (e.g. funding)
- f) School support (e.g. school principal)
- g) Integrating GIS into geography curriculum
- h) Combined efforts between government, school, and GIS industry

Thank you for completing this questionnaire

Appendix two: request letter

# The National University of Lesotho

Telephone: +266 Fax:  
22340601/3631



P.O. Roma 180  
Lesotho

## FACULTY OF EDUCATION

**Date: 16/04/2018**

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

### **A Letter of introduction to undertake research**

This letter serves to introduce Neo Mohashole, who is a master's student in the Faculty of Education of the National University of Lesotho (NUL). The student is undertaking research which involves administering a questionnaire to geography teachers and some observations or interviews, as might be necessary. Kindly accord the student the necessary assistance and support in this important activity.

Your cooperation is highly appreciated.

Yours sincerely,

**Dr. M. Seotsanyana (HOD-LASED)**