TEACHING AND LEARNING OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS) IN SOUTH AFRICAN SECONDARY SCHOOLS: A CASE OF LIMPOPO PROVINCE

By

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DECLARATION

I, Phetla Jacob Sefara, declare that this thesis, **'Teaching and learning of Geographical Information Systems (GIS) in South African Secondary Schools: A case of Limpopo Province'** is my own work and that all the sources that I have used and quoted have been indicated and acknowledged by means of complete references. I further declare that this work has not been submitted to UL or any other University for examination.

PJ Sefara DATE: 1 June 2017

DEDICATION

This research study is dedicated to my beloved wife and lifelong friend Kgaladi, who inspired me day and night to complete this doctoral project. Her support cannot be compared to any. Our belief in the Word and prayers that we shared every morning as a family, gave me Great Divine support. To my two sons Moloto and Leshoto, who were always there to assist whenever necessary, I thank you.

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“Nkosi Sikelel’ Afrika …”

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ABSTRACT

Teaching and learning of Geographical Information Systems (GIS) in the Secondary Schools of South Africa has some challenges that the Department of Basic Education must attend to. The purpose of this study was to explore how GIS technology can be taught and learnt in secondary schools in South Africa. GIS is a technology that combines hardware, software, data, people, procedures and arrangement of collecting, storing, manipulating, analysing and displaying information about spatially distributed phenomena for the purpose of making a decision or solving a problem. This technology is in fact a decision support system. It was initially taught and learnt only in institutions of higher learning. It was only recently, from around 1991, that some countries introduced it into the geography curriculum of secondary schools. It started in the secondary schools of developed countries, such as the United States of America, United Kingdom and Canada. When the National Curriculum Statement (NCS) for Geography at Further Education and Training (FET) Band for Grades 10 – 12 was implemented in South Africa in 2006, GIS was then introduced into the geography curriculum. In the same year, GIS was introduced in Grade 10, the following year in Grade 11 and Grade 12 in 2008.

The research study was done in one hundred secondary schools in the five districts of Limpopo Province. The research study used mixed methods in collecting and analysing data. Quantitative and qualitative data was collected in the form of a questionnaire and interviews. Learners in selected secondary schools were also given a test on GIS to assess their GIS knowledge. Data analysed indicate that GIS teachers are keen to be trained so that they could know how to teach it. Young teachers trained recently seem to know it because they were exposed to it during their training at universities. The only major obstacle is unavailability of teaching and learning resources. The study recommends that private cooperates and big businesses should participate in alleviating the shortage of hardware and software in South African secondary schools. Technology must play a key role in schools because of the technological innovations the world is experiencing.

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LIST OF ABBREVIATIONS USED

CAPS	–	Curriculum and Assessment Policy Statement
DBE	–	Department of Basic Education
DoE	–	Department of Education
ESRI	–	Environmental Systems Research Institute
ETD	–	Educational Technology Division
FET	–	Further Education and Training
GIMS	–	Geographic Information Management Systems
GIS	–	Geographical Information Systems
ICT	–	Information and Communication Technology
ICT PD	–	Information and Communication Technology Professional Development
IT	–	Information Technology
LDBE	–	Limpopo Department of Basic Education
MEC	–	Member of the Executive Committee
NCS	–	National Curriculum Statement
NIE	–	National Institute of Education
NRC	–	National Research Council of the United States
PBC	–	Problem-based Learning
PGCE	–	Post Graduate Certificate of Education
SGB	–	School Governing Body
SITA	–	State Information Technology Agency
SPSS	–	Statistical Packages for Social Sciences
SSA	–	Statistics South Africa
TREC	–	Turfloop Research and Ethics Committee
UK	–	United Kingdom
UL	–	University of Limpopo
USA	–	United States of America

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CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1 INTRODUCTION AND BACKGROUND

Geographical Information Systems (GIS) is a tool recently introduced and used within the academic study of Geography. GIS is a powerful tool for data storage, retrieval and presentation (Lam, Lai & Wong, 2009). GIS has great potential to contribute to effective learning of geographical concepts, knowledge and the formation of values (Lemberg & Stoltman, 2001). It is important that the school curricula be reviewed and updated timeously to make it relevant to the needs of the time. When there are socio-political and economic changes within a particular society, those changes need to be imbedded within the curricula taught in schools.

In the study of maps and spatial information; “data about the spatial distribution of important properties on the earth’s surface has long been an important part of the activities of organized societies” (Burrough, 1986:1). Geography teaching and learning is about the spatial distribution of human and natural activities. These activities need to be mapped and interpreted according to the needs of the time. Collection of data and information related to space was done by navigators, surveyors and geographers. Cartographers ultimately rendered the information into pictorial form (Burrough, 1986). In the last 200 years, many more different types of maps have been developed, “but there has been long, unbroken tradition of high cartographic standards which has continued up to the present” (Burrough, 1986:1). With the recent new developments in the study of earth, new materials that needed to be mapped emerged. Developments in the understanding of natural resources such as in geology, geomorphology, land and soil science provided more information to be mapped.

The 1:50 000 topographical map series of South Africa provides most information required as they are regarded as multi-purpose maps. Other specific-purpose maps referred to as ‘thematic’ maps are also available. They are referred to as thematic because they only provide a specific theme, for example, a map showing the

distribution of people in South Africa. The theme can be quantitative and qualitative. In this case, both qualitative and quantitative information can be expressed as a choropleth map (areas of equal value) separated by boundaries, for example, a map showing the results of population census. With quantitative data, the data could be modelled by a continuous surface that is capable of mathematical description. During the 20th century the demand for topographical and thematic maps accelerated greatly in South Africa and the world at large. Burrough (1986:2) notes that, "Aerial photography and remotely sensed images allowed photogrammetrists to map large areas with great accuracy." Many earth scientists such as geologists and ecologists benefited enormously from this technology. The demand for spatial data and spatial analysis is not only restricted to the earth scientists. Town planners, civil engineers and police departments all need information regarding the need to plan matters like the routes of roads and spatial distribution of criminal activities. The utilities in cities need to have a developed infrastructure so that all can be recorded and manipulated in a map form.

Burrough (1986:3) further notes that the emergence of computers in the usage of maps has resulted in many more consequences for collection, coding and use of the information it covers. Consequences such as the reduction of original data in terms of volume, so that the data could be understandable and representable, and secondly drawing maps accurately and making themes that were complex and clear were identified. The third consequence is that once the data has been put into a map, it is not cheap to retrieve and combine it with other spatial data. Lastly, the printed map is a static, qualitative document. When the demand for maps grew, drawing maps manually could not work. For example, if meteorologists had to produce synoptic weather maps hourly (as the weather changes all the time) it would be impossible to draw them by hand. To solve these problems, a new tool was necessary. As cartographers did not have skills to use this new tool, they were assisted in remote sensing and image analysis by mathematicians, physicists and computer scientists. The marriage between remote sensing, earthbound survey and cartography made it possible for the emergence of Geographical Information Systems (GIS). In short, GIS merges cartography, statistical analysis and database technology (Bernhardsen, 1999; Burrough, 1986).

In other studies, Nyerges and Jankowski (2010:5), define GIS as a “combination of hardware, software, data, people, procedures, and institutional arrangement for collecting, storing, manipulating, analysing and displaying information about spatially distributed phenomena for the purpose of inventory, decision making, and/or problem solving within operations, management and strategic context as related to issues at hand.” They continue to argue that GIS is a decision support system; a technological tool used in decision making regarding land, transportation and water resource management.

According to Bernhardsen (1999:3), GIS “has come to be associated with any activity involving digital geographical data”. Through GIS, a simplified world can be transferred into a computer. Montello and Sutton (2006:231) define Geographical Information Systems as “any information that is spatially referenced to the surface of the earth”. It is easy to purchase the constituent parts of a GIS (the computer hardware and the basic software), but the problem starts when one has to use and teach it without any prior training (Kidman & Palmer, 2006). The system functions well if the operator is trained to compile the data and the necessary routines are organized and programmes modified to suit the application.

GIS applications are tools that allow users to create interactive queries (user created searches); they communicate about human and environmental activities and events that take place on the planet (Harvey, 2005). Professionals such as environmentalists, urban planners, market researchers, retail site analysts, water resources specialists, and others whose work relies on maps use GIS frequently (Encyclopaedia Britannica, 2009). Many consumers are presently becoming familiar with GIS systems as navigation tools in their automobiles. A few examples of uses are as follows: GIS can be used to find wetlands that need protection strategies regarding pollution; GIS can be used by a company to site a new business location taking advantage of GIS data identified trends to respond to a previously under-served market; most city and transportation systems planning offices have a GIS department; GIS can be used to track the spread of emerging infectious disease threats, allowing for informed paramedic planning and enhanced preparedness.

In 2003, the South African Department of Education (DoE) identified GIS as a “skill to be acquired” in the National Curriculum Statement (NCS) for Geography Grades 10 to 12 (South African Department of Education, 2003:10). However, it was only in 2006 when GIS was introduced as a component in the learning and teaching of geography in Grades 10 to 12. Most rural and urban secondary schools offer geography as a subject. Some of the challenges arising from the introduction of GIS in the secondary school curriculum are: the preparedness of secondary schools for the introduction of GIS; proper training of teachers in South African secondary schools to teach this section; and the availability of the necessary hardware and software in secondary schools to facilitate quality teaching of GIS. The primary concern that this research addresses is the investigation of the teaching and learning of GIS in the secondary schools of Limpopo Province. In the investigations, the researcher examines the current methods used in the teaching and learning of GIS; establishes the availability of hardware and software in the secondary schools; determines how knowledge of GIS by the teachers and performance of learners in different schools relates, and finally proposes how best GIS could be taught in secondary schools of Limpopo Province.

1.2 RESEARCH PROBLEM

The National Curriculum Statement (NCS) for Geography at Further Education and Training (FET) Band for Grades 10 to 12 level was implemented in 2006 in South Africa. In the same year, Geographical Information Systems (GIS) was introduced in Grade 10, the following year in Grade 11 and Grade 12 in 2008 (South African Department of Education, 2008). GIS was introduced as an added section in the geography curriculum in secondary schools in South Africa (Grades 10–12). The problem is that most teachers do not know what GIS is. They were never exposed to it previously. Some geography teachers cannot even use a computer. Due to their lack of understanding of this section of the geography curriculum, they end up not teaching it properly or only covering the theoretical content and without providing opportunities for learners to be practically engaged with GIS. This disadvantages learners.

The introduction of GIS into the secondary school curriculum requires development of infrastructure, availability of hardware and software and training of educators. Limpopo Province is a rural province and many schools are located in a rural setting. The introduction of GIS in these schools was premature as no ground work was done before this took place. The present study investigates the how knowledgeable are the teachers in the teaching and learning of GIS in the secondary schools of Limpopo Province.

According to the report compiled by the Department of Basic Education (DBE) on the marking of Grade 12 Geography (Limpopo Province) in December 2010, the learners performed poorly on the question that was on GIS. The moderator remarked in her report that “the performance in question 4 (GIS) is very low, clearly indicating that educators also need extensive guidance from the Department” (DoE Report on Marking Grade 12 NCS, 2010:5). Still in December 2011, learners continued to perform poorly in the GIS related questions. The moderator went on to say that most teachers do not know and understand GIS, hence it is a problem teaching it to the learners. There is no specific textbook for GIS, and learners from rural areas do not have access to computers. The Internal moderator for Geography Grade 12 in the 2011 Report on Marking indicated that “the section on GIS will remain problematic until educators are better trained on this section and textbooks improved.” (Department of Basic Education: Report on Marking Geography Grade 12 NCS Limpopo Department of Education, 2011:2). These remarks support the need for research in this part of geography curriculum in the FET phase. The continuation of poor performance by learners in Geographical Information Systems on this part of the syllabus needs to be attended to.

Once resources to impart GIS are available, then teaching models could be introduced to successfully teach this section. The identified problem is general throughout South Africa. Most schools in the rural areas are not well resourced in terms of technology. Some of the schools are not even electrified so as to allow fitting the schools with hardware equipment. Security in the schools is not guaranteed since the equipment requires maximum security. Given the aforesaid challenges it seems too early to introduce GIS in such schools.

GIS is a practical part of Geography curriculum and does not differ much from teaching maps. It is not feasible to teach learners to calculate distances on a map without having maps in their possession. A learner must take a ruler and calculate the distance in centimetres on the map, before converting that distance in metres or kilometres using the scale of that particular map. In the same light, one cannot teach GIS without hardware and software. Currently most secondary schools teach it without the necessary equipment. The teaching is mainly theoretical. This research study proposes how GIS could be taught and learnt in secondary schools in South Africa; method that could make teaching of GIS more practical. In other words, a class situation where learners could do as they learn; and that is a real construction of knowledge by learners. This research study argues that it is currently premature for the Department of Basic Education (DBE) to introduce the teaching of GIS in South African secondary schools. Teachers need to be trained first and GIS teaching resources need to be available in secondary schools as well. The research further argues that secondary schools in Limpopo Province and the entire Republic of South Africa are not yet ready for this part of the curriculum. Other basic needs need to be put in place before the introduction of GIS in secondary schools. Currently, the section on GIS has been introduced into the geography curriculum, but learners are not being taught the practical component of GIS, which is essentially what GIS is all about.

1.3 AIM OF THE STUDY

The aim of this study is to investigate the teaching and learning of Geographical Information Systems (GIS) in secondary schools of Limpopo Province with the intention of proposing how best GIS can be taught.

1.4 OBJECTIVES OF THE STUDY

The objectives of this study are:

1.4.1 To examine current methods employed by geography teachers to teach GIS.

1.4.2 To establish the availability of hardware and software in secondary schools in Limpopo Province.

1.4.3 To determine the relationship between background knowledge of GIS by the teacher and performance of the learners in GIS.

1.4.4 To determine how learners currently learn and evaluate their experiences with GIS.

1.4.5 To propose how best GIS can best be taught in secondary schools in Limpopo Province.

1.5 THEORETICAL FRAMEWORK

GIS is a contemporary tool where the user creates searches in order to get solutions. Currently “there is a lack of a pedagogical framework for using GIS in education” Kinniburgh (2010:76). It is therefore imperative that contemporary pedagogy develops a framework through which GIS could be taught and learnt. This research study believes GIS teaching and learning is done through doing and finding solutions using the hardware and software that is fitted or linked to the hardware one is using. One is to construct knowledge in order to obtain results of what one needs to produce. Constructivism theory fits well in this research study.

GIS teaching and learning is based on the belief that knowledge is not something that can simply be given by the teacher to the learners while seated on their study desks. Knowledge of GIS should be constructed by learners through an active and mental process of development. Koohang, Riley and Smith (2009:91) state that “constructivism learning theory, which focuses on knowledge construction based on learner’s previous experience, is a good fit for e-learning because it ensures learning among learners”. Geographical Information Systems is an e-learning tool that encourages active participation from the learners as he constructs knowledge and this instructional design, namely constructivism is relevant “because it promotes active learning through knowledge construction” (Koohang et al. 2009:92).

Constructivist theory is a meaning-making theory of learning. Driscoll (2005:385) states that “constructivist theory assumes the learners construct their knowledge into meaning and are not empty vessels”. Constructivist learning goals encompass the skills of critical thinking and problem solving (Driscoll, 2005). By leveraging the GIS software, activities can be constructed to present learners with multiple learning

pathways. It is through this unclear pathway that learners will be asked to articulate and construct their learning. According to Driscoll (2005), only a learner who is active is a successful one. In GIS, learners learn by actively doing and this makes them to understand even more. Constructivism is therefore a relevant philosophical approach for learning and teaching GIS.

Yager (2000:44) presents a constructivist learning model that “encourages students to initiate group discussion or ideas on a topic”. In learning geographical information system, group work is encouraged. The teacher remains a facilitator of the learning process, while the learners work together in the co-construction of knowledge. Through skills of reasoning, logic and problem solving, learners will develop arguments based on their findings. Constructivism is not a theory of teaching but a theory of learning. When constructivist teachers teach GIS, they should only give help and guidance to learners. Learners’ knowledge of how to operate a computer will help in guiding them on how to develop data bases. From this point, learners can develop databases by themselves. This indicates the relevance of the constructivist approach to this study.

It is the duty of teachers to identify some pedagogical dimensions which should be considered when planning and implementing a GIS curriculum. There are three dimensions identified in this research study. The first dimensional contrast is the approach in which the focus is on teaching technical skills in a system operation against an approach in which the teaching of basic concepts is emphasised. The second dimension concerns the contrast between an approach which concentrates on GIS theory and one which considers the applications of GIS. A third dimension places the education about the management of GIS at the opposite pole from education about the use of GIS. In secondary schools, GIS should be used as a means through which learners can integrate knowledge about their local environments and how to solve problems. As learners attempt to make sense of their experiences in using the GIS technology, those experiences will be constructed anew so as to make sense of new information.

1.6 LITERATURE REVIEW

Due to the fact that GIS and other spatial technologies are widely used all over the world today, it is relevant that it be taught and learnt in secondary schools of South Africa as well. Research shows that throughout the world, the adoption of GIS-based teaching and learning in the secondary school geography curriculum has been extremely slow, owing to a variety of key technical and socio-technical factors (Brodie, 2006; Kidman and Palmer, 2006; Meaney, 2006; Lam et al., 2009). From this perspective, the aim of this study is relevant and necessary; that is to propose how GIS can be taught and be learnt in South African secondary schools. When implementing teaching and learning of GIS in secondary schools, Sui (1995:579) argues that "GIS education involves two aspects – how to teach about GIS and how to teach with GIS". The content of geography education should include the knowledge, skills and values of geography and the students should acquire an understanding of these skills to be able to use GIS. This could be viewed as learning about GIS (Lam et al., 2009). 'Learning with GIS' (Sui, 1995) is seen as being the major reason for using GIS in school geography.

The need for this research is important and could add value on the understanding of GIS in South African secondary schools. Teacher training in this area of the geography curriculum is also imperative because GIS is not like other geography sections. If new teachers are trained in GIS teaching in secondary schools, the problem could be alleviated. The implementation of GIS teaching and learning in secondary schools is long overdue worldwide. Kidman and Palmer (2006) argue that the technology exists, but the teaching is yet to catch up. GIS is there but qualified teachers to teach it are not there yet. In South African secondary schools it is therefore important that the teachers for teaching GIS be prepared so that it can be taught efficiently and effectively.

This research aims to develop a method of teaching GIS in South African secondary schools. The method will guide teachers to teach learners the GIS section in a distinct manner. The literature discusses what is in place with regard to teaching GIS in South African secondary schools as compared to other countries that have already incorporated it fully into their geography secondary school curriculum. As mentioned under the research problem, GIS has been added and introduced in the geography curriculum at Further Education and Training (FET) level in South Africa,

but learners do not perform well when they exit this level at secondary school. Grade 12 geography graduates cannot be employed in the GIS industry to work because they have little knowledge of GIS. In other countries such as Rwanda, Jamaica, USA, Canada, United Kingdom, New Zealand and Australia, GIS has been introduced in secondary schools and because the preparation was done prior to the introduction, the teaching of GIS has gone smoothly (Brodie, 2006; Foster, 2008: Lam et al., 2009; Meaney, 2006).

Rwanda's "handful secondary schools have 20 or more computers" (Foster, 2008:2), and is optimistic towards GIS literacy. In terms of international standards, Rwanda is still under-developed and poor when compared to South Africa, but they have managed to introduce GIS technology in their secondary schools. The infrastructure in this country is far less than what is available in South Africa. The Department of Education in Rwanda realized the importance of GIS and therefore could not wait for their learners to be introduced to this concept when they reach university. In 2008 the National Curriculum Development Centre of Rwanda developed a "framework for GIS curricula (Senior 1- 6)" (Foster 2008:4). The introduction of GIS in Rwandan secondary schools adopts Rwanda's general endeavour of becoming an IT centre of excellence. Introducing GIS in South African secondary schools has the potential to build capacity and create future job fields for the youth. When South African youth enter tertiary education, awareness with regard to GIS will already have been in existence. They will already have the knowledge about GIS. Research and the development of study programmes in terms of the production of maps and data will be enhanced.

The Ministry of Education in Malaysia, which is still a developing country (almost on the same level with South Africa) budgeted about RM 5 billion within a seven-year period to upgrade the computer literacy and ICT among the younger generation (Lateh & Muniandy, 2010). GIS in particular, has not yet been implemented in Malaysian secondary schools. Currently computer literacy has been introduced in the education system in Malaysia. This seems to be a way of preparing the schools for the introduction of GIS in secondary schools. Even though GIS in Malaysia has been successfully used in various fields such as crime investigation, engineering, hydrology and many more fields, it is only taught at tertiary institutions. Private schools are the only institutions at the secondary level in Malaysia involved in

introducing and offering GIS courses for school-leavers. The obstacles in most countries which delay processes of introducing GIS in secondary schools are related to technical, institutional, staffing, funding and other factors impacting system development and operation (Lateh & Muniandy, 2009). The readiness of the environment for the introduction of GIS in secondary schools is important. This research study argues that GIS in Limpopo Province and South Africa as a whole was introduced in secondary schools before the necessary preparations were done. This research will propose how teaching and learning of GIS in Limpopo can take place.

The National Research Council of the United States (Committee on Geography, NRC 2006), points to the critical value of introducing spatial thinking skills across subjects and to learners of all ages. Spatial thinking is the knowledge and skills to use concepts of space, tools of representation like maps and graphs and processes of reasoning to organize and solve problems. It is where the meaning of space and using the properties of space as a medium to structure enquiry problems is understood. NRC suggests that spatial thinking is at the heart of many advanced discoveries in science. By visualizing relationships within spatial configurations, students can visualize, memorize and analyse the static and the dynamic properties of objects and the relationships among objects. The Council continues to say that skills of spatial enquiry can be learned and be taught at all educational levels from primary school to college. Due to computational technology like GIS, spatial enquiry can be supported in ways that enhance its speed, accuracy and flexibility.

In Taiwan and many other Asian countries such as China and Hong Kong GIS has become a classroom learning tool (Lam, Lai & Wong, 2009). It is therefore important for South Africa to introduce it fully into the secondary schools; hence the development of teachers is crucial. In academic geography, the advancement of technology has made GIS a very important tool in research work. On the teaching and learning side, GIS is a powerful tool for data storage, retrieval and presentation, has a great potential to contribute to effective learning of geographic concepts, knowledge and the formation of values (Lemberg & Stoltman, 2001). In some countries, GIS has been included in school geography for the past ten years. GIS has transformed the manner in which the earth is described and studied. Geography

teachers teach learners spatial data. GIS is integrating and analysing spatial data and therefore provides a digital lens for exploring the dynamic connections between people, their health and well-being, and changing physical and social environments (Cromley & McLafferty, 2002). The importance of secondary school learners to understand spatial data using GIS software at that level cannot be ignored.

In South Africa, very few scholars have explored the teaching of GIS in secondary schools. It is therefore imperative for this research to investigate how GIS is taught and what is needed for GIS to be successfully taught in South African secondary schools. This study has attempted to answer some of these questions: Is the available infrastructure in South African secondary schools sufficient to teach GIS? Are the secondary school teachers in South African schools capable of teaching GIS?

1.7 RESEARCH METHODOLOGY

The aim of this study is to develop a method of teaching and learning GIS in secondary schools of South Africa, using Limpopo Province as a case study. A mixed method approach was followed in this research study. To achieve the aim and objectives of this research study, different approaches were employed. In the first phase of the study a questionnaire was used as a tool to collect both quantitative and qualitative data. Data were collected from geography teachers teaching Grades 10 to 12. Part 1 of the questionnaire was quantitative questions which ranged from personal data of teachers, their skills and knowledge in GIS, current methods they employ in the teaching and learning of GIS, to GIS related infrastructure available in their schools. These are methods that incorporate some combination of collecting numerical data using relatively structured and close-ended approaches and formats. “Quantitative research refers to counts and measures of things” (Berg, 2007:3). The second part of the questionnaire contained qualitative questions where teachers gave their own opinions regarding their experiences in schools. According to Montello and Sutton (2006:39), “qualitative data are non-numerical or, as in nominal data, numerical values that have no quantitative meaning”. Plano Clark and Creswell (2008:275) point out that “in a qualitative research paradigm, a primary focus is for researchers to capture authentically the lived experiences of people”. It is therefore

important for this study to collect information regarding GIS experiences from teachers.

Geography learners were also given a close-ended questionnaire to determine their knowledge of GIS. The researchers visited a few randomly selected schools to question learners on GIS, what they feel about it, and other questions related to GIS in general. During data collection, Grade 12 learners in selected schools were given a test on their knowledge of GIS. In the context of this study, questionnaires directed to both learners and teachers were designed so that the researcher could count how many of both variables are familiar with exposure to GIS and other related information regarding GIS. The use of mixed research methods is applied in this study because each method reveals different aspects of empirical reality. At the end of this study, a multiple theoretical perspective will increase the depth of understanding of the problem under investigation.

1.7.1 Research Design

According to Berg (2007:38), the research design “is literally the plan for how the study will be conducted”. The qualitative research phase of this study followed a phenomenological design in which the concept of GIS teaching and learning was investigated through interviews, questionnaires and lesson observations of teachers. Separate interview questions were specifically designed for learners and for teachers. The interviews were conducted formally in schools that were sampled in every district of Limpopo Province.

A cross-sectional research design was adopted in order to describe the relationship between learners’ preparedness in GIS and the interest to study geography in secondary schools. In the second phase of the study, a survey was used to determine the knowledge and skills of teachers and the available infrastructure in schools. Quantitative data were collected in the survey and were subjected to numerical analysis. The quantitative type of questions used a five-point Likert Scale.

1.7.2 Population and sampling

The research was conducted in Limpopo Province. Limpopo has five districts namely, Capricorn, Waterberg, Sekhukhune, Vhembe and Mopani. All these districts have both rural and urban schools. Limpopo Province is mainly rural and most schools are in a rural environment. The province constitutes the area that was previously covered by three homelands namely, Lebowa, Gazankulu and Venda. The infrastructure in many schools in this area is of poor standard. There are learners who are still taught under trees where physical school buildings are non-existent. This research study involved secondary schools that are located in both rural and urban areas of this province in order to uncover the true nature of GIS use in secondary schools. Main urban centres such as Polokwane, Tzaneen, Phalaborwa, Louis Trichardt and Mokopane are uneven in terms of their geographical distribution. In these centres, there are both public and private schools which were sampled in this study. Few rural private schools are also found and were included in the sample.

The reason for including the schools in rural and urban areas as well as private and public schools is to determine the extent of the problem. GIS implementation in most schools is related to finances. Schools in historically black townships were compared to former white-administered schools in the neighbouring towns. This was done to ascertain whether public schools struggle in purchasing both hardware and software required for infrastructural development within schools.

Sampling was done in all five districts of Limpopo Province. Although this study uses mixed approaches, for the quantitative sample, in every district 5% of all secondary schools doing geography in the FET phase were sampled. Depending on the number of learners in all schools, 5% of the learners in every school were sampled. The teachers were sampled according to size of schools, because in schools that have many learners registered for geography, there was more than one teacher teaching it. The selection of schools, although stratified was randomly selected for the qualitative sample. In each of the schools sampled, one teacher was interviewed and one lesson was observed. Geography is taught in almost all schools in these districts. All geography teachers in the sampled schools were engaged in data collection.

Furthermore, district schools were divided into those that are state managed and those that are privately managed. All privately managed schools from all districts in this study were selected because they are few in number. Distinction was also made between rural and urban schools. The urban schools comprise schools that were referred to as “Model C” (schools that only admitted white learners before 1994) and schools managed by religious organizations. Schools located in urban and semi-urban areas were grouped together. Areas such as Lebowakgomo, Giyani, Thohoyandou, Seshego and similar black townships were classified under the category of non-rural. GIS is a hardware and software tool which is associated with infrastructure mainly found in urban areas. Learners from the same schools were selected to establish whether there was a relationship between data collected from them and data collected from their teachers. The learners that were sampled were those in the Further Education and Training (FET) phase doing geography. A table of the sampling and sample size follows hereunder.

Table 1.1: Population, Sampling and sample size

Districts	**Population (No. of schools)**	**Total Sample**	**Rural (Sample)**	**Urban (Sample)**
Capricorn	303	20	13	7
Greater Sekhukhune	263	20	19	1
Mopani	254	20	16	4
Vhembe	307	20	16	4
Waterberg	128	20	15	5
TOTAL	**1255**	**100**	**79**	**21**

Table 1.1 above displays population which is made up of a total number of schools doing geography in Limpopo Province. Currently there are 1255 secondary schools doing Geography at the FET level in Limpopo Province. From this number, 1188 are public schools while 67 are private schools. The above table illustrates how these schools were sampled in all the 5 districts.

1.7.3 Data Collection Instruments

This research study acquired mixed-methods design, and therefore collected both quantitative and qualitative data to accomplish the objective of this study. Quantitative data were gathered using a questionnaire which adopted a 5-point Likert Scale. The questionnaire, which was close-ended, was used to acquire primary information regarding the teaching and learning of GIS in different secondary schools in the province. The questions were clearly divided into five thematic categories. Personal data of teachers, their GIS skills, Knowledge of GIS, Methods they currently using in the GIS teaching and the available GIS related infrastructure. Geography teachers were given questionnaires that asked questions related to GIS training and teaching experience, knowledge and skills they possess and GIS infrastructure-related questions.

Learners were given test as well. Their questions were mainly based on their understanding of GIS and the availability of the infrastructure (hardware and software) in the schools. The correlation coefficient to determine the relationship between their understanding of GIS and the availability of the needed infrastructure in their school was determined. The questionnaires were all in English. This is the medium of instruction in the sampled schools. The questions were clearly explained to both learners and teachers who were part of the sample. Data collection was mainly conducted after normal school hours to avoid disrupting the daily school programmes. The learners earmarked to respond to these questionnaires were placed in one classroom.

Qualitative questions were also used as a tool to collect data. The qualitative method involves interviewing all variables. In the context of this study, it will be learners and teachers. The data collection instrument used to collect qualitative data was the interview and open-ended questions. Separate interview schedules were drawn for learners and teachers. The standard of questions for both differed in terms of depth and context. The purpose of using the interviewing technique of data collection was to examine in-depth the teaching methods and learning taking place in GIS in secondary schools.

1.7.4 **Data analysis**

Descriptive statistics was used in analysing the quantitative data. The descriptive statistics “describe” data that have been collected. Commonly used descriptive statistics include frequency counts, ranges (high and low scores or values), means, modes, median scores and standard deviations. In the case of this research, the variables were geography teachers in secondary schools of Limpopo Province, available hardware and software, and learners doing geography as one of their subjects. The comparison was on the achievement of GIS test from both rural and urban schools. The correlation coefficient was used to determine whether there is correlation between GIS knowledge of the geography teachers and the GIS Grade 12 test performance of learners and the understanding of GIS of learners in rural schools compared to that of schools in an urban environment. Inferential statistics was also used to draw conclusions and make predictions based on the description of the data. The distribution of sampling was also considered when generating guesses through generated probabilities which might be said to be correct or close.

The qualitative data obtained from the both teachers’ interviews and from Grade 12 learners were analysed. The study adopted a mixed method design. The methods will later be triangulated to close some gaps left by both designs. Grade 12 geography learners wrote a test where the researcher wanted to measure their GIS knowledge and to also to use their performance as a yardstick to determine the GIS knowledge by their teachers. The test encompassed the GIS work they did from Grade 10.

1.7.4 Reliability, validity and objectivity

Reliability is the extent to which an experiment, test, or any measuring procedure yields the same result on repeated trials. To measure reliability of the findings, the test-retest method was applied. All teachers sampled in different schools together with learners were liable for the test-retest method. Validity refers to the degree to which a study accurately reflects or assesses the specific concept that the researcher is attempting to measure. Objectivity is ascertained when the data used are reliable and valid for the research. A pilot study to check the relevancy and quality of the questionnaire was done before data could be collected from other schools.

1.8 ETHICAL CONSIDERATIONS

The ethical considerations in this study included the following, namely, informed consent, permission, respect, honesty and transparency. Bryman and Bell (2007) indicate ten principles of ethical considerations in accordance with guidelines adopted by nine professional social sciences research associations. Some ethical considerations adopted in this study are discussed.

1.8.1 Informed Consent

Informed consent forms were filled by all the participants. In accordance with Bryman and Bell (2007), one important principle is to get a full consent from the participants prior to the concerned study. In this study, learners took part in the interviews needed consent from their parents. All participants were informed that participation in this research was voluntary and that they could withdraw at any time. All data were anonymously collected and analysed.

1.8.2 Permission

The Department of Basic Education in Limpopo Province granted the researcher permission to conduct this research (See Appendix B). All conditions outlined in the permit were adhered to. Ethical clearance was sought from the Turfloop Research and Ethics Committee (See Appendix C).

1.8.3 Respect

The cultures and religions of participants were respected. All participants remained anonymous.

1.8.4 Honesty and transparency

All type of communications was done with honesty and transparency. Principal of schools sampled, geography teachers in school and learners interviewed were given all the information related to the study.

1.9 SIGNIFICANCE OF THE STUDY

GIS is a modern technology used in different fields of study. It is therefore important for South African secondary school learners to be introduced to it while still in the FET level. This means that the Department of Basic Education must train qualified teachers in geography to teach this important section. The proposed recommendations of how GIS could be taught is of significance in this study, because it will assist geography teachers in teaching GIS in their respective schools. This will also help in reducing the failure rate in geography when they exit the FET level in Grade 12. In addition, future implications in relation to employment opportunities for suitably qualified and trained GIS specialists are enormous.

1.10 KEY CONCEPTS

The main key concepts in this study are Geographical Information Systems (GIS); teaching and learning. Lam et al. (2009) indicates how in academic geography, the advancement of technology have made GIS a valuable and significant tool in research work. GIS has become an important tool in geography analysis and exploits location as one fundamental principle of geography (Scheepers, 2009). Özgen (2009) defines GIS as a system capable of performing functions such as collecting, storing, and processing graphic and non-graphic data and then present it to prospective users. One other significant role of GIS is that of improving aptitude of learners in thinking, ability to analyse available data, ability to access geographic data with ease and geographical inquisitiveness (Kerski, 2003).

Prozensky (2000) says teaching is helping other people to learn. Teaching is the process of attending to people's needs, experiences and feelings and make them learn particular things. Learning is the process of constructing meaning by students themselves with the facilitation of a teacher. In the context of this study, geography teachers are guided on how to facilitate GIS lesson in a classroom.

1.11 SUMMARY OF THE CHAPTER

In this chapter, the researcher gave a brief background of what GIS technology is. GIS as a new technology within the geography curriculum fraternity was clearly outlined. The problem, aim and objectives of this research were detailed. This research adopted constructivism theory in explaining how GIS could be taught and learnt in the secondary schools of Limpopo. A brief literature review was also cited to show countries that already introduced the teaching and learning of GIS in their secondary schools and the problems their encountering. The reasons why GIS should be introduced at this level are also outlined. The chapter further showed the study area of the research, the instruments that was used in the collection of data and how the data was analysed. The researcher concluded by showing the significance of studying GIS in the secondary schools.

CHAPTER TWO

REVIEW OF THE LITERATURE

2.1 INTRODUCTION AND BACKGROUND

The aim of this study is to investigate teaching and learning of Geographical Information Systems (GIS) in secondary schools in Limpopo Province, South Africa, with the intention of developing methods that could be used in its teaching and learning. The South African National Department of Education incorporated GIS into the Geography Curriculum for the first time in 2006 (DoE, 2008). Scheepers (2009:40) argues that the introduction of Geographical Information Systems into the South African Geography Curriculum, “poses many challenges to education authorities, educators (both at tertiary and secondary levels), scholars and vendors of GIS software”. The challenges facing the Department of Basic Education (DBE) are training teachers who will be able to impart GIS to the learners, budgeting funds to equip schools with hardware and software, creating time to train the teachers and for the vendors to develop software that will be appropriate to the secondary school level and that is not designed for industrial use, and that can be affordable (Meyer,

Butterick, Olkin & Zack,1999; Qadri, Ahmed, Shahid, Rehmani, ul Rehman, Muhammed, Ejaz and Qadri, 2014). These challenges may impact negatively on the smooth implementation of GIS in South African secondary schools' geography curriculum.

The study is limited to Limpopo Province, which is one of the nine provinces of South Africa. The National Department of South Africa controls and prescribes the curricula for all subjects offered within all the provinces in the country. Each of the provinces has a Provincial Department of Education that administers and manages the implementation of the prescribed curricula of all subjects. In this study, Limpopo Province is sampled as a case study to investigate how GIS in geography curriculum is taught and learned in the secondary schools of South Africa.

The introduction of GIS in secondary schools throughout the world has met obstacles and challenges (Bednarz, 2004; Komlenović, Manic & Malinic, 2013; Lam et al., 2009; Akinyemi, 2015). In Africa, thus far it is Rwanda, Uganda and South Africa that have implemented GIS in the geography curriculum of their secondary geography study (Akinyemi, 2015). Akinyemi (2015) explains the reasons why countries such as Uganda had challenges that retarded the progress of introducing ICT in rural schools. Uganda implemented ICT curriculum in secondary schools, but only urban schools made great strides in its use than rural based schools. The challenges in rural setting schools include inter alia "lack of electricity, inability to afford computers and a limited number of teachers with ICT skills" (Ayorekire & Twinomuhangi, 2012 cited in Akinyemi, 2015:28). In their article, Breetzke, Eksteen and Pretorius (2011) identify similar challenges in South Africa that are related to lack of funding, and poor infrastructure such as electricity, water and sanitation in schools and insufficient theoretical grounding and practical experience in the use of GIS by teachers. From the explanation cited by Breetzke et al. (2011), conditions in Uganda as outlined by Akinyeni (2015) seem not to differ much from those of rural schools in South Africa, especially in a rural province like Limpopo, which is the focus of this research study. Desktop Study Report on Development of the Rural Transport Strategy of Limpopo Province (2010) cites that Limpopo is rural where 78.9% of the population lives below the national poverty line and 74.4% of the population dwells in tribal or traditional areas. In terms of infrastructure, most schools

found in the tribal areas of this province are still without electricity and are poorly resourced. The provincial government is trying its best to allocate funds for this initiative.

ArcNews (Spring, 2008) reported that initially the government of South Africa relied on the private sector to facilitate the introduction of GIS in schools after it was included in the curriculum for the first time in 2006. GIMS (Pty) Ltd., (the ESRI distributor in South Africa) assisted the government in the training of geography subject advisors from all the nine provinces in South Africa. They used former geography teachers and other key people to develop GIS materials that would address GIS that is relevant to the educational needs of the Department of Education. Realizing that there were huge differences that existed between urban and rural schools, the GIS school material included three separate approaches that formed the fundamental steps for the learning of GIS namely, Paper GIS, ArcExplorer and ArcView. The differences highlighted in the report are the shortage of well-qualified teachers in rural schools, access to electricity, poor infrastructure and funding. The report emphasized what Akinyemi (2015), Breetzke et al., (2011) and Eksteen et al. (2012) argue in terms of factors limiting the smooth introduction of GIS in South African secondary schools. Paper GIS was specifically developed for the schools that do not have computers. ArcExplorer was for the schools that had limited access to computers (one computer in a school) and ArcView addresses all GIS requirements that might be necessary for the schools with access to computers.

To establish a convenient infrastructure on GIS in secondary schools of developing countries, the countries concerned need to inject more capital. Many developing countries struggle to implement GIS curriculum in their education system due to lack of funds. The question of funding is a widespread problem in most countries (Kidman & Palmer, 2006; Breetzke et al., 2011; Bednarz & Van der Schee, 2006). In South Africa, the problem of funding delayed the smooth implementation of GIS. The problem was further entrenched by the former policy of apartheid, where schools' funding method was skewed. Schools for Whites had good facilities compared to schools belonging to other racial groups. At some stage, the white learner was funded ten times more than the black learner (Breetzke et al., 2011). This resulted in unequal distribution of resources. After the new democracy dawned in 1994, the

African National Congress-led government, was faced with a great task of closing the gap in “both the funding and structure of public education” (Breetzke et al., 2011:3). South African School Act of 1996, was introduced to address the legacies of apartheid. Today, more than twenty years after democracy was introduced, some schools in rural South Africa are still without electricity and computers. Schools that historically belonged to ‘Whites’ (whether rural or urban), are still well equipped with technology required for GIS implementation. In Uganda only a few international secondary schools sponsored by foreign countries “have started to integrate GIS into their lessons, especially in the teaching of geography” (Akinyemi, 2015: 28). In South Africa, private schools, which are expensive, are better off in terms of equipment. They have technological facilities such as computers that attract parents who are financially well-off, as they are more expensive than public schools where education is, in most cases, free. This research study also looks into the extent to which private schools in Limpopo Province have contributed in the development of GIS in secondary schools.

The introduction of teaching GIS in secondary schools was a breakthrough in the South African Geography curriculum. Learners learnt how to use computers and got other Information and Communication Technology (ICT) skills. Geography teaching was made even more creative, effective and interesting than before. In this case, the constructivist theory of learning would apply because learners would learn through creating using computers. A learner would be taught how to construct a map of Gauteng or any area around where he/she stays and from there, he/she would do the construction on his/her own. The learner would be practising skills that would be needed in future in the workplace. Computer skills through the learning of GIS would make learners more marketable for their future employment. Using GIS in education “is said to support effective thinking by learners” (Roulston, 2013:41). In Kemp’s words, GIS in the lower education, referring to the primary and high schools, is “being used as an enabling technology, as a means for teaching students about their environment and how to solve problems” (Kemp, 1995:6). Constructivist learning is an active process that gives learning meaning. The main problems faced by the Department of Basic Education in South Africa are lack of capacity and the necessary infrastructure for teaching GIS in schools. Many geography teachers in South African secondary schools are not computer literate, which is basic before one

could have GIS knowledge and skills. It is therefore necessary to develop methods of teaching GIS efficiently in secondary schools. This research study investigated the extent of computer literacy amongst teachers in Limpopo Province.

Akinyemi (2015) in her article also explains some of the problems that South Africa faced when introducing GIS. She cites the fact that teachers did not have sufficient theoretical and practical experience in using GIS. This research study argues that the poor performance of learners on GIS in Limpopo Province is basically caused by the inadequate qualification of teachers to teach it. It further investigates the availability of hardware and software that can support the teaching of GIS in the Limpopo Province schools, the difference between rural and urban schools in terms of available teaching equipment and their performance is also addressed. The study further looks at what private schools provide in terms of their teachers' qualifications in GIS and the available ICT infrastructure in their schools.

2.2 ASSESSING BENEFITS OF TECHNOLOGY IN MODERN EDUCATION AND ITS IMPACTS ON THE STUDY OF GEOGRAPHY

As technology changes daily, it influences many aspects of our lives; among others education. It is imperative that these changes be updated in the school curricula to satiate the socio-political and economic changes of the day and to make other inroads within our own academic world (Lawton, 1983; Lam, et al., 2009). Technology has benefited teaching and learning to a great extent in education worldwide, South Africa included (Muir-Herzig, 2004; Rasinen, 2003; Saba, 2009). The first objective of this research work is to examine current methods employed by geography teachers to teach GIS in the secondary schools of Limpopo Province (South Africa). Geography has benefited greatly from technology in its teaching and learning all over the world. The technology of Geographical Information Systems (GIS) has changed the traditional trends through which geography was taught and learnt in all levels of study (Kerski, 2003; Audet & Ludwig, 2000; Aladağ, 2014). By introducing GIS in the geography curriculum of secondary schools in South Africa, it will benefit teachers and learners, impacting positively on the economic needs of today's generation. It will as well make South Africa to be on the same footing with

other countries in teaching and learning modern technologies in geography. For quite a long time, geographers have been developers of theories that looked into different aspects of the human and physical environment (Kemp, 1995). With the introduction of computers, geographers through GIS can now do spatial analysis in determining the location of any phenomenon. GIS technology has changed the approach of different aspects in geography and has made a turn-around on its traditional perception.

Saba (2009) argues how in general, technology in education benefited the educational environment differently. He specifies how the integration of technology benefited secondary school education learners in the improvement of their achievement on tests; improvement in the quality of their work; improvement in their attitude towards learning; decrease in the drop-out-of-school rate by the At-Risk learners; and above all, prepares learners for their future workplace. One of the aims of teaching Geography in Grades 10, 11 and 12 as stated in the Curriculum and Assessment Policy Statement (CAPS) of the Department of Basic Education of South Africa (2012:6), is to "promote the use of technology, such as Information Communication Technology (ICT) and Geographical Information Systems (GIS)". This denotes that the Department of Basic Education is keen to introduce technology in the teaching and learning of the geography of today in secondary schools of South Africa. The Department of Basic Education and Saba (2009) agree in principle on the promotion of technology in education. Innes (2012) outlines how South Africa is still in its infancy with the use of GIS, especially in municipalities and water suppliers. It is therefore necessary that we produce competent geospatial practitioners in South Africa who can take these municipalities forward in managing them through GIS technology. Innes (2012) proposes that for South Africa to produce professional Geographical Information Scientists, the "first step on that journey is acquiring map skills" (Innes, 2012:92). Acquiring map skills needs technology training in class. Innes (2012:92) emphasizes that "it is in the classroom at school that these skills are usually acquired." These skills will be needed in future when the learners look for permanent employment. Exposing the learners to GIS technology while they are still in the lower levels of their study will make them ready for any challenges that they may come across when they are professional Geographical Information scientists in future.

Introducing GIS technology in secondary schools will pave the way for South Africa to have qualified geospatial practitioners that can carry the GIS technology forward. Acquiring geospatial knowledge through the GIS technology prepares learners for different future careers in life. By introducing learners to the technology at the secondary level, it will increase their interest in learning and change their attitude towards learning. Representing spatial distribution of phenomena on the map using GIS technique is a good skill. The days of drawing substandard maps by bare hands are over. Saba (2009) states that through the application of technology the quality improves. The map products of GIS technology equipment will obviously be of higher quality than the ones drawn by hand. Scales on those particular products will be correct. All spatial features will be correct and will resemble their positions as they appear on the landscape. Exposing geography learners to GIS while still in secondary schools will benefit the learners, because by the time they get to tertiary level, they will have developed a strong GIS background necessary for GIS career training.

Aladağ (2014) argues that through the years, numerous studies have revealed how the benefits of using GIS in geography education have increased during the recent years. The researcher argues that one of the benefits for GIS is that it enables student-centred approaches which motivate students/learners to create, produce and express ideas (Audet & Ludwig, 2000; Aladağ, 2014). GIS involves modern technology application. Baker (2005) elucidates that GIS promotes the computer skills of students and their attitudes towards technology. They develop passion towards the technology of GIS because computer skills are fundamental towards the teaching and learning of GIS. Wechsler and Pitts (2004) also argue how GIS in high schools geography curriculum integrates both geography and technology. They emphasize that through GIS technology in high school, geography learners can learn many skills such as collecting, storing, analysing and presenting data that are graphical and non-graphical. Aladağ (2014:1534) also add another important benefit that “GIS is also an important tool for aiding students to gain geographical consciousness, which can be defined as willingly having, protecting, using, organizing, planning and saving nature and elements belonging to humans”. By

differentiating between natural and human elements, when planning and analysing the data related to these elements, decision-making becomes easy (Aladağ, 2014).

After all these benefits have been outlined, there will still be many teachers in South Africa who are technologically illiterate and unwilling to engage themselves with the technology (Innes, 2012). Innes (2012) states that one reason why geography teachers in South Africa resist the GIS curriculum is because of their low level of spatial competency in under-resourced schools found in both rural and urban setups. Teachers, who are technologically illiterate, do not even want to come close to a computer. They feel left out and end up developing a negative attitude towards the use of computers and GIS as such. This study looks into the effect of such personalities in the implementation of GIS in Limpopo Province. Changes and innovation in most cases meet with resistance, as people are reluctant to accept change. Another reason for resisting change, according to Innes (2012:103) “is lack of access to the necessary hardware and software required to teach GIS effectively”. This research also looked at the problem of software and hardware in secondary schools of Limpopo Province in both rural and urban areas. It also focused on the willingness of the teachers to be trained so that they can impart their knowledge of GIS to learners without fear. Naish (1982), Lambert (2002), and Innes (2012) argue that teaching GIS needs some specialized skills than when one teaches ordinary geography content. This research study proposes those specialized methods that can be applied when teaching GIS in secondary schools. Teachers should be able to differentiate their methods when teaching GIS and when they teach other sections on geography content.

Many research studies have found that when students learn through technology, they tend to develop a better attitude towards learning (Muir-Herzig, 2004; Saba, 2009). They also have confidence in themselves. Geography is a practical subject. The introduction of technology in the teaching of geography will make it more practical. Saba (2009) shows how mathematics students in five junior high schools in Oklahoma (USA), using computer technology in the cognitive tutor curriculum, developed more confidence than students who attended traditional classes that were without any technology. Saba (2009) further indicates how technology made it easy for students to learn and were confident of getting better jobs in future, and students

with special needs felt that they were doing better on tests that were computer-based than the normal traditional teaching that was not technology based. The majority of modern learners will obviously enjoy being taught through the use of technology than being taught manually in a traditional fashion. Breetzke et al. (2011) support this argument. Technology facilitates a knowledge-constructed learning situation-like classroom (Muir-Herzig, 2004; Papert, 1980; Ragosta, 1982). These researchers view the use of computer technology in the classroom as student-centred situation "and that more individualized learning would take place than ever before" (Muir-Herzig, 2004:113). Muir-Herzig (2004) elucidates that through the support of computers, students can collaborate, think critically and find solutions to problems. ESRI South Africa (Pty) Ltd in collaboration with the Department of Geography, Geo-informatics and Meteorology at the University of Pretoria facilitated the introduction of GIS in resource-poor schools in South Africa through the development and resource based GIS educational package (Breetzke et al. (2011). The use of technology cannot be undermined in modern teaching and learning. When learners graduate from secondary school, some continue into tertiary level of education while others get straight into the work market. Using technology in secondary schools empowers and simultaneously prepares learners for future careers. Learners, who after Grade 12 go straight into the work environment, will experience lesser problems because they will be conversant with the basics of GIS technology.

Yuen, Law and Wong (2003) argue on the model of change sampled in 18 schools that struggled to integrate Information and Communication Technology (ICT) in teaching and learning across the school curriculum in Hong Kong. Their study shows that integrating ICT in teaching and learning in Hong Kong, strongly depended on the school leadership's vision and mission. Furthermore, it also depends on how the school leadership understands the role and the impact of ICT in the curriculum, its goals and objectives as well as the history, culture and background of the school. Leadership is a very significant stakeholder in every organization. It has influence and power to build and to destroy. In Limpopo Province, on policy documents, GIS technology is available, but the leadership that must bring about change is slow in taking action. The training of GIS technology teachers in secondary schools is overdue. Local universities around the province are not utilized to expose secondary school teachers to short workshops which the department can financially support. Prior research (Alibrandi & Palmer-Moloney 2001; Muir-Herzig, 2004; Baker, 2005)

have indicated how lack of support impeded the widespread adoption of GIS in secondary schools in the USA around the late 1990s and the early years of this current millennium. The support must first come from the top authorities who implement the policies of the government of the day because they have power. In South Africa the support must come from the provincial and national leadership in the Department of Basic Education. At district and Circuit levels, geography subject advisors with the knowledge of GIS technology must be employed to train the teachers on teaching and learning GIS technology in secondary schools. The last phase of leadership must come from the schools themselves. Principals with support of the School Governing Body (SGB), must support the GIS technology in their schools by seeking donors for the required hardware and software and by employing the geography teacher with GIS technology skills and by including GIS equipment when they draw up budgets at the beginning of each financial year.

Kidman and Palmer (2006) distinguish three levels of support that is required when introducing GIS in schools. The first is the support from school leadership and the community. The school leadership should level the ground by ensuring that finance and facilities are available to develop and sustain the GIS technology in the school. Community around the vicinity of where the school is located is also important. These are people who will identify benefits which the school will gain once GIS is implemented in the school. The second level of support is that of local tertiary institutions that offer education and training programmes. This should not only train learners in the hardware and software of GIS, but must as well develop GIS support material to support the prescribed books they are using. These programmes should as well train learners on the building up of a database and how it is used. The third and last support is that of government and industry. Government should create a conducive climate for the diffusion of GIS technology in secondary schools by collaborating with private and cooperate world. The Department of Basic Education must provide funds for training teachers and equipping schools with hardware and software. The corporate world could also help in training personnel that can train learners in schools. Some South African schools still lack leadership support because some school management still do not take the initiative of approaching the private sector for donations or for hardware and software that could create the basics of introducing GIS technology in secondary schools. GIS technology is an innovation

in geography teaching and learning and should be given significant support in South African schools.

In South Africa, GIS technology has already been introduced in the Geography curriculum in the Further Education and Training level which is Grades 10, 11 and 12 (DoE, 2012). This technology will improve the quality of representing spatial information on the maps. One can take an example of weather maps that are produced at most three times a day. Without the application of GIS technology it will not be possible for the South African Weather Bureau to cope with the production of their end products. More skilful GIS users are needed to produce and supply local and international clients with the daily meteorological standing of Southern Africa. It is therefore very significant to groom young people with the technology of GIS while they are still in secondary school. It is as well fundamental that geography teachers of today have knowledge of this technology and have models in place that could help them to impart the GIS technology to learners. Most literature on teaching and learning GIS in secondary schools do not propose methods of how this technology can be taught at the secondary school level; but mainly emphasize its introduction in the secondary schools (Baker, 2005; Favier & Van Der Schee, 2009; Aladağ, 2014).

Alibrandi and Palmer-Moloney (2001) state how they were involved in training students in North Carolina State University on methodologies of integrating GIS technology in geography and social studies education. The teaching of GIS technology is possible when one has equipment like hardware and software. Alibrandi and Palmer-Moloney (2001) emphasize in their article that GIS cannot be taught without hardware and software. To apply any effective method of teaching GIS, this equipment forms the fundamental requirement. ICT teaching cannot be taught without supportive equipment. Imparting GIS technology to secondary school learners will need control and much more discipline unlike university students who are already independent and can work on their own. Secondary school learners cannot make references on their own. They still need basic guidance at the beginning. After examining the methods that are currently employed in geography teaching in secondary schools of Limpopo Province, the present research work proposes methods that could be employed to teach this technology in schools.

2.3 GEOGRAPHICAL INFORMATION SYSTEMS IN SOUTH AFRICAN SECONDARY SCHOOLS

The geo-information industry is growing very fast in South Africa, just like it is happening in other countries in the world such as United Kingdom, Europe, Australia, the United States of America and the Scandinavian countries (Innes, 2012; Seremet & Chalkley, 2015; Komlenović et al., 2013). Today millions of people are employed in the geospatial industry that is estimated at generating more than $60 billion and growing at 20% per annum, by the US Department of Labour (Milson, Demirci & Kerski, Ed., 2012). In fact, the production of GIS practitioners supplied today by both secondary and tertiary institutions worldwide cannot meet the escalating demand required in both public and private institutions. To compete with other countries and to meet the number of geospatial practitioners, South Africa needs also to open up the scope for GIS training in the country. The only route to become professional qualified Geographical Information Scientist is to fundamentally acquire map skills (Innes, 2012). Teaching and learning of these skills can only be done in the geography lesson. Spatial competences need to be acquired to lay a good foundation for GIS. The foundation for spatial competence can be laid in the secondary phase of geography teaching and learning.

2.3.1 Spatial competence of teachers and learners in Limpopo Province

One of the problems related to map study in Limpopo Province and South Africa in general, is low spatial competence (Innes, 2012). The performance scores of learners who wrote Geography Higher Grade (1st Paper - Practical Paper) between the years 2000 and 2007 were plotted in rank order to determine the spatial competence of all the provinces in South Africa on the data supplied by State Information Technology Agency (SITA) (Innes, 2012). The findings showed the Western Cape Province as having an average score of more than 50% and their scores showed trends of improvement as the 2007 score was higher than the 2000 score. The following provinces showed an improvement trend: Gauteng, Eastern Cape; Free State and North West, while Kwazulu-Natal's score remained consistent. Northern Cape, Mpumalanga and Limpopo provinces showed a decline between those years. Limpopo Province was the worst performing province in terms of spatial competence level.

The results from this survey study show a need for concern in spatial competences of geography teachers in particular, in Limpopo Province. If geography teachers were competent enough, the learners in Limpopo would have scored above 50% like the Western Cape Province; but instead it scored below 30%, and to be exact the scores were 27%, 25% lower than the schools in the Western Cape Province. The other seven provinces with the exclusion of Limpopo Province also scored below 50%. Generally the spatial competence of South African school leavers who studied geography between 2000 and 2007 were poor. Although this research work would concentrate on Limpopo Province, which was the worst performing province, it is critical that other provinces and South Africa as a whole be researched. The need for GIS technology in secondary schools in Limpopo Province is critical. One of the objectives of this research is to determine the relationship between the background knowledge of GIS by the teachers and performance of the learners in GIS.

The results from the survey (Innes, 2012), indicate that geography teachers in Limpopo Province were not spatially competent enough to teach maps. Many teachers seemed not to be familiar with cartographic terminology (Innes, 2012; Breetzke et al., 2011). The introduction of GIS in schools could improve some cartographical skills for both learners and teachers. Forster, Burikoko and Nsengiyumva (2012) mention in their article on the integration of GIS in Rwanda that adopting GIS in the schools could help in making the learners grow their knowledge in the field of ICT and develop knowledge of how to develop and manage a database. The practical part of their work at school can as well assist in the future planning and development of their schools. GIS could as well assist the school administration in decision making. These reasons convinced the authorities in Rwanda to support the introduction of GIS in that country. Introducing it in secondary schools of Limpopo with well-trained GIS teachers will benefit the province.

Innes (2012) argues that one of the reasons contributing towards poor spatial concepts, techniques and skills, is language of teaching. As most teachers are not teaching in the language of their learners or their own indigenous languages, this results in poor spatial competence. In the Western Cape Province, the majority of teachers and learners are from the Coloured, Afrikaans speaking community who

use Afrikaans as their home language and as medium of teaching and learning. In support of Innes (2012) it may be correct that learners understand spatial concepts, techniques and skills when they are taught in their own home language. In a province such as Limpopo where the majority of teachers and learners are Pedi, Tsonga and Venda speakers, geography is still taught in English. Perhaps this could be cited as one reason why learners in Limpopo Province performed so poorly in spatial concepts, techniques and map skills. This question is open for other GIS scholars who can conduct research on the relationship between home language and spatial concepts to prove this hypothesis.

2.3.2 Impacts of GIS on spatial awareness

Geographical Information Systems is a fast growing industry today. It is even used by people in other fields of life that are not geographic, such as in engineering, environmental studies, mapping crime affected areas, real estate land use, politics, business development, statistics and many other areas in different sectors of the economy (Singh, Kleeman & Van Bergen, 2013). Some of the questions that we need to ask ourselves are the reasons why people want to study GIS. Kemp (1995) argues that people study GIS for two reasons: to get a job and to create an opportunity for new employments. As a new technology in the market, most people who are GIS qualified users are able to get jobs. People who have been stuck in one job and looking for a change of job can do GIS and be employed in a new career. It means a person can change his/her career to become a GIS professional user. With the demand of GIS users in this industry, introducing it in the secondary school geography curriculum will benefit learners willing to follow GIS as a career.

Teaching and learning GIS makes learners to be more creative. When they go into the working environment, learners will not only be passive employees, but will assist in resolving the problems related to their job (Scheepers, 2009). They will become critical thinkers who will promote spatial awareness. Geographers have to think critically in a spatial manner and be able to explain spatial concepts. It is imperative that such skills be developed at the secondary level of geography learning to give geography learners a fundamental base on which to build on when they go into

institutions of higher learning. Teachers should cultivate these skills in learners while still at secondary school.

The Community Tool Box designed and implemented by the University of Kansas (2015) in the United States of America, outlines reasons why GIS is useful within our own communities. The University of Kansas used GIS to assess community needs and resources through Tool Box. The Community Tool Box was a service of the Work Group for Community Health and Development, organized by the University of Kansas to assess community needs and the resources available in a defined area. They needed a technology that could, for example, map the area – a district, a rural area, a city or a specific part of the city where they are going to operate. They needed to know the population density of the area under study, the current industrial and residential section of that area and to project future developments. They also needed to locate water sources and to identify those sources that were healthy for human consumption. GIS technology was applied to do all these aspects. In this project, GIS helped them to add and to subtract spatial information from the maps they were producing for the project so that other phenomena can be clear.

Training learners for future careers should start at the lower age. With the smart phones that are in the market today loaded with GIS software, in the long run GIS will even be introduced in the lower grades of our education system. One such career is to be a professional GIS-user. As teachers promote the use of technology in schools, learners will be skilled towards different future careers. GIS learners in particular will be exposed to skills such as capturing of data, building up database, analysing spatial data, manipulating data and producing maps from the data that is available in their database. These are ICT skills learners could use in their workplace in the future. Teaching through technology will therefore be a positive move that will change perceptions of studying geography.

Rasinen (2003) analyses the technology education curricula in the following six countries: Australia, England, France, The Netherlands, Sweden and the United States of America. The Finland government wanted to introduce technology in their education curriculum. He indicates that national goals of implementing technology in Finland’s curriculum were “to provide those skills that will allow students maximum

flexibility and adaptability in their future employment and other aspects of life" (Rasinen, 2003:33). GIS has become an industry that supplies different fields with the needed technology in their area of operation. Today people use it in most spheres of the economy. Technology continues to impact on our daily lives and it cannot be ignored. The countries analysed above are developed countries that are far ahead in the use of technology.

2.4 CURRENT METHODS EMPLOYED BY GEOGRAPHY TEACHERS

Teaching and learning through computer technology in Limpopo Province and South African schools has generally been very slow because of insufficient practical experience of teachers in the application of GIS technology. To add to this disadvantage, many schools are in a rural setting and therefore characterized by poor infrastructure such as the absence of an electric grid (Breetzke et al., 2011; Eksteen et al., 2012). In the absence of electricity it becomes difficult to equip schools with hardware and software that could assist in the deployment of this technology in rural schools. The problem of security also becomes an important issue. Without tight security in schools, criminals vandalize school buildings and steal the hardware. This occurs in both rural and semi-urban township schools.

Mdlongwa (2012:2) argues how some schools in South Africa used traditional methods of teaching that remain "the same for the last few decades." He cites previously disadvantaged schools as being the most affected. Among other things they cannot use ICT as a method of enhancing teaching and learning for learners because of lack of funds to purchase hardware and software. He argues further that there are schools that benefit from digital technology and those that do not. Obviously those that gain from the digital technology are schools that are located in cities and former Model C schools. The most disadvantaged schools are those in rural areas, where some schools do not even have electricity and standard classrooms. Using ICT in schools will support both teaching and learning and defeat some challenges faced by schools. The end product of the introduction of the digital technology will close the gap between the schools that do not use technology in teaching and learning and those that use it. GIS technology counts amongst technologies that are digital and currently included in the CAPS curriculum. It is

therefore relevant to introduce GIS in secondary schools. Basic requirements to swift GIS technology well into secondary schools should be considered.

The introduction of GIS in South African Geography Curriculum gives geography a new direction within the South African context that can compare and compete with other international communities. The young generation doing geography today can unearth the new dimensions in geography training. They conduct research on how people think and reason about spatial concepts and how the design of GIS can be a solution to problems that are spatially related (Bednarz, 2004). Authorities are facing challenges in the introduction of this technology in the curriculum. There are no trained and qualified teachers that could teach GIS in Limpopo Province's secondary schools. The authorities could not first train capable GIS teachers before introducing it in secondary schools.

Today, eight years after GIS was introduced in the geography curriculum in South Africa, teacher-related problems in the introduction of GIS are still experienced by teachers who were never exposed to it (Akinyemi, 2015). Akinyemi (2015:35) cites problems such as teachers without knowledge and skills in GIS and "lack of guidance to develop pedagogies involving GIS" that derail the flow of the implementation of GIS teaching in South Africa. Pedagogies she is referring to here are methods of teaching and learning this technology, which learners can easily grasp and apply and be able to produce local maps around the vicinity where their school is found. When GIS was introduced, no groundwork was done to prepare the geography teachers to teach this part of the curriculum and even methods of teaching and learning it were not in place. This research work looks at the relationship between the background knowledge of geography teachers on GIS and the performance of the learners in GIS in secondary schools in Limpopo Province. It proposes methods that could be put in place to teach and learn the GIS technology in secondary schools.

The education authorities in Limpopo did not have capital support that schools needed when introducing GIS in secondary schools. Educators were not trained to teach GIS. Vendors did not have software specially designed for learners in secondary schools. This study addresses the challenges which GIS is facing in the

secondary schools in Limpopo Province. The environment in the schools of this province should be used to decide whether the situation is conducive for the introduction of GIS technology or not. Geographical Information System (GIS) is a system that is applied and used by different disciplines. Schuurman (2008:16) points out that "what you eat, where it comes from, and the route it takes to reach your local supermarket are each dependent on GIS technologies." Her argument here is that GIS is used in different disciplines: Agricultural Economics, Economics, Animal Production, Logistics, Geography, Business Economics and many other related fields of study. Our basic daily activities and services that we need are made possible by the used technology of GIS. The argument of Schuurman (2008) is that different sectors of our daily activities are influenced by GIS technologies. It is therefore imperative that GIS be introduced at the lower level of our teaching and learning institutions, in this case secondary schools. Teaching and learning GIS at the lower level cultivates love and interest among learners to follow careers related to this needed technology. This study is appropriate in the sense that learners in Limpopo and South Africa at large will be able to produce GIS-user specialists who can carry this technology forward.

Many people who are interested in spatial information throughout the world today, have interest in GIS. They can be either individuals or organizations. Ozgen (2009: 1880) argues that "GIS may be regarded as a tool to be made use of in helping improve such aptitudes of students as thinking skills, ability to access geographic data with ease as well as inquisitiveness." Ozgen (2009) alludes the positive effects that GIS could deliver to secondary school learners. They can develop skills in thinking geographically and analysing geographical data while still at secondary school level. In terms of preparing them as future researchers, this skill is fundamental. He continues to say that in geography teaching, student-centred teaching methods aided by GIS have shown to provide very good results in favour of students. Students can work on their own, autonomously with little assistance from their teacher (Bognar, Gajger & Ivic, 2015). This is what constructivist theory of learning dictates. Students through the support of GIS work on their own. One can argue: how can one teach and make the learners to learn GIS independently without the assistance of the teacher if hardware and software are not available? How can the learners mediate and control the learning situation by themselves if hardware

and software are not in place? This chapter later looks at the constructivism theory in detail to unpack how it is applied in teaching and learning.

The chapter examines the teaching and learning of Geographical Information Systems in secondary schools in other countries of the world. Literature related to teaching and learning of GIS in the post primary schools of other countries are looked at, in order to gauge whether South Africa's geography curriculum in secondary schools is in line with what other countries are doing. The pattern in these countries is compared to the South African situation, where teaching and learning of GIS in secondary schools is still at its infancy stage. Teachers are not yet acquainted with GIS and to make the teaching of GIS successful in schools, "teachers are the key factor" (Lam et al., 2009:58). Many teachers have never studied it and yet they are expected to teach it. Schools do not have the necessary equipment to teach it and they are expected to produce quality results in GIS. It is therefore a big challenge for teachers and the Limpopo Department of Basic Education (LDBE) and South Africa in general.

2.5 UNDERSTANDING TEACHING AND LEARNING OF GIS IN SECONDARY SCHOOL OF FOREIGN COUNTRIES

2.5.1 Introduction

GIS is a worldwide geography technology today and since its inception, it was mainly taught in higher educational institutions, because a key concern was graduate employability (Seremet & Chalkley, 2015). It was during the mid and late 1990s, that few countries such as the United States of America and some few European countries like Germany and others, recognised GIS as the new teaching tool that could be applied in the geography curriculum in the secondary school classroom (Bednarz, 2004; Komlenović et al., 2013). Later it diffused to the United Kingdom, The Netherlands, Eastern Europe, Scandinavian countries, Australia, and many

more countries in Asia (Kerski, 1999; Meyer et al., 1999; Bednarz, 2004; Lateh & Muniandy, 2010; Manning, 2013; Singh, Kleeman & Van Bergen, 2013; Komlenović et al., 2013).

In Africa GIS has not made much impact in the secondary school's geography curriculum because most countries have challenges that are specific and prevent the use of GIS in schools (Eksteen et al., 2012; Ayorekire & Twinomuhangi, 2012; Akinyemi, 2015). Lack of teachers who are technologically knowledgeable, poor ICT equipment in schools and lack of capital to invest in this technology (Akinyemi, 2015) are some of the challenges experienced in African countries. Currently, GIS technology has been phased in in the secondary geography curriculum in countries such as South Africa, Uganda and Rwanda, to name some few (Eksteen et al., 2012; Akinyemi, 2015). Although in South Africa it was introduced in 2006 in the secondary school geography curriculum (Grade 10, 11 and 12), it is not widely spread. The deterrents to this are investigated in this research study. Understanding factors that hinder diffusion of GIS technology in secondary schools in other countries around the world can assist this research study to determine whether the same deterrents are experienced in Limpopo Province's secondary schools or not. GIS technology is global technology, therefore some solutions in other countries may as well be a solution to the GIS problems in Limpopo Province and South Africa.

2.5.2 Teaching and learning GIS in the United States of America and Canada

The United States of America was one of the first countries to introduce GIS in the secondary school curriculum of geography. Even though the United States of America is advanced in technology and development, GIS made an inroad in their secondary school curriculum "in the early 1990s" (Bednarz, 2004:191).The introduction of GIS in K-12 (Grade 12) classes in the US, even with available resources, "has not been significant, nor has it been widespread" (Mah, 2012:8). Teachers resisted it and could not adopt it easily. The question of resistance seems to be a general trend. In South Africa, teachers resist it because it is a new section of the curriculum which they are not conversant with, citing many different reasons (Scheepers, 2009). The resistance might be due to lack of understanding GIS as it is

new or for some other reasons. This research investigates why GIS teaching diffuses so slowly amongst the teachers and schools in Limpopo Province.

Milson and Earle (2008) argue that some of the barriers in the United States were lack of professional development and teacher understanding of GIS, costs to acquire hardware and software, using GIS in the classroom, complexity and sophistication of learning GIS software and access to technology. The introduction of GIS in South African secondary schools faces almost the same barriers. There are geography teachers who are professionally not yet developed in terms of teaching GIS in the South African secondary schools. Some teachers are not prepared to learn computer technology and yet they aspire to teach geography in secondary schools. Without understanding computer technology these teachers cannot prepare GIS lessons successfully. GIS is technological and needs a person who will continue to explore more in the field of technology. Some teachers are not prepared to pursue professional development in GIS and related technology. This research unfolds the possibilities of eliminating such barriers.

In most schools within the South African fraternity of teaching and learning, the geography departments do not have enough funds to acquire GIS software and hardware. They lack computers, insufficient computer literacy among teachers and "lack of computer-trained subject teachers and the absence of a computer skills curriculum." (Innes 2012:103). Poor schools in the townships and rural areas in this country remain victims of these factors. The department should look into how it can raise funds to attend to this barrier. Private schools and the former Model C schools in urban areas seem to be better equipped in this regard than public schools. This study reveals figures on number of teachers who are computer literate and the hardware available in Limpopo schools to determine the severity of the problem in secondary schools of Limpopo Province.

Bednarz (2004:191) argues that in the United States, GIS is diffused into K-12 classrooms "through the efforts of geography and environmental educators". She outlines three justifications for incorporating GIS in K-12 (Grade 12) education in the country. The first one is educative justification which means that by including GIS in the secondary schools education, "it could be used to enhance students' geographic

skills and ability to think spatially" (Bednarz, 2004:192). This means that they have geographical skills such as collecting spatial data, using the data to produce geographical information, and organising and presenting information in a coherent manner. It means that GIS supports the teaching and learning of geography and environmental studies in secondary schools. The constructivism theory of teaching and learning is applicable here, where learners must construct knowledge based on their past experiences, on their own (Koohang, Rilley & Smith, 2009). Then learners utilise their previous knowledge to produce what they require to do, while guided by the GIS software. Learners develop geographical skills as they practically engage themselves with the computer that is loaded with the necessary software. They learn and think spatially as geography learners. From their early level of learning GIS at Grade10 level, where this technology is first introduced to geography learners in the South African Curriculum, learners begin to construct knowledge. This can for example include learning directions on the map, identifying features on the map, interpreting the scale of the map and so forth. Learners can learn how to orientate a map of an area in which their school is located, to coordinate directions on that map and real directions on the ground. They can as well associate the features on the map with the features in the real setting to be sure as to whether all features around their school are covered on that particular map.

The workplace justification is the second one. This emphasises GIS as an essential skill and tool for the 21st Century. It is important that learners acquire this skill which they can use in their different workplaces to earn a living when they have completed school. Understanding GIS while still at the secondary level makes learners to develop interest in it and build enough background that is important when they resume their careers at the tertiary level. The type of skills in this regard include skills that are technologically related to GIS. These are general computer skills, database building skills, learning skills such as writing reports and making presentations, and geographic and cartographic skills.

The last one which Bednarz (2004) mentions is the place-based justification. This means that GIS studies the environment of a local community in which a learner lives. It is important that when we teach geography to secondary school learners, the understanding and knowledge of their local environment should be emphasised. For

example, it will not be right for geography learners in secondary schools to be taught the geography of Nigeria without having first been taught the geography of South Africa. Learners have to understand their own environment first before studying other regional and continental environments so that they can start comparing them with their own environment.

Even though Bednarz (2004) identified barriers, she still emphasises the importance of introducing GIS in the secondary schools of the United States of America. The barriers must not stop the authorities from introducing modern technological innovations into the curriculum. The same justifications apply in the South African secondary schools' situation of teaching geography and GIS in particular. Geography learners in secondary schools must acquire skills such as those of using GIS to enhance spatial thinking and to relate phenomena on the earth's surface. It is therefore imperative that Geographical Information Systems be taught in secondary schools and be supported with all the necessary equipment. This endeavour will benefit learners.

Bednarz (2004) goes on to argue on the need for the development of pedagogy in the teaching of GIS in the United States of Americas' schools. She emphasises that in the first instance, hardware and software were basic requirements. Many schools in Limpopo Province do not have hardware that is used by learners. They only have few computers that are allocated for teachers. The current state of affairs in many schools is not conducive to teaching GIS. The pedagogical aspects in the learning and teaching of GIS is not yet levelled to teach GIS in secondary schools.

Mah (2012) continues to show the importance of GIS in secondary schools of the United States of America. He cites that different GIS software analyse map data in different ways. One can measure distances between two points, identify and understand different coordinates (latitude and longitude) and be able to display different types of maps (Mah, 2012). This skill is very important and learners should develop it while still in secondary school. Learners should be able to "create boundaries on maps, compare different map layers, and create a geographic timeline," (Mah, 2012:3) while still at Grade 12. When boundaries are created, markers are established on the map and are then connected. These type of skills

need to be developed while students are still at secondary school. The same can be applied in the South African situation where learners in secondary schools can be exposed to these skills while still at the Further Education and Training (FET) phase.

Mah (2012) further argues that computers are not as expensive as previously and connecting to the internet is not as difficult like previously. He notes that many learners come to class with internet enabled smartphones and tablets through which the internet could be accessed. It is important that geography teachers in the United States of America take advantage of the available sources and use them to teach learners Geographical Information Systems (GIS). Both learners and teachers have more access to information and tools (software) than before. To fulfil the educational objectives, educators need to fuse the technology of Geographical Information Systems with the curriculum. It is important that educators come with strategies of merging the two to give them a sound meaning within the educational fraternity. Learners and teachers can access this information and use it in the classroom as well as in their homes.

Johnston and Bishop (2011:6) argue that GIS has gained support in both primary and secondary schools in the United States of America and, teachers are now using this tool as a tool to "promote global awareness, encourage critical thinking, with real-world technology applications and instil students with a sense of place and community". If the study of GIS can be introduced at the primary level, surely the South African Department of Basic Education (DBE) can introduce it at the secondary school level. Critical spatial thinking should be developed from the basic stages of GIS learning. It is therefore imperative that South African schools introduce quality GIS teaching and learning at secondary schools. Teachers have to be trained and schools should be equipped with the necessary equipment that can make GIS teaching feasible. Learning from other countries in terms of teaching and learning GIS technology, can teach us how some of the impediments can be avoided. It can also help to regroup and avoid repeating and duplication of some problems experienced by other countries. This research study proposes how some of the problems experienced by other countries can be avoided.

In Canada GIS was integrated into the secondary school curriculum in the 1990s and the main problem of integrating GIS technology into secondary schools has been teacher training (Huynh, Sharpe, Charman, Tong & Greesmith, 2012). Most teachers in Canada are not GIS literate. Workshops operated on one or two days are not enough to bring teachers to the required level of knowledge on GIS. Huynh et al. (2012) identified five challenges faced by teachers in Canada in the course of integrating GIS in the secondary schools.

i. Lack of availability of school computers is one major challenge that impedes the implementation of GIS in Canada. About 1 500 computers were needed in the Province of Ontario alone. The school board in the province does not have funds to equip schools with such a number of computers. It is therefore not possible to teach and learn GIS without the necessary hardware.
ii. Educators also face a challenge with the IT departments who do not supply schools with the necessary required software and data. The IT department lacks knowledge on GIS and gives GIS low priority in schools.
iii. Teachers do not get enough time to learn geo-technology necessary to develop their skills and expertise that can help them teach GIS in secondary schools. Even when teachers have to attend weekend workshops, there is no incentive that attracts teacher interest. Their GIS skills and confidence level remain low.
iv. GIS teaching and learning is more of facilitating than transmitting knowledge and skills into learners. It is therefore necessary that it be taught by experts who will teach learners to learn through exploration.
v. Another basic barrier to geography education in Canada is that the authorities in Canada do not value geography as such. Until such time when the decision makers recognise the value and contribution of geography in the Canadian society then introduction of GIS technology can gain grounds and be introduced in their secondary school geography curriculum.

From these challenges faced by the Canadian geography teachers, it is evident that if authorities in a country do not take leadership in the implementation of any policy,

the idea will fail to succeed. This research study investigates as to whether there is support on the part of the authorities in terms of financial support in GIS teacher training and supply of hardware and software for GIS. Without well trained GIS teachers, its teaching and learning in secondary schools may not be successful. In Limpopo and South Africa, research studies should identify what other measures the authorities are doing to support the successful implementation of GIS in secondary schools. Enough funds should be invested in this venture to support the training of GIS teachers.

2.5.3 GIS in the European Secondary Schools' Curriculum

The United Kingdom (UK) introduced GIS in their National Curriculum for Geography in 1990 (Bednarz, 2004; Wiegard, 2007) and "fully utilised it to support the teaching of primary and secondary school students" (Singh et al., 2013:103). In the UK, the specific key aspect of the National Curriculum for geography is enquiry (Roberts, 2003). When learners or students enquire, they learn on their own. They are looking for solutions alone. They are adventuring in knowledge seeking. The teachers only guide them in their teaching. This is based on the constructivism theory of learning on which this research is rooted. Even though the National Curriculum in the UK has laid the ground, "very little specific guidance exists on how to plan our pedagogy around it" (Fargher, 2004:2). The teachers in the UK did not have a pedagogical approach of teaching and learning GIS. They did not have anything to guide them as they introduced GIS in their schools. Some of the educators offering geography in primary and lower secondary schools were non-geography specialists (Fargher, 2004). It would be difficult for these educators to embrace GIS because they still lack professional development and direction in the teaching of geography. "The result of the teacher survey carried by map agency in Great Britain suggests that the uptake of GIS in schools is patchy and inconsistent" (Fargher, 2004:2). In South Africa, GIS is part of the work plan and teachers are compelled to know and teach it. Methods of teaching and learning GIS in South African schools are therefore necessary and should be put in place.

Manning (2013:33), an experienced geography teacher in England, also argues, "Geography in United Kingdom secondary schools is at a cross-road, and under

pressure to justify its place in the National Curriculum as never before". The interest of doing geography was declining in the UK and geography has to position itself by appealing to the student 'marketplace,' in the words of Manning (2013). For Geography to save itself, GIS was introduced in secondary schools. "GIS emerges perhaps a unique and crucial tool to help Geographers rise to deliver the spatial literacy component of this new curriculum (Manning, 2013:35). GIS is not only a component of technology, but a career by itself. Geography was also one of the influential contributors' towards the emergence of New Curriculum in England.

In his article, Baker (2005) indicates the main barriers, which were identified in the UK. Resources and time are some of the obstacles which cannot be controlled by schools as such. Northern Ireland, which is the smallest part of the UK in terms of population, had about 21 000 teachers, 900 primary schools, 45 special schools and 240 secondary schools in 2009 (Roulston, 2013). In terms of introducing GIS in schools, Northern Ireland "was the first part of the United Kingdom to have a strategy for Geographic Information" (Roulston, 2013:45). As a sequel to this idea, a publication called *Northern Ireland Geographic Information Strategy 2009-2019* was developed and a section on "Education, Skills and Staffing" was identified as the most important strategic part. A free online GIS providing internal-based information on Northern Ireland was made available to all schools in the country. In addition, there was provision for thematic maps in colour with data ranging from 2001 population census to information on health, agriculture, migration, social and welfare. GIS tool assigned specifically to be utilised in schools was also provided. Education advisors, educators and educational professionals are using the online GIS provider for any geographic information related to geography teaching in Northern Ireland. Many Geography textbooks have been produced in line with the Northern Ireland Geography Curriculum. GIS activities have been incorporated into these textbooks (Roulston, 2013). These formed the basis of the development of GIS in the secondary schools of Northern Ireland. In line with what Bednarz (2004) argues about the three justifications of studying GIS in K-12 of the United States of America's secondary schools, she mentions the place-based justification as one of the justifications for studying GIS in secondary schools. This justification gives the reason why a learner should learn about his or her local environment.

The teaching and learning of GIS in Northern Irelands' secondary school geography curriculum was supplied with information that related to Northern Ireland by the Education Authorities in Northern Ireland. Learners could easily associate the data they use with the real situation of their environment in Northern Ireland. It meant that the teaching and learning of GIS in Northern Ireland was connected to their environment. It is very important that when teaching in secondary schools, the learners should relate the content with the reality they see around them. Teaching and learning of GIS should be applied within the context of local environment.

In South Africa, strategies towards the approach of learning and teaching GIS are still necessary. This research brings forth proposals of how South African schools can benchmark in other countries like Northern Ireland to improve approaches on how to teach and learn GIS in secondary schools. A similar strategy can be developed firstly at provincial level and later with the availability of funds, the whole country. From the information on population census of 2011, migration, number of schools, number of learners in South Africa, social and welfare, people with HIV and Aids, agriculture and many more data is available from the database of Statistics South Africa (SSA), and could be made available to schools for free. Government printers could also provide the schools with 1: 50 000 Topographical Maps and 1: 10 000 Orthophoto Maps online which teachers and learners could access and use. The Department of Basic Education (DBE) could supply learners with laptops and tablets so that they have a tool of accessing databases. The availability of all this information could open the gate for GIS teaching in schools.

The data and maps of provinces could be made available electronically for use by secondary school teachers and learners. All this are a good foundation for GIS teaching and learning in secondary schools. Teachers and learners could learn how to download maps of different towns, cities and their surroundings in different provinces. The data and the maps on different themes could be overlaid for comparison reasons or to produce one map with different themes together. Learners can plot out a map from the information retrieved and print out the map. All these skills are necessary for modern geography learners so as to prepare them for future careers.

GIS in secondary schools could be made available by supplying schools with laptops and tablets. The current Member of the Executive (MEC) for Education in Gauteng Province (South Africa), Mr Panyaza Lesufi, has recently made an announcement that all secondary school learners in Gauteng Province must be supplied with tablets. By the year 2019, all the learners should have tablets. A tablet is a mobile tool for GIS. Through this tool, which is for educational purposes, geography teachers and learners can utilise it for GIS. The example which the Gauteng Province would set can probably be an example to other provinces like Limpopo.

In Norway, the approach towards teaching and learning GIS has been different. In 2006, the Norwegian Government introduced some reform which was called Knowledge Promotion Reform 2006 and referred to as K06 (Rod, Larsen & Nilsen, 2010; Rod, Andersland & Knudsen, 2012). K06 is a national curriculum in Norway and applied to any subject taught in every upper secondary school in this country. The reform stated that geography would be compulsory in the upper secondary level (pupils of between 16 and 19 years) and at the end pupils should be able to use digital maps and GIS. The year 2006, in which Norway introduced GIS in secondary schools is similar to the period during which it was introduced in the South African secondary school's curriculum. Norway seems to have been reluctant in introducing GIS in their secondary schools until recently. The reason for this is that K06 pronounces that learners should know how to use GIS, but does not provide the guidelines on how to achieve it (Rod et al., 2012). The hindrances, like supply of resources, time for teachers to learn the technology, the didactic constraint as to what and how to teach GIS in secondary schools remained a challenge in Norway.
For one to teach geography in the upper secondary schools of Norway, it is compulsory that one should have a bachelor degree and additional one year of pedagogical training (Rod, et al., 2012). Furthermore, in his/her bachelor degree, the student teacher must take one more year of geography study. Geography is provided in the three universities namely, Bergen, Oslo and Trondheim and one regional college in Steinkjer. In all these institutions, a student may study GIS. It is only at NTNU where GIS is compulsory for one year (Rod, et. al., 2012). The didactic constraint is also a problem in the South African secondary schools. Teachers need to know what to teach in GIS, why and how to present GIS lessons. In the training of geography teachers in South Africa today, GIS is not compulsory. This study

answered some of the questions to clear the hindrances that could open up a way through which GIS could be taught and learned in secondary schools of South Africa. The challenges in Norway seem not to differ much from those experienced in South Africa recently. The difference between the two countries is that in Norway, geography was compulsory from Grade 10 to Grade 12 (Rod, Larsen and Nilsen, 2010), while in South Africa it remains an elective subject in the same grades (Grades 10 -12).

GIS has been found to be a tool that makes the understanding of phenomenon very easy, even though it has its own technical challenges ((Rod et al., 2012). Netherlands and Turkey introduced GIS technology in secondary school geography curriculum in 2003 and 2005 respectfully. Incekara (2010:553) states that in Turkey, "the GIS activities in secondary schools appeared in the 2005 geography curriculum, thus GIS was first introduced to high school geography teachers with the 2005 program". It was stated that GIS would be used in geography lessons in the curriculum that was issued then. Later it was realized that no solid evidence was reported anywhere in Turkey to indicate where the teaching of GIS existed. Several challenges faced its introduction and it was later realized that it failed because there were not enough teachers that were trained to use GIS, the software was expensive, the physical conditions of the schools were poor and the time allocated for the GIS lessons was not sufficient. In South African schools it is therefore very important that we do not fall prey to these reasons and fail like Turkey. The study comes up with methods that could be used to make the success of teaching and learning GIS in secondary schools.

Uğurlu (2013) researched on the opinions of middle school students (6^{th}, 7^{th} and 8^{th} Grades) on GIS in Turkey where the results showed that their opinions related to motivation to use GIS and its use in the teaching process was positive. The researcher further cites that learners did not have any significant difficulty with GIS technology. He then concluded that it will be appropriate for the authorities to consider using GIS as an appropriate tool for teaching some subject matter or curriculum content in the middle schools of Turkey. Uğurlu (2013) mentions that it is the responsibility of the teacher to instruct learners in using the various devices such as GIS technology in the teaching of geography. Geography is a subject that deals

with maps, and it is appropriate to include GIS in geography curriculum because "GIS is a mapping system" (Uğurlu, 2013:407). GIS has been scientifically proven to increase students' attention towards the subject, geography (Baker, 2005; Kidman & Palmer, 2006; Aladag, 2010; Uğurlu, 2013). According to Uğurlu (2013) the middle school learners confirmed that GIS is an interesting tool to use in their daily life and away from the classroom. Learners in Turkey indicated that they would like to learn geography using the current GIS technology rather than using the traditional way of learning geography such as books, atlases and globes (Uğurlu, 2013). One main advantage in Turkey is that their middle schools have been equipped with "modern computers that can be used to acquire GIS data and view thematic maps via the internet" (Uğurlu, 2013:417). While South Africa is still encountering some problems regarding GIS in Grades 10, 11 and 12, in Turkey they already considered introducing it at the middle level of secondary school geography curriculum. The cornerstone to laying out good grounds for GIS in Limpopo Province and South Africa lies basically with the education authorities' perception towards GIS, investing on the training of GIS teachers and funding schools to procure the technology.

Defining what GIS is, could also be a psychological constraint in teachers. Realising that the definition of GIS is technical, Green (2001) argues that is rather better to get a definition that can define GIS in the context of education instead of adopting the definitions that are technical and ICT (information and communication technology) based. Definitions that are technical put fear into most teachers who end up thinking that GIS is too much of a technical character than of education. Rod et al. (2010:22) define GIS "as a set of tools that transforms geographical data into geographical information and thereby increases our knowledge and/or helps us to solve geography-related problems." The definition is less technical like that of Green (2001). It emphasises tools than technical terminology. The definition is in line with the classical definition by Burrough which "uses cognitive terms rather than technical ones."(Rod et al., 2010:22).

Two approaches are identified when learning GIS; learning about GIS and learning with GIS. Many scholars believe that a good approach that could be used in schools is learning with GIS (Rod et al., 2010; Baker 2005). At the secondary school level, learners do not require to study how GIS came into existence; how GIS software is

designed and issues related to its programming. Learners only need to know how to work with it. They must know and understand its application. They need to be assigned with GIS projects that are related to their surroundings so that they can know how to apply it in practice. In applying GIS towards resolving some of these geographical problems identified, learners will be working with GIS. Simplified GIS-based web applications can be introduced to learners so that they can know how to display data. With time they can then be taught how to analyse it.

Keeping up with the changing trends in Europe, the Serbian Education System also changed and GIS was brought in as part of the geography curriculum. The GIS by itself enhances inquiry-based skills as compared to the traditional geographic education (Sui, 1995). The GIS in the secondary schools of Serbia is still in its initial stages and “changes in vocational education were initiated in the 2002/2003 school year to respond to the needs of profession and real market demands” (Komlenovic et al., 2013:98). Later on after several evaluations, GIS was introduced into the secondary school geography curriculum in four fields of work: economy, law and administration; chemistry, non-metals and graphic art; transportation; geodesy and construction. Students were enthusiastic in these fields of study and could find jobs immediately after completing their secondary schools classes (Komlenovic et al., 2013). In all these aforementioned four fields of work, geography is compulsory.
The structure of the curriculum in Serbia is in such a way that the modules “are based on learning outcomes, forming a set of functionally related knowledge, skills and abilities considered necessary to perform a certain job” (Komlenovic et al., 2013:99). The modules themselves form part of different professional fields in GIS. When comparing secondary schools’ inclusion of GIS in Serbia curriculum to other European countries, it looks more careers oriented. This is good for the students because they can be absorbed immediately by the corporate world. GIS on its own is a skill and a career. Once one qualifies as a GIS user, one can get a job in any institution requiring that skill.

Serbia is a developing country like South Africa. The problems of economic development in this country may not be too different from those experienced in South Africa. If we can skill learners with GIS while still in secondary schools, most learners will be professional GIS users when they exit the FET level of education. By

the time they complete secondary education, they will be ready to get into the job market where GIS skills and other ICT-related jobs are required. This research study is therefore relevant because it has a positive influence on the economy of South Africa. The secondary schools' geography curriculum should aim at producing Grade 12 graduates that are already competent in GIS, and who can be immediately be employed after completing matric.

2.5.4 GIS in Asian secondary schools

Like other regions around the world, in Asia the inclusion of GIS in secondary schools' geography curriculum is noticed. In countries such as the People's Republic of China, Taiwan, South Korea, Singapore and Hong Kong, the diffusion of introducing GIS in their curriculum was evident (Lam et al., 2009). In China the authorities required that by 2003, all students in senior high school geography learn some basic GIS concepts, while in Taiwan, it was in 2009 that the secondary school curriculum included the aims of teaching GIS in analysing environmental resources (Lam et al., 2009). Singapore also took an initiative to introduce GIS in 1998, as an important tool for teaching Geography in the secondary schools.

The Malaysian government introduced Information and Communication Technology since the 1970s in their school curriculum and was widely used in their schools (Habibah & Vasugiammai, 2010). More than twenty years later in 1996, the Malaysian Government decided to establish the Multimedia Super Corridor project in order to develop Malaysia as "ICT hub of the region" (Singh, 2013:149). Singh et al., (2013), argue that the Malaysians believed that the development of the national ITC field will enhance the growth for computer literacy workforce and that professionals in ICT will be in demand in the coming future. As an extension of this idea, the Malaysian government established a Smart School Project in 1999 which emphasised the use of technology as a tool of learning and teaching with computers, and they regarded computers as the only teaching aid they could use to accomplish that (Habibah & Vasugiammai, 2010; Singh et al., 2013; Singh, 2013).

Geography was not a popular subject in Malaysia like it was in most developed and developing countries. The smart schools introduced in Malaysia did not cover

geography in their initiative of introducing technology. Geography remained side-lined in this project. Even though geography was introduced in Malaysia in 1927 it was “Empire-centred” and learners were taught map drawing, chief towns and rivers in British Malay vernacular and emphasising the method of memorising (Singh, 2013). In 1928 it was then that geography education was introduced in primary and secondary English Schools. Singh (2013) indicates that the curriculum emphasised more geography terms, map reading, map drawings and geographic regions on the five continents. During the Second World War geography education came to a halt in Malaysia and was reviewed again in 1956 where more attention was on topographical map work, weather observations and physical geography (Singh, Kleeman, Van Bergen, 2013). It was in 1979 that the primary school geography curriculum was revised and the draft emphasised the spatial organisation of geographical phenomena in a national context. In 1988 the integrated secondary school curriculum was introduced as a continuation of changes. These changes also affected geography because it was made compulsory in the lower secondary schools (Form 3) and was made elective in the upper secondary school (Forms 4 and 5). These affected the introduction of geography in secondary schools and the pre-university level as it was an elective subject.

The Smart School Project was introduced in Malaysia in 2003 due to the fact that ICT components and multimedia-based learning were widely applied in the classroom (Singh, 2013). The aim of the Smart Schools was to provide more interactive teaching facilities to improve the quality of teaching and the student’s results in schools. The schools were equipped with ICT equipment. Students were provided with laptops and those in the outskirts were each supplied with a PC. Teachers involved in the project were also provided with laptops to implement the computer technology in the classroom. Both primary and secondary schools were supplied with CD-ROM, browser-based teaching and learning materials and the Malaysian Department of Education collaborated with private companies to develop interactive software (Singh, 2013). Close to 2 000 interactive coursework were developed and they only involved Malay Language, English, Science and Mathematics, and they did not have any positive impact on the curriculum and methods of teaching Geography in Malaysia (Singh, 2013). Instead geography in Malaysia became one subject with “minor computer skills among Malaysian schools”

(Habibah & Vasugiammai, 2010:2847). The Malaysian authorities could not embrace GIS into the general ICT dispersion programme as a result geography continued to be an unpopular subject in their secondary school curriculum (Habibah & Vasugiammai, 2010).

The Malaysian Department of Education took time to introduce GIS in both their primary and secondary schools even though some professionals successfully used it in other fields of study like engineering, crime investigation mapping, land use and politics (Singh, 2013), but the Education Department in Malaysia could not embrace it in the secondary school geography curriculum, as it was not evident in both primary and secondary school's geography curriculum (Habibah & Vasugiammai, 2010). In almost all universities in Malaysia, GIS was used in research and was also taught as a major subject, but geography as a subject was not there in primary and secondary school's curriculum (Singh, 2013). Singh (2013:152) argued that by integrating GIS in secondary schools of Malaysia, it would prepare "a skilled workforce for spatial data analysis in the future".

GIS had a positive influence on the study of geography in Malaysia, especially in higher institutions of learning. It is surprising that the Ministry of Education in Malaysia delayed to introduce GIS in secondary school geography curriculum and yet all Universities in Malaysia introduced it as part of geography study (Singh et al., 2013; Habibah & Arumugam, 2005). Habibah and Vasugiammai (2010:2849) indicated how GIS "could be implemented as a tool for gathering, analysing and viewing data" in the study for local area in Malaysia secondary schools. They further cited how learners got excited when they were taught pattern and population, and mountain landscapes respectively, through ICT tools in Malaysia. The excitement demonstrates that young learners enjoy learning through technology instead of using the orthodox methods such as chalkboard and narrative method.

Learners accepted the technology but were disappointed by educational authorities who did not want to give them the opportunity to study through it. According to literature by other GIS scholars it has been shown that the application of GIS in Geography teaching and learning improved students' achievements as some of them were involved in difficult tasks but managed to go through because of the knowledge

of GIS (Lam et al., 2009; Singh, 2013; Singh et al., 2013). The use of ICT and GIS in teaching motivated learners to learn geography (Kerski, 2003; Milson & Earle, 2008). Wiegand (2007), Shin (2006) and Sharifah (2006) also mention in their findings that the use of GIS increased the performance of students in geography and attracted even more students to study geography. The thinking skills of learners and the level of concentration of students also changed. The introduction of GIS in geography attracted greater number of students in geography. This indicated the zeal which other countries showed as an endeavour to let their secondary school learners be exposed to GIS.

In Malaysia today, GIS has not yet been integrated into their geography education secondary school curriculum (Singh, 2013). The Malaysian Education Ministry still discusses the implementation of GIS in schools which at the moment still looks impossible and mythical due to lack of ICT infrastructure and trained teachers. Obstacles that impede the integration of GIS in Malaysia are not different from the obstacle experienced in other countries like Hong Kong, Singapore, United Kingdom, the United States of America, South Africa, and others (Donaldson, 2000; Kerski, 2003; Fargher, 2004; Baker, 2005; Lam et al., 2009; Eksteen et al., 2012; Akinyemi, 2015). Even with these obstacles, these countries continued to introduce and implement it in their secondary schools. Teachers who are not interested in GIS always give daunting reasons such as: teachers are always busy and do not have time to study GIS software; software such as Arc GIS is expensive and most schools cannot afford to buy it and, how schools can procure GIS software that can be suitable for their learners in secondary schools. All these reasons delay GIS implementation in different countries.

In the People's Republic of China, GIS technology was introduced in the secondary school geography curriculum in 2003 and the curriculum required that learners at secondary school level only be introduced to the basic GIS concepts and their applications (Lam et al. 2009; Dong & Lin, 2012). According to the Curriculum Development Council and the Hong Kong Examinations and Assessment Authority (CDC-HKEAA) of 2007, GIS in Hong Kong's secondary school geography curriculum was introduced in 2009 (Lam et al., 2009). Curriculum developers in Hong Kong realised the importance of GIS in the secondary schools curriculum. Lam et al.

(2009) argue that the curriculum reforms all over the world today emphasises skills of higher thinking and competencies in the acquiring, storing, processing and analysing of data. This is in line with GIS because it covers all the aspects mentioned above. By including GIS in the secondary school curriculum of Hong Kong, it enables geography learners to develop the skills mentioned above. From the perspective of the geography curriculum developers in Hong Kong, GIS is an important tool not to be ignored at all. GIS is a very important technique in geographical research (Lam et al., 2009). Lam et al. (2009:59), highlight that "using GIS in teaching and learning geography requires hardware and software, as the technology is basically digital." Teachers are always important as they are the drivers of the whole process. The policy of the government of the day is also important. If the government through its Education Ministry undertakes to change the curriculum, changes will be effected and new items will be introduced and implemented in the curriculum.

From the study that was undertaken by Lam et al. (2009) in Hong Kong, it is evident that GIS use in geography classes is low. Even if the government can provide hardware, software and trained teachers in GIS, it will not be enough for GIS to be implemented. For it to be successful, "it will require that teacher development initiatives for preparing teachers for GIS implementation be reconceptualised and that government initiatives be in place to provide the push for GIS"(Lam et al., 2009:70). It is important that the preparation for GIS teachers be considered seriously when real successful changes have to be made in the curriculum. Teacher empowerment leads to professional growth and strong leadership development.

In Singapore, the in-roads for introducing GIS teaching in secondary schools were advanced in 1998 where training workshops on IT tools for teaching and learning geography were conducted (Liu, Tan & Xiang, 2012). It was through these workshops, organised by the National Institute of Education (NIE) and the Educational Technology Division (ETD) of the Ministry of Education in Singapore, that GIS was first introduced in secondary schools and junior colleges as a tool for teaching and learning geography. In 2002 the IT Masterplan was launched with the purpose of redesigning the curriculum and to make more student-centred learning milieu (Liu et al., 2012).

Even though the IT Masterplan offered opportunities such as that of exposing geography teachers and learners to GIS technology in teaching and learning, challenges were also experienced. Liu et al. (2012) indicate that the Ministry of Education in Singapore is planning to develop a nationwide framework on introducing GIS into the geography curriculum from lower secondary and upper secondary schools to junior colleges. The advantage of teaching and learning GIS is that it will enable students to become spatial thinkers and problem solvers. Challenges are: lack of time to develop GIS lessons to add on the existing curriculum; and lack of support for training teachers and the perceived complexity of GIS software. This movement made GIS to be a requirement for all senior secondary learners in Taiwan.

An interesting pattern of how GIS was designed and implemented successfully in the secondary school curriculum is that of Taiwan. In Taiwan geography is a “core subject in the senior high school” (Chen, 2012:264) as it is a required subject in Grades 10 and 11 and optional in Grade 12. From 1995, GIS has been included into the senior high school geography curriculum and was revised in 2006 and 2010, respectively (Chen, 2012). In the revisions of the curriculum standard, it demonstrated how GIS technology was becoming important in Taiwan’s geography teaching and learning. In 2006, two major revisions occurred where introduction to GIS was moved from Grade 12 to Grade 10. In the Grade 10 curriculum, they also covered application of GIS for everyday life and were expected to collect field data using GPS and use GIS to query environmental issues using geographical information. Since GIS lessons require more time, they increased their duration from 3 to 6 hours (Chen, 2012). In Grade 12, they changed more, to applied geography where learners had to understand the application of GIS in national land planning, monitoring of diseases, forecasting floods and other related issues. At Grade 12 students could use software such as ArcGIS, Google Earth for about 1 to 2 hours (Chen, 2012).

In terms of teachers training, the Ministry of Education enrolled teachers for GIS in the geography department of the National Taiwan University, where more than 200 senior secondary teachers were trained. They were given projects where teachers had to develop GIS lesson plans on both physical and human geography (Chen,

2012). From 2002, the Ministry of Education continued to send more than 300 teachers a year for GIS training to an extent that by 2009, more than 1 000 geography teachers went through the GIS training programme. The Taiwanese Ministry of Education invested a lot on equipment and human resources to make the implementation of GIS successful. It is without doubt that Taiwan is one of the leading countries in GIS secondary school teaching and learning today. South Africa can be one of the leading countries in teaching and learning GIS in secondary schools in Africa if it follows the programme followed by Taiwan. The inclusion of GIS technology in secondary schools' geography curriculum in South Africa was a huge milestone. Well trained teachers are therefore needed.

The GIS curriculum development in Asian countries seem to be generally slow, except in Taiwan, where the government made great efforts in the implementation of GIS in secondary schools. In Taiwan they made GIS compulsory from Grade 10. By the time every learner completes secondary education he or she will be equipped with GIS technology knowledge. In Malaysia, the Education Ministry is still not yet decided on whether to introduce it in secondary schools or not. It is taught in institutions of higher learning and used in different sectors of economy. The question still remains as to when GIS will be officially taught and learnt in secondary schools of Malaysia.

The introduction of GIS in secondary schools in Asian countries looks very much set, but was not smoothly introduced. GIS in the Asian secondary schools had some hassles. Lack of funds, insufficient funds, qualified GIS teachers, and availability of teaching resources are some of the factors that hinders the progress of GIS in most countries in Asia. Some challenges experienced in these Asian countries are common to challenges experiences in South Africa and Limpopo Province. It is important that intensive research on GIS in secondary schools be done.

2.5.5 The use of GIS technology in the Dominican Republic (Caribbean Islands)

Incorporating GIS technology in the secondary schools also spread to the countries in the Caribbean Islands, such as Dominican Republic. The use of ICT within the

communities of the Dominican Republic paved the way for the integration of GIS into schools (Perez Sierra & De la Rosa, 2012). Although GIS is not currently directly applied in the teaching and learning in the Dominican Republic schools, the GIS project is piloted and recommendations are being made for its introduction into the curriculum of their secondary schools (Perez Sierra & De la Rosa, 2012).

Secondary schools in the Dominican Republic have three modalities; general, technical and art. General modality teaches learners about life lessons that give them an opportunity to continue studying humanistic studies. Technical professional modality prepares students for qualified technical careers in industrial, services and farming sectors, while art provides learners with foundation for developing skills in art, music, visual and applied art. GIS technologies in the Dominican Republic could play a role in the incorporation of ICT in teaching and learning history, geography and natural science (Perez Sierra & De la Rosa, 2012). In the context of this research study, GIS teaching and learning could be viewed from geographical perspective where GIS technology is encompassed in the secondary school curriculum of teaching and learning geography and related subjects such as geology and environmental studies.

In the Dominican Republic, the authorities recommended that in geology as a natural science subject for example, should include the digital cartography editors from the superposition of layers of remote perception images, superposition of layers of soil and land use, and layers of seismic risk (Perez Sierra and De la Rosa, 2012). Students could use these resources to examine and analyse the problems of the island using the seismicity map of the island. Students could then design their own risk maps of the island from the population layer and layers of the seismic risk with the resources provided. The population map could be overlaid on top of the seismic map to determine the life risk that the people in the Dominican Republic are exposed to.

Lack of learning resources such as hardware and software retards the smooth diffusion of GIS in secondary schools because these allow students to interact directly with reality surrounding them on a daily basis. It is necessary that the authorities look into financing secondary schools so that they could be in a position

to acquire the required equipment. In terms of Perez Sierra and De la Rosa (2012), the following resources are needed in the Dominican Republic:

i. Terrestrial space image interpretation;
ii. Application of spatial and geographical location;
iii. Application for the analysis of remote perception images, and
iv. Application for vector cartography development and how is edited.

The environmental education pilot study that was undertaken in the Dominican Republic to demonstrate that ICT can be used as a tool for constructivist learning supports the theoretical framework of this research study. With many environmental problems such as deforestation, pollution, floods, population growth and climate change experienced in the Dominican Republic, it was easy to identify a problem where GIS could be applied. Teachers collaborated and selected software, Google earth and ArcGIS, which they used in the project. In the first project, learners had to identify the position of the island using Google Earth; and the second project involved the mapping of Los Haitises National Park using ArcGIS. Learners developed groups in which they continue to do other related projects that included area of high waste concentration and many other problems. Learners did the projects on their own and constructed knowledge on their own.

The introduction of GIS in the curriculum of the Dominican Republic had a positive impact on the teaching and learning of the school curriculum. GIS in the Dominican Republic can spread to other Caribbean countries like Puerto Rico, Haiti, Jamaica and Cuba. Even though most countries such as Haiti, Puerto Rico still reflect the characteristics of Third World countries, GIS seem to be making inroads in these countries. The introduction of GIS in the secondary schools of the Caribbean Islands shows the need for this technology in secondary school in all countries worldwide.

2.5.6 The need for GIS in Ghanaian secondary school education

In Ghana, like in most developing countries in the world, GIS technology made an inroad as well. Kerski (2003) and Meyer et al. (1999) indicate how GIS education

became prevalent in the secondary schools' curriculum of many countries around the world. In developing countries, individual access to computers continued to be a problem because of their high cost. It is only in urban areas where the electricity is uninterrupted, with an improved communication infrastructure and skilled people where the usage of computers is affordable (Oppong & Ofori-Amoah, 2012).

In Ghana, disparities of developed and developing country in terms of GIS usage can be identified. The value of GIS as a decision-making tool in both public and private sectors of Ghana is still remote (Oppong & Ofori-Amoah, 2012). In tertiary institutions of Ghana GIS education is still in its initial stage and limited to few universities. Computer-based GIS in these universities is only available to graduate students. Undergraduate GIS education students only learn theoretical parts of GIS without any exposure to practice (Oppong & Ofori-Amoah, 2012). From this background, one could realise the challenges that still face the Ghanaian's Department of Education to introduce GIS in their secondary schools.

Oppong and Ofori-Amoah (2012) point out that GIS does not exist in the secondary schools of Ghana, but they want to highlight its importance so that the authorities can consider the possibilities of introducing it. They are looking at GIS challenges and prospects of introducing it in secondary education. The diffusion of the use of GIS in Ghana was mainly retarded by the poor infrastructure of schools in rural areas, which lead to the quality gap between rural and urban schools. Although there is strong awareness of GIS technology in Ghana, its use has only been limited to the work of emigrants whose work cannot be sustained after they returned back to their indigenous countries. Equipment could not be maintained after some projects were piloted in Ghana. Lack of trained personnel locally in Ghana affects the deployment of GIS tools and hence its sustainability. GIS in Ghana is only offered in the three premier tertiary institutions of Ghana. Different institutions do run short-term GIS projects which lack longevity. In essence, GIS does not exist in secondary education of Ghana (Oppong & Ofori-Amoah, 2012).

2.5.6.1 Challenges of introducing GIS in secondary education of Ghana

The following are some challenges faced by the Ghanaians education authorities in the introduction of GIS:

a. The aspect of recognition

GIS is not recognised in Ghana. The major universities in Ghana that offer GIS are struggling to make inroads in making both private and public economic sectors to accept it. The government of Ghana which continues to talk about the introduction of ICT in its policies, but GIS is not mentioned. This indicates that GIS in not yet recognised as an important tool of technology in Ghana. In Oppong and Ofori-Amoah's (2012:119) words, "there currently is neither a demonstrable demand for GIS-trained personnel nor a commitment to provide the necessary environment to hire them". The best option will be to make it to become part of the secondary school curriculum.

b. The weak national infrastructure of ICT

Another challenge is the lack of electricity grid in rural Ghana. Even in the big cities of Ghana, there is always an interrupted access to electricity. The unstable supply of electricity in Ghana impedes effective use of computers. The once government policy of one laptop per child and the promise to extend computers and internet service to all secondary schools in Ghana remains a dream (Oppong & Ofori-Amoah, 2012). Secondly, Ghana has an ICT policy that fails to take-off because of limited physical and human resources. NGOs also donated some computers to urban secondary schools in Ghana and this provided basic computer skills to the learners (Oppong & Ofori-Amoah, 2012).

Rural areas are yet to be developed and connected to the electricity grid. Many rural secondary schools do not have access to electricity and telephones. In such conditions, much more financial backing is required. Lack of electricity and telephone services are the major impediments to the introduction of ICT in the rural secondary schools of Ghana, which may open up gates for the introduction of GIS in schools.

c. Lack of GIS trained teachers

One of the challenges facing the introduction of GIS in Ghana is the availability of trained teachers. The teachers training institutions that train secondary school teachers in Ghana do not have GIS as part of the curriculum that they are teaching (Oppong & Ofori-Amoah, 2012). Even if introduced, they will not be able to provide it as they would still need hardware and software and laboratory facilities to train their would-be GIS teachers successfully. For GIS to be introduced in secondary schools, they would still need to introduce GIS as part of teacher training curriculum. The Department of Education in Ghana can train interested geography teachers GIS through organizing workshops and in-service programmes. In the interim, the DoE can invest capital on developing the infrastructure. Infrastructure here includes computer labs and electrifying schools.

d. The unavailability of spatial data infrastructure

GIS needs to have a strong, quality and consistent backing of dataset. In Ghana there is lack of spatial data. The data does exist but it is not nationally centralised and cannot be deemed to be of high quality. There is no national metadata system that is in existence that documents all the existing spatial data (Oppong & Ofori-Amoah, 2012). Furthermore, spatial data that is available was created for a specific project and when that project ended the data collection also came to a halt. Lastly, there have been efforts to have standardised geological mapping, but there are no national data standards that govern how data is collected and standardisation of place names. Without a well-ordered infrastructure, GIS education will experience problems.

2.5.6.2 Prospects for GIS education in the secondary schools in Ghana

As geography is already one of the subjects provided within the general curriculum in Ghana, revising geography curriculum to include the introduction of GIS concepts within the map work section could be a positive beginning. The lack of facilities in Ghana, especially in the rural areas could be improved through pilot program
mmes. During the pilot, these teachers can be trained and their schools can be equipped with the necessary hardware and software. Most learners today are interested in ICT. This forms the good basis of introducing GIS. GIS professionals

from local universities could collaborate with the Ministry of Education in Ghana to train teachers GIS.

2.5.7 Implementation of GIS in New Zealand

New Zealand is not a third world country. It is advanced in many aspects of life such as education, technology, sport and agriculture. Authorities in New Zealand realised how spatial technologies such as GIS would allow students to explore and manipulate information directly, and bringing new teaching practices and innovations in geography pedagogy (Eddy & Olsen, 2012). In New Zealand teachers are engaged in a professional development programme during the first two years of their teaching career. The aim of this development is to control the quality of their teachers (Eddy & Olsen, 2012). Advancement in Information and Communication Technology Professional Development (ICT PD) started in 1999 by clustering secondary schools. The aim of ICT PD was to encourage the use of ICT in the classroom to support teaching and learning, as part of the DoE's ITC strategy Interactive Education, released in 1998 (Eddy & Olsen, 2012). This development of ICT PD cluster programme, benefited teachers who ended up gaining professional development in GIS. Many geography teachers attended GIS workshops and GIS institutes funded from the ICT PD cluster programme.

The interest of GIS in New Zealand started in 1994 and from 2000, GIS interest moved towards integrating it as a teaching tool to boost the teaching of geography (Eddy & Olsen, 2012). Eddy and Olsen, who were geography teachers had a company called GISMAPED which provided quality development on geography teachers in the use of spatial technologies. They facilitated over 30 workshops throughout the whole of New Zealand since the year 2000 and 45 secondary schools purchased the software (Eddy & Olsen, 2012). It was out of this project that teachers in New Zealand developed vision on how GIS could be used, and had confidence in the teaching of GIS.

Kinniburgh (2010) explains how the development of the revised New Zealand Curriculum provided an opportunity to investigate GIS-based teaching and learning strategies within the social sciences classroom. The revised curriculum emphasises

the ‘learning to learn’ message which sees the inquiry method of learning as the effective teaching method. The inquiry-based method connects knowledge across learning areas, and has a more participatory approach to learning and provides students with more independence in their studies. It is from this background that Kinniburgh (2010) shows the value of GIS technology for extending student learning when situated within a problem-based learning (PBL) framework. The student undertakes geographical inquiry through meaningful learning, solving a particular geographical problem and this is a constructivist learning approach. This research is grounded in constructivist theory that GIS technology gives student an opportunity to work alone, independently and develop whatever geographical end-product he/she is working on. The New Zealand Revised Curriculum of 2007 emphasises that it is not enough to have knowledge, but one must be able to use it. In GIS teaching and learning, students must prove to the tutor that s/he knows by working on a geographical project alone that will justify the understanding of what he has learned.

2.5.7.1 Technical factors limiting the number of schools using GIS in New Zealand

Eddy and Olsen (2012) outline the following as few factors in New Zealand that limit the number of schools using GIS:

i. Limited computer access by learners;
ii. Insufficient network strength;
iii. Availability of computers to access the Website;
iv. Problems by the teachers to manage GIS data files;
v. Problems with school network managers mishandling the software, and
vi. Limitations of web-based GIS technology.

Besides all the above obstacles mentioned, the more serious obstacle is the attitude that GIS is not relevant in New Zealand; it is not needed in tertiary study of geography or in the workplace. Teachers in New Zealand do not view GIS as a tool that can change the way spatial data are manipulated, analysed, and presented (Eddy & Olsen, 2012). It will not be easy for the introduction of GIS in secondary schools if those in power do not see its significance. The problems do not look the

same with that of developing countries, where there are serious infrastructural problems.

2.6 INCORPORATION OF GIS IN SOUTH AFRICAN GEOGRAPHY SECONDARY SCHOOL EDUCATION

South Africa introduced GIS when the National Curriculum Statement (NCS) replaced Outcome Based Education (OBE) in 2006. Scheepers (2009:40) argues that many schools “in the Western Cape, like the rest of the country, are challenged by the difficulties of implementing GIS as part of the school curriculum.” He outlines the importance of GIS in the school curriculum, but goes on to question the “level of preparedness of education departments, as well as educators.” (Scheepers, 2009:40). One of the objectives of this research study is to determine the relationship between background knowledge of GIS by the teacher and performance of learners in GIS. The results emanating from the test of this objective will stimulate the Department of Basic Education to consider retraining geography teachers for the teaching and learning of GIS technology. It is fruitless to include GIS in the FET level of schools while there are no qualified teachers available to teach it.

Scheepers (2009), Innes (2012), Eksteen et al. (2012) and Breetzke et al. (2011) highlight the lack of adequate training in GIS, inadequate computer laboratories in South African schools and change in the teaching approach. This study investigated the teaching and learning of GIS in secondary schools in Limpopo Province of South Africa with the intention of developing better methods to teach it. In the context of what Scheepers (2009) argues, there are still some unanswered questions in the introduction of GIS technology in South Africa’s geography curriculum regarding its teaching and its learning in geography.

In South African schools, most geography learners do not do geography because they like it. They do it because they cannot cope with other subjects. To attract many learners in studying geography in South Africa, it is crucial that GIS is taught well. Training teachers in this area can have a positive impact on learners’ involvement and can motivate them to learn and study geography. Geography without any form of technology may be perceived by learners as a "dry” subject, to use the words of Singh (2013:151).

The ESRI publication of “GIS BEST PRACTICES” of March 2009 shows how Senior Geography Curriculum Advisers were invited to a three-day training course on GIS in Midrand, Gauteng Province. The strategy was to ensure that GIS is introduced via the curriculum advisers in their different provinces. Most teachers were nervous “as most of them had not heard of GIS and there was a lack of skills for imparting this knowledge to the students”(Anonymous, 2009:31).The article goes on to show the huge difference that exists between the rural and urban schools in terms of resources. It shows how rural schools lag behind in well-qualified teachers and access to electricity, infrastructure and funding. Before introducing GIS, the infrastructure must first be improved in most schools. If the school does not have electricity, they are unable to connect to a computer.

The above arguments support the essence of this study. It is significant that some ground work be done before this technology can be introduced. Since GIS was introduced in 2006, interest in some learners is there but there is not enough equipment to support teaching and learning GIS in the secondary schools. Another disturbing issue is that of not performing well in exams on the section based on questions that are on GIS. Many schools are not performing well in this section. The Grade 12 end of the year results shows that learners perform poorly on questions that are GIS-based. Currently, the section on GIS has been introduced into the geography curriculum in South Africa but learners are not being taught the practical component of it which is essentially what GIS is. Internationally, most countries have introduced GIS in their secondary school geography education as part of the curriculum.

In many countries, subjects such as Science, Mathematics and English, integrate the use of technology in their teaching and end up attracting most students. Geography remained unattractive to learners until GIS technology was introduced. The introduction of GIS in the developed countries injected more interest in the subject. Geography attracted many students due to this element of ICT. Young geographers today in South Africa are identifying GIS as a way to build their future careers.

2.7 THEORY OF CONSTRUCTIVISM AND GIS CURRICULUM

Researching on the teaching and learning of GIS technology in the secondary schools of Limpopo Province, without subscribing to a theoretical framework in which we can root our argument on, will render this research study incomplete. This research study has adopted a theory of constructivism as a framework of argument. In the constructivist approach, learners are allowed to create their own findings as they continue to enquire. Fargher (2004:2) interprets constructivism in education as "a model of practice where students create and adapt their own knowledge and skills". In the context of this theory, learners must create and adapt their own knowledge and skills while the teacher remains a facilitator. To be able to produce geographical information in a GIS assignment that a learner was given by a geography teacher, requires skills in GIS training. The learners can collaborate with one another in order to learn. These help them to share the knowledge and skills they learn in GIS. According to Muller (2013:315), constructivism theory "is a theory of learning that values questioning, considering and analysing information to develop an understanding of ideas". In GIS teaching and learning, learners could question data and consider whether spatial data at their disposal give sense and could deliver what the learner or student is intending to achieve. The consideration can be reached after learners have analysed the data. All this is done by learners themselves without engaging with the teacher. Learners operate with their personal computers in front of them, manipulating data as they wish in order to come out with the geographical information they intend to produce. "A constructivist view of learning suggests an approach to teaching that gives learners the opportunity for concrete, contextually meaningful experiences through which they can search for patterns; raise questions; and model, interpret, and defend their strategies and ideas" (Muller, 2013:315).

The two explanations do not differ much. They both emphasise autonomy in learning. It means that learners become independent, not relying on the teacher to be fed with information. The learners use data and information that they have, to come up with spatial features they intend to develop. In GIS teaching and learning, learners are given an exercise to adventure on their own after they have been shown

how the software operates. If learners are given data on agricultural products of a particular province to represent on the map, they will adventure alone, following the steps and instructions from the software, ending up producing the end product correctly. This is constructivist theory of learning in action. Learners construct maps by themselves, model them as they deem right, do the interpretation and present the final product. Everything that they represent on the map, they can defend by themselves. This reflects independent learning.

Piaget, who is regarded as the father of constructivism, believes that knowledge from the child is gained when he interacts physically with the object (Kamii, 2000). If a learner interacts with hardware and software that can do and produce what s/he intends to produce, that is gaining knowledge. At the end of his/her schooling, the learner in question can become a qualified GIS user and apply the very knowledge s/he accumulated while he was still learner, for employment. Korcova (2007:2) cited in her article the characteristics of constructivist education, as stipulated by Murphy (1997), that “activities, opportunities, tools and environment are provided to encourage metacognition, self-analysis, self-regulation, self-reflection and self-awareness”. GIS teaching and learning is not a passive lesson where one sits and listens. A learner must do as s/he learns in GIS learning. In constructivist teaching, learning takes place as learners are active during the process. This theory of learning proceeds well where a learner has tools to work with. A favourable learning environment that is conducive to both the teacher and the learner will develop. It will be difficult for teachers to impart GIS technology without hardware and software within their teaching and learning milieu.

Sharma (2014:17) argues that constructivist theory “is a learner-centred approach in education”. Learners learn how to think because they are involved in the real world where activities take place. The teacher is a facilitator who learns together with learners in class. Learners are given more *laissez-faire* in class to think and to air their views on how they understand the subject. GIS technology allows learners to work on their own and they can manipulate the software as they understand it to produce whatever is spatially related from the data that is available or accessible. Learners have freedom of thinking, constructing and producing features on the map the way they understand the process. Learners can make references on the map

that they have produced through GIS, so that whoever wants to use the map can understand it. Constructivism's main emphasis is on the construction of knowledge by individual learners, independently, as argued by Muller (2013). Sharma (2014) further alludes to the fact that constructivism is able to transform thinking beyond today's traditional models of teaching in schools, and in GIS, that room of thinking beyond is available. Learners who are in Grades 10- 12 can be encouraged to think and come up with the type of geographical information they want. What is important is that the information they would come up with, will be their own independent design. Constructivism demonstrates what the learners would have produced on their own.

Schweitzer and Stephenson (2008), share the following tenets on constructivism: learners construct knowledge socially; learners construct knowledge physically and as a result knowledge must be embodied for the learner to acquire it, and lastly learners can create knowledge symbolically by using their representations for meaning and concepts. In GIS knowledge is created symbolically when representing features on maps. A symbol can be used to represent a geographical feature on the map. The very feature can give meaning to the whole map on geographical information. The geographical information can then be interpreted and give meaning to the concepts represented on the map. Any person can read and understand the concepts symbolised on the map after analysis. Concepts such as direction, scale and steepness of the slopes on the map could be conceptualised.

Richardson (2003:1631) argues that "constructivist teaching requires a deep understanding of the disciplines, of the ways in which students learn the content, and of the teaching practices specific to that discipline on the part of the teacher". Richardson (2003) in this context, elucidates that when using constructivism theory, it is fundamental that one understands the subject matter properly. The learners you teach must be clarified on any question that they ask. Teaching using GIS technology in secondary schools needs teachers who are well trained and who understand GIS. It will be embarrassing on the side of the teacher if s/he fails to answer questions posed by learners during a GIS lesson. Where a learner cannot follow the instruction of the software properly, it is the duty of the teachers to explain this. GIS teaching and learning is a practical activity. Constructivism theory entails

that learners must learn by doing. It is the teacher who must overlook as to whether what they do is correct so that at the end they must produce a product that is excellent.

It must be emphasised that the theory of constructivism is not a theory of teaching, but a theory of learning. Matoti and Lekhu (2008:129), argue that constructivism is a "learning process of constructing meaning derived from the learner's action in the world or a process of knowledge construction." Constructivists further allude "that learners are not passive beings that respond to 'stimuli' and that learning is not a process of perceiving and recording ready-formed and pre-packed knowledge that is stored in the brain to be retrieved later" Matoti and Lekhu (2008:129). In constructivism, knowledge is constructed, like a builder constructing a house. During the erection of the house, a lot of thinking is involved throughout until the house is completed. In GIS learning, learners are encouraged to construct, for example, a map which is geographical information. The learners must first capture data of a particular spatial area. From there they must manipulate the data they possess. Learners must then decide on what to do with the data, and on this they will be guided by exactly what information they intend to produce as a final product. The data must then be analysed to establish if the data is enough to produce the end product envisaged. If revisions are needed, the learner will consider editing where necessary. If additions on the data are needed, they will consider adding. During the process, the learners experience many things that at the end make them potential GIS experts. Introducing GIS at the secondary school level, where they learn on their own, independently of the teacher, the learners will develop the skills of capturing spatial data, manipulating it, analysing the data and ultimately producing an end product referred to as geographical information.

According to Driscoll (2005), constructivism teaches students to think critically and to collaborate skills. GIS encourages critical thinking. When learners intend to produce any geographical information, they need to think. The way they unpack, the data will involve thinking in a critical way. Eventually they will acquire a variety of skills, like computer skills, understanding the software, map skills, analysing data and many more skills. The only disadvantage of constructivism is lack of attention on students' behaviour. Some learners might fail to work independently due to lack of the ability to

concentrate and focus on their learning goals. Constructivism theory does not have room for learners who are playful. Driscoll (2005) proposes that constructivist teachers should aim at maximising the abilities, capabilities and needs of the learners, to avoid the downside of constructivism. GIS teaching and learning will not differ from any constructivist lesson that is imparted to learners.

Some of the conditions for learning in the constructivist approach as outlined by Driscoll (2005) and relevant to GIS, are that GIS should encourage ownership in learning and that self-awareness of the knowledge construction should be nurtured. If in GIS learners produce interesting geographical information from a GIS activity given by the teacher, the learners must own it. They must take pride to say 'this is my work'. The teacher can in fact publicise it in the local newspaper, in the school or in a local regional show to encourage other learners.

2.8 SUMMARY OF THE CHAPTER

Literature has indicated that in South Africa there is a need for GIS teaching and learning in secondary schools. To accomplish this objective, qualified and well trained GIS teachers together with the provision of equipment are necessary. The situation in Limpopo Province and South Africa on GIS teaching and learning in secondary schools does not differ much from other countries around the world. The challenges they encounter are almost similar to those experienced in South Africa. It is important that South Africa introduces this technology to geography learners in secondary schools. Literature also indicated that constructivist theory suits well in the teaching and learning of GIS, only if necessary equipment are available. This research study proposes necessary steps that are needed in the implementation of methods that could be used to teach and learn GIS in secondary schools.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

In Chapter One the research design and methodology of this study was synoptically outlined. Research design of this study falls within mixed methods as these will direct one into procedures to be followed when designing this research. Tashakkori and Creswell (2007) explains that in employing mixed methods, the researcher collects and analyses data, integrates the findings, and draws inferences applying both qualitative and quantitative strategies in one single research study. Creswell (2014) notes that due to computer technology, designs on research has grown and has advanced our data analysis and enabled us to analyse even data that is complex. The aim of this study is to investigate the teaching and learning of GIS in secondary schools in Limpopo Province, South Africa, with the intention of developing different methods of teaching and learning. The research involved both teachers and learners of secondary schools in which geography is taken as a subject.

In the Limpopo Province there are secondary schools that are in rural areas and some in urban settings. An infrastructural difference in these two settings is enormous. Starting with shortage of classrooms, lack of electricity and water, furniture, books which are not adequately supplied lack of teaching staff and lack of teaching and learning facilities. These are some of the differences one would identify from the schools in these two settings. Technological infrastructure in these two settings is also not the same. Urban schools have access to internet facilities whilst those in rural settings do not. Urban schools are located in affluent areas, which in itself is advantageous. These schools are further categorised into private (independent) and public (government) schools. The categories further show the difference in terms of available teaching aids that could assist teachers and learners in the teaching and learning of GIS in their respective schools.

3.2 RESEARCH DESIGN OF THIS RESEARCH STUDY

Research design can be explained as the overall plan for collecting data with the aim of answering the research question. Johnson and Christensen (2014:332) define research design as “the outline, plan, or strategy that you are going to use to seek an answer to your question(s)”. This will involve the data analysis techniques or methods which the researcher intends to employ in getting the answers for the research questions (Fraenkel & Wallen, 2010). Research design can further be said to be a structured framework that one intends to follow when conducting research in order to solve the problem in question. It is done at the beginning of a research study and will involve all the subsequent steps that are to be followed during the investigation of the problem (Babbie & Mouton, 2014). The research design can be classified into empirical and non-empirical designs. Empirical design includes research involving laboratory experiments, field experiments, programme evaluation studies, survey studies, ethnographic studies and participatory action research. Research design that involves empirical data can also be classified according to the type of data collected. The data could be numerical or textual (Babbie & Mouton, 2014; Ary, Jacobs, Sorensen & Walker, 2014; Drew, Hardman & Hosp, 2008). Non-empirical studies will cover philosophical analysis, conceptual analysis and literature review studies. The research design for this study involves empirical data where quantitative and qualitative questionnaires were involved. Basically this is a survey research study where data were collected from teachers and learners from different secondary schools which have geography as one of the subjects. GIS is a section within the secondary geography curriculum and is still new.

3.2.1 Adopting mixed methods research strategy in this research study

This research study adopted mixed methods research strategy (approach) of inquisition to unpack the problem under investigation. The mixed methods strategy is still not commonly used as it is still new and not popular as the quantitative and qualitative approaches (Teddlie & Tashakkori, 2009). It is an alternative research methodology to the quantitative and qualitative traditions. The strategy “provides a

framework for conducting a study that incorporates quantitative and qualitative research approaches" (Johnson & Christensen, 2014:495). Both quantitative (closed-ended) and qualitative methods (open-ended) are integrated and used in collecting, analysing, validating and interpreting data using organized and systematic principles in a single study to respond to the research question or hypothesis (Fraenkel & Wallen, 2010; Johnson & Christensen, 2014; Creswell, 2014). To afford good results, good data collection for both strategies should be conducted carefully (Creswell, 2014). This research study is an empirical study where survey studies with numerical data are dominant with minimal interviews to supplement the close-ended data. The survey involved closed-ended and open-ended questionnaires to get different dimensions on the current teaching and learning of GIS in secondary schools. Non-empirical study of this research involved the conceptual analysis of the research.

Johnson et al. (2007:119) define mixed methods research approach as "an approach to investigate the social world that ideally involves more than one methodological tradition and thus more than one kind of technique for gathering, analysing and representing human phenomena, all for the purpose of better understanding". The main assumption of this approach is that when both quantitative and qualitative approaches are combined, they will provide better understanding of a research problem than either approach alone. It employs elements from more than one approach to research and benefit from the strength of each approach (Creswell, 2014; Drew et al., 2008).

3.2.2 Pragmatist view of this research study

Pragmatism is basically concerned with applications and solutions to problems. It is a paradigm where researchers involve both quantitative and qualitative methods in answering the research question. Creswell (2014:11) explains that pragmatism "is not committed to any one system of philosophy and reality". It is therefore associated mainly with mixed methods approach. Johnson and Christensen (2014:32), elaborate by saying that in pragmatism philosophy "what is ultimately important and justified or valid is what works in particular situations in practice and what promotes social justice." Pragmatism says that programmes or theories that work for a certain group of people, are the ones that we should consider to be valid and we should

justify them. In investigating the teaching and learning of GIS technology in secondary schools in Limpopo Province, pragmatism philosophy seems to relate well with this research study because this research has adopted a mixed method approach. The findings from quantitative approach are justified or validated by the findings from qualitative findings. As we explore this question, rational and reasonable ideas found in qualitative and quantitative research should are considered.

3.2.3 Value and rationale for mixed-method research strategy

Mixed methods research strategy was adopted because this is a collaboration or synergistic approach that gives one an opportunity “to capitalize on the strength of various methods” (Drew et al., 2008:200). In the context of this research, the strength of both quantitative and qualitative research methods considers what is called mixed-methods strategy in this research. The integration of both quantitative and qualitative methods allowed a researcher to explore the research from different perspectives. Applying the two methods helped minimize the limitations and weaknesses of these two paradigms (Drew et al., 2008; Creswell, 2014).

Fraenkel and Wallen (2010) highlight that mixed methods could help in clarifying and explaining relationships found to exist between the variables involved in a research study. In this study, teachers rely on the availability of hardware and software to execute their GIS lessons effectively. Correlating data collected between the two variables could indicate either minimal negative or positive relationship between the schools that have hardware and software, and those that do not. To find out why such a relationship exists, one can engage teachers in an open-ended questionnaire where more information could be drawn to elaborate on the relationship.

Furthermore, Fraenkel and Wallen, (2010:558) indicate that the mixed methods strategy “allows us to explore relationships between variables in depth”. In this case, qualitative methods can be employed to find out more about the relationship between the teachers, learners and GIS technology in secondary schools through interviews or questionnaires. The variables can also be quantified through questionnaires directed to learners who gave more information on the research

questions related to their understanding of GIS and issues that impede the teaching and learning of GIS in their schools.

Mixed methods could again assist in confirming relationships discovered between variables used in the study. This comes in when quantitative and qualitative methods are compared to find out whether they converge on a single interpretation of a phenomenon (Fraenkel & Wallen, 2010). If they cannot converge, the reason can be investigated further. Creswell (2012: 218) argues that mixed methods approach "can be an ideal research methodology to use if one has access to both qualitative and quantitative data". In the investigation of the research question in this study, the researcher collected both quantitative and qualitative data. The availability of these data enabled the researcher to apply mixed method in this research study. Johnson and Christensen (2014) developed a framework for a mixed research study based on the use of the following five rationales:

(i) Triangulation

This is when a researcher seeks convergence, correspondence, and collaboration of results emanating from different methods investigating the same phenomenon. The methods in the context of this research are the quantitative and qualitative. Triangulation can increase the credibility of research findings (Johnson & Christensen, 2014).

(ii) Complementary

When the researcher seeks elaboration, enhancement, illustration and clarification of the results from one method with the results from the other method. In this case, the two different methods applied will be complementing one another.

(iii) Development

This is the name given when the researcher uses the results from one method to develop or inform the other method. Development will include sampling and implementation of the results and the measurement of decisions.

(iv) Initiation

When discovered paradox and contradictions provide different perspectives and framework that may lead to reframing research question or results. New ideas and concepts could also be initiated.

(v) Expansion

The purpose of research is called expansion when the researcher or investigator seeks to extend the breadth and range of inquiry by using different methods for different components that are under inquiry.

The framework of Greene et al. (1989) is helpful when a researcher is to select a mixed method design. If for example, the aim of the researcher is developmental, sequential design is necessary, and if the results are triangulation, mixing should occur during data interpretation and report writing.

3.2.4 Constructing the mixed research design and mixed sampling design

In mixed research design, a researcher has all the research designs and methods at his or her disposal that he or she can apply. A researcher is not confined to a particular philosophy or method. One can be creative to come up with a design that can be appropriate for the research questions. In this research, quantitative and qualitative components were carried out sequentially. This research followed a quantitatively driven design where quantitative method was dominant and often included supplementary qualitative component in answering the research questions. Later, other qualitative interviews followed in interpreting and validating the earlier findings. The design for both quantitative and qualitative components within the mixed research design of this research study are explained hereunder.

3.2.4.1 Quantitative research design questions

This research study adopted a survey design in inquiring about the teaching and learning of GIS in secondary schools in the Limpopo Province. Both teachers and learners were engaged in quantitative research questionnaires to acquire the primary information regarding the GIS teaching and learning in different secondary schools in

the province. Questionnaires can be defined as a self-report data-collection instrument that is filled by research respondent or research participant during a research study (Johnson & Christensen, 2014). The reason for engaging the survey design method is that this research needs to capture the characteristics of the members of the target population. For example, the members of the population distribute themselves on one or more variables under survey (Fraenkel & Wallen, 2010). Teachers' questions involved their personal data in which their qualifications, gender and their age brackets are covered. The researcher attempted to measure many different kinds of characteristics in the study using the questionnaire (Johnson & Christensen, 2014).

The target population for this research are geography teachers and learners doing geography in secondary schools of Limpopo Province. The aim of this research study is to investigate the teaching and learning of GIS secondary schools in the province. A portion of the target population was sampled randomly and from the sampled population of the target population inferences were drawn. The quantitative questionnaire for learners doing geography in the FET- Band (Grades 10 -12) was also designed to answer questions related to their understanding of GIS and the availability of GIS infrastructure in their respective school, the number of computers they have in their schools, their exposure to available hardware and the environment of their schools. Learners were also be given a test to determine their knowledge of GIS. The test was specifically written by Grade 12 learners because they are at the exit level of the FET-Band. The test measured their GIS knowledge accumulated from Grade 10 until Grade 12. The test comprises multiple choice type of questions. The results of the test were compared to the knowledge of the teacher in every school which took the test, to determine whether there was a correlation between the results of the test in that school and the GIS knowledge of the teacher. To avoid extraneous influences, the questionnaires for teachers and learners were not conducted on the same day but on separate days. The test was also scheduled for a later date.

3.2.4.2 Qualitative research design questions

The qualitative phase of this study took on a phenomenological design in which the concept of GIS teaching and learning was investigated through interviews and a questionnaire on lesson observations with teachers. Qualitative designs focus mainly on data collection, analysis and writing (Creswell, 2014). The questions dwelt much on the methodology employed by teachers currently in the teaching and learning of GIS and how they want the Department of Education to assist in elevating GIS teaching and learning to the required standard. This helped to understand whether the method used currently by geography teachers is in line with GIS teaching method applied in other schools.

The qualitative approach in this research also involved a phenomenological study. A phenomenological study describes the meaning for several individuals of their lived experiences of a specific phenomenon. The phenomenon in question is GIS teaching and learning in the secondary schools of Limpopo Province. The researcher collected data from persons who have experienced the phenomenon and developed a composite description of the essence of the experience for all the individuals – "what" they experienced and "how" they experienced it (Creswell, 2014). This description focuses on what all the participants have in common as they experience the phenomenon. By considering multiple perspectives on the same human experience, the researcher can then make generalizations of what the experience is like from an insider's perspective. The task of the phenomenologist is to depict the essence or the basic structure of the specific experience (Creswell, 2014).

Qualitative questions were designed for both learners and teachers. The learners' qualitative questionnaire dwelt much on the experience gained since they started learning GIS at Grade 10 level. The questionnaire for learners helped this research to determine how learners learnt and the experiences gained with GIS. The learners also expressed their views about the value of GIS technology in their daily lives. The research followed QUAN → qual mixed methods design. This indicates that the research is a quantitatively driven project that is followed by qualitative project to back the quantitative results revealed by the study.

3.2.4.3 Mixed methods approach

An embedded mixed research methods was employed in this research study. According to Creswell (2014), embedded mixed-methods are methods that nest an explanatory sequential method within a larger design. The qualitative data collected was embedded within a larger design of quantitative origin. This study is an exploratory study research. In this research study, quantitative data are a priority while qualitative data are to be used in the explanation of the quantitative results. In this case, the qualitative results provided more explanations regarding the variables. This kind of study is essential because it enhances the answer as to why this happened (Drew et al., 2008). Some of the quantitative questions engaged in this research questionnaire would obviously need an explanation. The only solution to these questions would be the qualitative data. Although quantitative data are helpful and necessary to get an overview and perception of GIS teaching and learning in secondary schools in Limpopo Province, it is limited in terms of explaining why they happen as they do. Engaging qualitative research strategy added more strength on the results of the research study.

Johnson and Christensen (2014) provide a practical typology of mixed methods designs and conceptualize mixed methods research as a function of two fundamental dimensions namely, time orientation and paradigm. Time orientation refers to whether qualitative and quantitative components occur at the same time (concurrently) or whether they are organized in phases of the study in a sequential order. Paradigm emphasis refers to whether the qualitative and quantitative sectors of the study are given equal emphasis when responding to research questions and in the interpretation of results or whether one paradigm has more weight than the other. This research study followed a quantitative driven design in which the quantitative perspective of thinking is emphasized, while supplementary qualitative component is included without impacting on the overall approach to the research. All the procedures for both quantitative and qualitative methods must be conducted austerely, for example, source of data, adequate sampling and analysing steps, etc. should be followed correctly so as to avoid confusing the two approaches in a mixed methods setting.

3.3 TRIANGULATION DESIGN: DISCUSSION

3.3.1 Introduction

In the beginning of this chapter it was outlined clearly that this study engaged the mixed methods approach: quantitative and qualitative methods were used sequentially. Johnson and Christensen (2014) abbreviates the combination of the two methods as QUAN → qual sequential design method. The design shows that the quantitative method is dominant while qualitative is minimal, hence QUAN → qual. The capital letters denote that the priority of the research study is quantitative, while that lowercase shows the supplemental role played by the research design (Johnson & Christensen, 2014). This study examined at the teaching and learning of GIS in South African secondary schools with reference to Limpopo Province. Both quantitative and qualitative data were collected. The research analysis is dominated by the quantitative method with qualitative method running sequentially with it. The triangulation design was engaged to complement the two methods used in this research.

3.3.2 What is triangulation design?

The word *triangulation*, as a metaphor is supposed to indicate that which comes from different points or angles towards a "measured position" then you find true position (Henning, 2013). Springer (2010) explains triangulation as the use of more than one perspective so that a fact can be established. He goes on to define triangulation design as the type of mixed-methods research design in which qualitative and quantitative data collection take place simultaneously. The two methods corroborate each other, hence the name triangulation design (Springer, 2010). Punch and Oancea (2014:345) explain that "the purpose of the triangulation design is to obtain complementary quantitative and qualitative data on the same topic, bringing together the different strengths of the two methods". Johnson and Christensen (2014:299) explain that "triangulation is a validation approach based on the search for convergence of results obtained by using multiple investigators, methods data sources and theoretical perspectives". In this research close-ended and open-ended questionnaires were used in the collection of data. Data was also collected from both

geography teachers and learners doing geography in Grade 12. Patton (1999:1192) argues that “the logic of triangulation is based on the premise that no single method ever adequately solves the problem of rival explanations”. His argument supports the fact that each method reveals different aspects of empirical reality, multiple methods of collecting data and analysis that provides more results on the research topic one is investigating. Triangulating this study meant collecting both quantitative and qualitative data related to teachers teaching GIS and learners studying geography as one of their subjects in Grades 10-12. Mixed-methods design was used to investigate the research problem in this study.

3.3.3 Triangulation in the analysis of data in this study

Triangulating quantitative and qualitative methods in this research study closed the gaps left by each of these methods. As outlined by Springer (2010), the two designs corroborate each other and in triangulating data collected, qualitative design closes down on the gaps left out by the quantitative design. Patton (1999:1190), while looking into the techniques for enhancing the quality of analysis, states that “statistical (quantitative) analysis follows formulas and rules, while at the core, qualitative analysis is a creative process, depending on the insights and conceptual capabilities of the analyst.” Formulas and structured rules that are followed when collecting, testing and analysing data, together with personal creative approaches that emanate from personal analysis in qualitative analysis, add value towards the credibility of the research. Creative approaches are able to extend more repetitive kinds of statistical analysis, although in most cases qualitative analysis depends from the onset on the shrewd pattern that one engages in.

The QUAN-qual approach was applied in this study. The two methods ran concurrently when data was collected. This research also used two sets of data, that is, data collected from teachers teaching geography in secondary schools (FET level) in Limpopo Province and data collected from Grade 12 learners doing geography as one of their subjects. Questionnaires were used as instruments for collecting both quantitative and qualitative data from both parties. Teachers’ questionnaire had two parts. Part one of the questionnaire consisted of close-ended questions, while part two covered open-ended questions. In addition to the

qualitative data collected from teachers, direct interviews were conducted and recorded. The recorded interviews were later transcribed and analysed. Data related to both method designs were therefore collected simultaneously. Geography teachers had to respond first to the quantitative questions in part one, and proceed immediately to the qualitative questions in part two of the questionnaire. Although these methods were run at the same time, they were not run on equal fifty-fifty basis. The two designs were run sequentially with the quantitative method having the upper hand. The researcher also visited few schools to interview learners on GIS technology. The learners in urban schools responded actively compared to the other schools which were semi-urban, that is, township high school and the other one rural school. This data was there to compliment the data collected quantitatively and qualitatively.

3.4 THE DESIGN AND METHOD EMPLOYED IN THIS RESEARCH

The design and methodology employed in this study must guide it towards achieving the purpose envisaged. When the National Curriculum Statement for Geography was implemented by the Department of Basic Education (DBE) of South Africa in 2006, GIS technology was introduced in the geography curriculum of the Further Education and Training (FET) Band (Grade 10 – 12). Many teachers offering geography at this Band, did not know what GIS was all about. It was a new part or section of the geography curriculum included in the syllabus which needed attention from the authorities governing education in Limpopo Province in particular and South Africa at large. Teachers had to be taken through workshops and short course training to acquaint themselves with the GIS technology. GIS technology needs ICT equipment such as hardware and software which requires financial backing.

This study argues that teaching and learning GIS technology in the secondary schools' geography curriculum in Limpopo province was introduced before other important aspects were considered; such aspects include inter alia the development of infrastructure in schools, availability of hardware and software and trained teachers who can teach GIS. This research study investigated the readiness of the teachers who offer GIS in the secondary schools in Limpopo Province. The application of mixed-methods research design in this research, together with the

data collected guided this research work to achieve its envisaged results. The approach used was to be able to quantify in a statistical manner, whether the secondary schools in Limpopo Province have enough equipment to allow the smooth teaching and learning of GIS in the secondary schools doing geography. The mixed-methods also provided more explanation of the quantitative results, through the qualitative research method. The results led this study towards proposing a model through which GIS could be taught in Limpopo Province and South Africa as a whole. Application of the closed-ended and open-ended questions provided proposals and recommendations for this research study. Gaps left out by one approach should be closed by another so that this research has value.

3.5 RESEARCH METHODOLOGY

Research methodology refers to the methods, techniques and procedures that will be employed during the designation of a research plan. These cover the principles and assumptions that prescribe to the techniques and procedures of the research design. The present research study engages mixed methods research design in investigating the teaching and learning of GIS in the secondary schools of Limpopo Province. The data-gathering tools or research instruments that were applied were survey questionnaires to teachers currently teaching geography and learners doing geography in secondary schools. The questionnaires are explained in detail later in this chapter.

3.5.1 Survey method plan

This study followed a survey method plan in collecting quantitative data. A survey “is a systematic method for gathering information from (a sample of) entities for the purpose of constructing quantitative descriptors of the attributes of the larger population of which the entities are members” (Groves, Fowler, Couper, Lepkowski, Singer & Tourangeau, 2009:2). The purpose of this study is to investigate the teaching and learning of GIS in secondary schools in Limpopo Province with the intention of developing a model to teach and learn it. The reason for this survey method plan is that this study needed to get answers from a population of teachers and learners who are currently teaching and learning geography in Grades 10, 11 and 12 in secondary schools in Limpopo Province. Information was therefore

collected from only a subset of the population of teachers and that of learners through questionnaires. These two populations were sampled so that inferences could be made about the characteristics of the secondary schools doing geography as one of their subjects. Groves et al. (2009) indicate that the main reason for surveys is to have an understanding of a social problem in a particular society.

The study under review wanted to understand the problems relating to the teaching and learning of GIS in secondary schools. The attitude of learners and teachers regarding teaching and learning through computers and their response towards being taught through computer technology could best be measured through the survey method.

3.5.1.1 Teachers questionnaire

The research study followed a mixed methods design. The first set of questions dominating the survey follows a quantitative design type. The other last set of questions that will follow is that of qualitative type. The research followed a sequential QUANTITATIVE → qualitative mixed methods design in which quantitative perspective is emphasized and some qualitative data are added to the study (Johnson & Christensen, 2014). The qualitative perspective supplemented the quantitative perspective.

3.5.1.1.1 Questionnaire design

The researcher designed the questionnaire himself. This is to ensure that problems such as ambiguity are avoided. You are the only person who knows what you want and therefore the responsibility is upon you to construct the questions by yourself. From the literature that the researcher went through, there is no study in South Africa that was conducted in teaching and learning GIS in secondary schools. The researcher used a five-step process in the inquiry to get answers for this research as outlined below. In the questionnaire that was distributed to schools the name of the school and of the teacher was omitted due to the confidentiality agreement with the Department of Education in Limpopo Province.

Step 1: What is the basic required information of this study?

The questionnaire in use determined if the current methods employed by the geography teachers in Limpopo Province in teaching and learning GIS are appropriate. Questions focused on the personal data and experience of teachers, their skills and knowledge, methods employed when teaching GIS and availability of GIS infrastructure in secondary schools.

Step 2: Specifying the content of the questions

The independent variables here are geography teachers. Teaching and learning of GIS in schools is driven by teachers. The questions got information on the individuals who teach GIS in terms of their gender to determine whether GIS technology is male or female dominant. The questionnaire collected information regarding how long the teacher has been teaching geography, his/her qualifications and age. Ageing and the service of the teacher comes in because most people who are old are not interested in issues that involve computers. This can have a negative impact on the teaching and learning of GIS technology.

The following reasons are advanced as to why these questions regarding geography teachers in secondary schools are important:

i. To examine the current methods used by geography teachers in teaching GIS in secondary schools are influenced by the qualifications teachers possess in relation to GIS. This could influence the methods applied in the teaching of GIS technology in the schools.
ii. To determine whether age influences their interest in terms of teaching and learning GIS technology. Most elderly teachers seem to have negative attitude towards teaching and learning through hardware and software. In the questionnaire there are questions that provided information about the perception of teachers towards GIS technology in general.
iii. To determine whether schools have hardware and software to teach and learn GIS technology. Questions relating to the availability of hardware and

software in schools are important. There are schools where there is only one laptop and no electricity and funds to purchase hardware and software. In such schools learners end up learning every GIS technology related information through theory.

iv. To determine the attitude of geography teachers towards GIS in the secondary schools in Limpopo Province. The negative attitude of teachers could end up influencing learners' interest in the learning of GIS. Attitudes develop when a person lacks knowledge on something that s/he is responsible for.

Step 3: Structure of questions

This research study followed a mixed methods design and the questions include both close-ended and open-ended items. Close-ended type of questions were designed in the completion of the quantitative questionnaire. Johnson and Christensen (2014) explain that close-ended questions focus on getting participant responding to standardized items to confirm research in which specific variables are measured and hypotheses are tested. The reason for choosing this type of questions was to make it easier and quicker for both the teachers and the learners to answer the questions. Teachers are busy and if questions are closed-ended it is easier for them to answer. The questions that are quick and easy to complete are associated with a high response rate from the respondents because the questions asked did not need much of their time. The principle of standardization in quantitative research is important because the aim is to provide common stimulus to each person in the research study (Dillman, 2007). This also helps to make sure that there is maximum comparability of responses.

Qualitative set of questions directed to teachers are also designed for this research study. Qualitative questions rely mainly on the collection of non-numerical data such as words and pictures (Johnson & Christensen, 2014). The questions were open-ended type of questions where teachers gave their opinions regarding their experiences on how they teach and learn GIS technology in secondary schools in Limpopo Province. Teachers are asked to motivate and substantiate on the methods they employ when teaching and learning GIS technology in their schools. Teachers

also shared their problems of teaching GIS informally with the researcher. The information would be recorded down in the special diary which the researcher used to record information related to the research study. This is referred to as memoing (writing memos) which Johnson and Christensen (2014:588) explained as “recording of reflective notes about what you are learning from the data you collecting as researcher”. Memos in this context would include comments made by geography teachers, thoughts on the teaching of GIS in their respective secondary schools, the speculations about GIS teaching and the impact it can have on the high unemployment people. Teachers also remarked on how GIS in secondary schools could build a foundation for prospective GIS students who are planning to register for GIS at institutes of higher learning. All this information was recorded and formed part of the interim analysis.

Learners doing geography in Grade 12 from different schools were interviewed on their perception towards GIS. Questions mainly dwelt on their experiences on the understanding of GIS, its importance and the impact GIS could have on their future careers. Learners were asked to explain how GIS was being taught in their respective schools. Learners were also required to indicate as to whether they are ready to answer questions on GIS in their final year geography examination. Comparisons were made between learners in former Model C schools in towns and those in the townships found at the outskirts of town and cities of the province as well as those in the deep rural areas of the province.

The Limpopo Province has five districts namely, Capricorn, Waterberg, Sekhukhune, Vhembe and Mopani. In all these five districts there are schools that are in rural as well as in urban areas. Most schools are public with few private schools distributed throughout the province. All these schools were sampled to get a true reflection of how GIS is taught and learnt in Limpopo Province. These data was also used in comparing the understanding of GIS in rural secondary schools and urban secondary schools doing geography. The comparison of privately owned secondary schools and public owned secondary schools was drawn from these data as well. The distinction between rural and urban, private and public was distinguished to be able to compare the two settings or environments of teaching and learning GIS. A survey method was therefore suitable for this research study.

In the first phase of the study, quantitative methods were applied. The questionnaires were designed by the researcher. The answers to these questionnaires reflected on the current situation of GIS teaching and learning in the schools in Limpopo Province. To the knowledge of the researcher, there is no similar research that was conducted in South Africa. The questionnaires cover the core understanding of what geography teachers and learners experience in the teaching and learning of GIS in their respective secondary schools in Limpopo Province. The names of the schools and those of learners involved in the survey were not important in this research. The names were excluded due to the confidentiality agreement with the geography teachers and their learners as well. The schools were divided into rural schools and urban schools and private schools were separated from public schools.

The study adopted a cross-sectional survey method when collecting data. Fraenkel et al. (2010) and Creswell (2014) explain cross-sectional survey as survey in which information or data are collected at one point in time. Time here can take from a week to few weeks or even more depending on the population sampled. Information was collected as primary information from geography teachers and geography learners in different schools around the province. Other dependent variables are geography learners in secondary schools in the FET- Band and the GIS curriculum. Schools from both rural and urban settings were sampled, and they included private and public schools so that one can get a general perspective of the teaching and learning of GIS in Limpopo Province.

Stage 4: Wording in the construction of questions

The statements on the questionnaire avoided ambiguity. Questions were kept short, with simple language and were specific about what was needed. By constructing short questions one avoids the risk of different interpretation from the respondents. Since most questions are closed-ended, this minimizes the risk of different interpretations and misunderstanding. Johnson and Christensen (2014) mention that questions should be interesting, easy, short and non-threatening. The researcher

also avoided leading questions to decrease the possibility of evoking emotional responses by teachers.

Stage 5: Sequence of the questions

The questionnaire starts with personal, non-sensitive data and experience of the respondent teacher. Personal information questions are easy to answer especially in a close-ended designed strategy. Questions demanding deep thinking and that could make respondents unease are reserved for later when the interviewee is settled. Johnson and Christensen (2014) explain that one should consider placement of each question when designing a questionnaire. They note that it is good not to start with the most difficult or time consuming questions at the beginning of the questionnaire. In their words ask “warm-up” questions at the beginning.

Stage 6: The layout of the questionnaire

The quantitative questionnaire consisted of five user-friendly pages that encouraged all the respondents to participate. The questions were clearly divided into five thematic categories: a. Personal data and experience of teachers, b. Skills in GIS c. Knowledge of GIS, d. Methods of teaching GIS and e. GIS related infrastructure. The sub-heading of each category was bolded and underlined to make them clear to the respondents so that they knew exactly what each category was about. These questions were close-ended questions that were not controlled by the length of the available space for answering. The respondents had to mark the answer that suited them. At the end of the questionnaire, the participants were made aware that the exercise was finished. This was done by a closing statement which showed appreciation for their participation in the research project such as ‘thank you for your time’. This can have a positive impact on the response should the researcher need to do any follow up research with the same participants.

3.5.2 Learners’ questionnaires

The other main participants in this research project were learners. Teaching and learning GIS technology are activities that take place between teachers and learners.

Information needed to provide answers to some questions relating to this research was sought from learners. The research envisaged to develop a model of teaching and learning GIS in secondary schools in Limpopo Province and South Africa as a whole. Secondary school learners doing geography in Grades 10 to 12 were the main participants in this research project.

3.5.2.1 Designing learners' questionnaires

Questionnaires for learners were quantitative with only one question that was qualitative. Creswell (2014) explains quantitative research questions as questions that inquire about the relationship between variables where the researcher or investigator seeks knowledge of and they are common in survey studies. This research is a survey study and these questionnaires were therefore relevant because they had to reflect on the secondary school learners' knowledge of GIS in Limpopo Province. Hofstee (2013) explains that by using survey-based research design one is basically trying to obtain information from a limited number of individuals whom the researcher believes have the information he/she is seeking. The group that one samples represent a larger population. In the context of this research study, learners from rural and urban; private and public secondary school environments were sampled. The statements in the questionnaire were written in a simple and straight-forward language to avoid misunderstanding of the questions that might lead to unintended answers. The questions as well tried to cover the core elements of teaching and learning GIS technology in the secondary school environment. The questionnaires for collecting data used structured close-ended approaches and formats. The questionnaire developed by the researcher is provided in the last pages of this thesis. To adhere to the confidentiality agreement with the schools concerned, the names of schools and those of learners have been left out.

The learners' questionnaire was structured in both closed-ended design and open-ended design. Both types of questions are easy to understand. The closed-ended questions involve information on the personal data of learners, the location of their schools (rural or urban), and the type of school (Model C or ordinary school). The questionnaire was structured in such a way that learners would take more or less three minutes to complete. The open-ended questions required learners to indicate

what they learnt in GIS. The learners had to explain again the uses of GIS and its importance in the technological world of today. They had to give reasons for the answers that they gave. This study also indicated whether teaching and learning GIS in an environment where computers are not available, is feasible or not. The question on the use of computers when teaching GIS was imperative.

3.5.2.2 GIS test for Grade 12 learners

The researcher gave Grade 12 learners a GIS test to test their knowledge on GIS. The test covered the GIS syllabus they did in Grades 10-12. The test assisted the researcher in deciding whether or not the learners have good GIS teachers and knowledge. The performance of the learners in the test was used as a yardstick to gauge their GIS knowledge. Learners with good GIS teachers performed better in the test than those without good and knowledgeable teachers. To gauge the knowledge level of a teacher, the performance of learners was categorized into levels. The table representing the results of the test appears in chapter four (pp.116), where analysis of results is explained. The performance of the learners in the test was used to rate the teachers' knowledge. Statistical Pearson Correlation Coefficient was used to measure teachers' knowledge measured by the performance of learners.

3.6 SAMPLING PROCESSES

Sampling can be explained as a process where a smaller group is drawn from a larger group called the population so that we can understand the characteristics of the larger group (Johnson & Christensen, 2014; Fraenkel & Wallen, 2010). One important step in the sampling process is the selection of individuals who are to participate in the research study. Fraenkel and Wallen (2010) explain that the process of selecting these individuals is sampling. For a sample to be more representative of the target group, it must resemble the population that comes from

all different characteristics such males and females, old and young, teachers and non-teachers and many more. In the context of this research study, teachers (male and females) from both rural and urban schools were sampled. Privately administered and government owned schools were sampled as well in this research study. This gives us a good picture of GIS teaching and learning in both situations. The research adopted a five-step model to describe the sampling process adopted from Cassim (2011). The model used to define the sample of teachers and learners who completed the questionnaire is described below in steps.

3.6.1 First Step: Defining and mapping out the target population of this study

The target population of this study is all the teachers and learners in the secondary schools of the Limpopo Province who are doing geography as a subject. In 2012, there were 1255 secondary schools doing geography from Grades 10-12 in Limpopo Province. Drew et al. (2008) define target population as “everyone or everything within a clearly defined group of people, events, or objects constituting the focus of a research study”. This number includes both private (independent) and public (government controlled) schools. GIS technology is part of the curriculum in the teaching and learning of geography in secondary schools. In the case of interviewing teachers, it does not mean that in each school there is one geography teacher. In some of the big schools, you find geography between Grades 10 - 12 being offered by three teachers. In this case only one teacher was interviewed.

3.6.2 Second Step: Constructing a sampling frame for this study

A sample frame is a list of all the elements in a population (Johnson & Christensen, 2014). In a single-stage sampling design, the sampling frame is simply a list of the study population (Babbie & Mouton, 2014). In the context of this study the sampling frame was all secondary schools doing geography in Grades 10 – 12 in Limpopo Province. The target group was 1 255 secondary schools. The size of the sample is that sample group which is drawn from the target group. This group needs to be representative of the target population which is the larger population. If a researcher fails to be aware that his or her sample is unrepresentative, he or she may draw

inaccurate inferences about the larger population. The population sample to be studied must accurately represent the larger population to avoid inaccurate results. The population sample in this study are teachers who teach geography between Grades 10 - 12 and learners who are doing geography in the said grades. These two samples have to be managed well when collecting data. The teachers teaching geography in a particular school were requested to administer the questionnaire for the learners in their schools.

The demographic profile of the sampling frame, regarding issues such as gender, race, age, were taken into consideration as teachers were pooled from all the schools in the province. In terms of learners they were divided according to their grades as the questionnaire states that learners who are to participate are those doing geography in the grades mentioned earlier. One problem is that some schools were not willing to participate in the research, especially the independent schools who felt that the researcher was delaying their school teaching programme when learners and teachers were to participate in the data collection process. The information related to their GIS technology understanding and their performance is important because they are unlikely to perform like the public schools because most of them lack ICT equipment. Framing sampling in this regard requires one to be very careful.

3.6.3 Third Step: Adopting a sampling technique

There are a number of different possible techniques or designs that a researcher can adopt or select when doing sampling. Fraenkel and Wallen (2010); Babbie and Mouton (2014); Johnson and Christensen (2014) outline a number of probability and non-probability sampling methods. They range from random sampling to non-random sampling, single stage to multistage methods, single-unit to cluster sampling, stratified to unstratified methods of sampling. In this research study the research involves learners who do the same subject and grade, and the same age group as well. This research study involves all schools ranging from independent schools to public schools, rural and urban schools, and Christian and Muslim schools. This research adopted a stratified, systematic sampling method. Schools were arranged in terms of homogeneity before being sampled systematically. The stratified,

systematic sampling method is explained in detail as a method employed in this study.

3.6.4 Fourth Step: Deciding on the sample size

The simplest answer when determining the size of a sample is that the larger the sample size, the better because larger samples result in smaller errors (Johnson & Christensen, 2014). Had it not been for the expenses and time incurred when collecting data one would argue that for zero sampling error, it would be good to include the whole target population for any research study. This study employed a mixed methods design, and the sampling method used is stratified systematic sampling method. The factors hereunder influenced the decided sample size when using this method.

i. When using homogenous population, the sample size can be small because the target population is composed of similar people (Johnson & Christensen, 2014). In this study 20% of the population target was sampled because the target population are teachers and learners teaching and learning Geography in Grades 10 – 12.
ii. Simple random sampling was also not chosen. The advantage of this sampling is that each member of the population has an equal chance of being chosen in the sample group. It would be time consuming to sample randomly schools that are not categorised the same in terms of their geographical setting and ownership. It is therefore important that the schools were stratified into rural and urban, private and public before sampling schools. These enabled the researcher to get authentic results from the target population.
iii. The variable also has to be stratified into learners and teachers because there are questions that are specifically directed to learners and those directed to teachers. There was a target population for learners, and that of teachers tackling questionnaire designed for teachers.
iv. Snowball sampling was avoided. Teachers, as you engage them in the questionnaire, could as well refer you to some other colleagues who, even though not teaching geography can assist in the answering of questions

related to GIS technology. This can consume time as one is forced to trace other potential respondents in this regard.

A sample size in this study varied between the number of learners and that of teachers. In a school that had 40 geography learners in Grade 12, the researcher requested 10 learners to answer the questionnaire, while only one teacher was requested to answer the questionnaire. The number of learners interviewed in a school could always be many, while the teachers were one or two depending on the size of the school. The learners were limited to 5% in every school to avoid having many questionnaires. The researcher believes that 5% of the learners doing geography at FET level in school A, was enough to represent the views of learners in that particular school. Johnson and Christensen (2014) explain that if the complete population is included in a research study, sampling error is zero. The table (Sample Sizes for various Populations of sizes 10 to 500 million) cited in Johnson and Christensen (2014:267) suggests the number of samples that should go with the size of the population. If for instance, the whole population is 100 or less, then the whole population can be used. In the context of this research, there are currently 1 255 secondary schools doing geography in Limpopo Province. Using this table will mean that a sample of about 291 schools need to be chosen to get results that will give one a zero sampling error. In practice, 58 schools were sampled in every district. The 58 were further grouped into rural and urban secondary schools that were categorised into public and private secondary schools.

3.7 SAMPLING BIAS AND SAMPLING ERROR ISSUES

Babbie and Mouton (2014) explain sampling bias as sampling selected without being the representatives of the larger populations they have been chosen from. A representative must resemble the population that it comes from on all characteristics (Johnson & Christensen, 2014). Non-random samples are usually said to be biased samples because they are systematically different from the population they claim to represent, while random samples are said to be unbiased since they tend to be representative of the population from where they come from (Johnson & Christensen, 2014). This study used stratified systematic sampling in sampling both

the teachers and learners. Only teachers and learners doing geography in Grades 10-12 in Limpopo Province were sampled. Bias was therefore minimised.

Sampling bias can be a cause of sampling error. Fraenkel and Wallen (2010) explain sampling error as an expected, chance variation in sample statistics that occurs when successive samples are selected from a population. It is unlikely that samples can be identical to their parent population. According to Johnson and Christensen (2014), sampling error is the difference between sample statistic value and the population parameter. The difference between a sample and its population and the difference is referred to as sampling error. Sampling error usually decreases the accuracy with which a sample represents the population of the research. To minimise sampling bias it is important that many members of the target population be included in the sample size. In this research many more schools and learners were sampled to minimise the sampling bias which can impact positively on the sampling error. Potentially, this was to address the sampling bias. Schools in rural and urban areas of Limpopo province were sampled and the response rate was overwhelming. The potential for sampling error was also taken care of so that one could have a large sample size that is feasible.

3.8 SUMMARY OF THE CHAPTER

This chapter indicated the methodology that was used in the investigation of the research problem in this study. The study investigated the teaching and learning of GIS in the secondary schools of Limpopo Province. The mixed methods approach used in this study is consolidated at the end of the analysis to show how the quantitative method was supplemented by the qualitative method. The aim of applying mixed methods design in this research study was sequential. The quantitative method is the dominant method in this research. The qualitative approach in this research is used to close gaps that might have been left out by the quantitative method. Interviews and open-ended questions in this research added more information that achieved some of the objectives of this research study. The chapter also indicated how the two designs will be triangulated to close gaps left by each of the designs.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS, RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter presented data collected through questionnaire, interviews and tests given to learners. The results of statistical tests undertaken in this research study was analysed and discussed in detail to clarify the relevance of the topic in the teaching and learning of GIS. The study investigates the teaching and learning of GIS technology in the secondary schools of Limpopo Province, South Africa. The research study adopted a mixed methods approach and therefore engages this approach in the analysis and interpretation of data collected. As was indicated in the previous chapter, this study approaches the analysis using a mixed methods strategy which is predominantly quantitative. Qualitative data will be analysed to corroborate the data gained from the quantitative analysis. Mixed methods data analysis involve combining, connecting and integrating both quantitative and qualitative data analysis strategies in research studies (Teddlie & Tashakkori, 2009). This research also further follows sequential mixed data analysis. Sequential mixed data analysis is the design where one approach of study is followed by another

(Johnson & Christensen, 2014). The research study first analyses quantitative data using SPSS Statistical Package Version 23 collected through questionnaire and later on analyses qualitative data collected through interviews. The data was collected from different geography teachers, who offer geography at Further Education and Training (FET) level; that are Grade 10 – Grade 12 in all five districts of Limpopo Province.

4.2 DATA PRESENTATION

Data was collected through closed-ended questionnaires (quantitative data) and open-ended interviews (qualitative data). The analysis first presented data collected quantitatively through a questionnaire that was divided into five themes from 100 secondary schools, and later the qualitative analysis of data collected through interviews from the same sample is also presented. Different type of graphs and tables are used in the presentation of the state of GIS teaching and learning in the secondary schools of Limpopo Province. The secondary schools were sampled from the five districts constituting the Limpopo Province. Twenty (20) secondary schools, in which geography is taught were randomly selected from each district. The sample included secondary schools from both rural and urban settings. The analysis of the quantitative data collected through questionnaires was analysed using the SPSS Statistical Package Version 23. Qualitative data was collected through interviews from both teachers and learners. This research study applied a mixed methods approach, and later in the analysis both quantitative and qualitative approaches are triangulated to indicate the state of the teaching and learning of GIS in Limpopo Province.

4.2.1 DISTRICTS CONSTITUTING LIMPOPO PROVINCE

Limpopo Province constitutes of five (5) political districts (Figure 4.1) where each is led by Executive District Mayor. Each district further consists of local municipalities which are led by local municipal mayors. In managing education, each district is led by District Manager who oversees few circuit managers under his/her jurisdiction. In each of these districts, (20) geography teachers from 20 schools were sampled for this research bringing to a total of 100 teachers sampled. In schools where there are

more than one geography teacher in the FET- level, only one questionnaire was issued. This was to avoid duplication of information where two teachers from the same school could end up giving the same information. Sampled schools include schools located in both rural and urban setting of Limpopo Province. The five districts are Capricorn, Mopani, Sekhukhune, Vhembe and Waterberg.

4.2.1.1 Capricorn District

Capricorn district encompasses the city of Polokwane, the capital city of the province, located at the centre of the province. Most schools in the city are well equipped and rated among the best performing schools in the province. The vast part of this district is rural with few developing urban centres found in areas such as Seshego, Lebowakgomo, Senwabarwana and Mankweng. The University of Limpopo is found in this district.

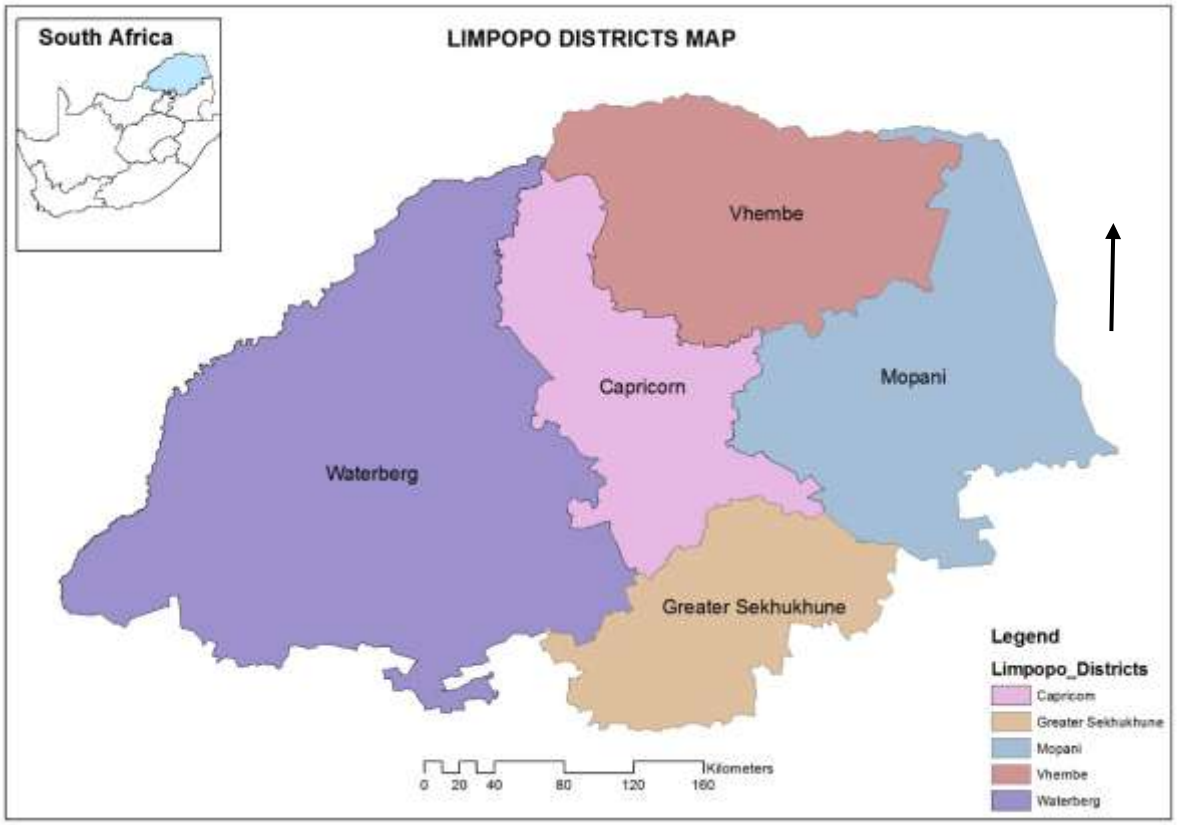

Figure 4.1: Five districts of Limpopo Province

4.2.1.2 Mopani District

This district is located on the eastern part of the province. It covers Tzaneen, Phalaborwa and Giyani which forms the nucleus of this district. These few urban centres are surrounded by abundant rural areas with secondary schools where geography is part of the curriculum. The district shares the boundary with the Kruger National Park in the east and Mpumalanga Province in the south eastern part of the district.

4.2.1.3 Greater Sekhukhune District

Greater Sekhukhune District is located to the south east of the province, sharing its boundaries with Mpumalanga Province. With few historical urban centres like Groblersdal (capital town of the district) and Burgersfort, the district is mainly rural. New urban nuclei shopping complexes have recently been developed in Apel and Jane Furse. There are many secondary schools in this area because every small area under the rule of a particular traditional leader has a secondary school. Some of the secondary schools in this district are small in terms of numbers; secondary schools with less than two hundred learners are common.

4.2.1.4 Vhembe District

This is the district located to the far north of the province, sharing its borders with Zimbabwe. District offices are located in Thohoyandou. Few urban centres in Louis Trichardt, Musina and Thohoyandou exist. Vhembe has a number of schools known for their historic good Grade 12 results over many years. The district is mainly rural and boasts of the University of Venda located in Thohoyandou. Many secondary schools do geography as one of their subjects.

4.2.1.5 Waterberg District

Waterberg district is located to the south-west of the province. It shares its borders with Gauteng Province in the south, Northwest Province in the south west and Botswana in the west. Waterberg District has urban centres like Mokopane,

Mookgopong, Modimolle and Bela-Bela. Most schools are in farms and villages and few in urban areas. The district offices are stationed in Modimolle. Geography is done in many schools in this district.

4.3 QUANTITATIVE ANALYSIS OF DATA COLLECTED

Quantitative data analysed in this chapter was collected through a closed-ended questionnaire. Details of the questionnaire were explained in the previous chapter. Below follows the explanation of the schools sampled and themes covered in the questionnaire used as a tool for collecting data for this research.

4.3.1 Schools sampled

Limpopo Province has about 1 200 secondary schools doing geography as a subject. A total population of 100 secondary schools were sampled for this research study. Table 4.1 represents number of schools sampled in each district. The schools sampled included those in rural areas and urban settings, both private and government controlled. A 46-item questionnaire (See Appendix D, Part 1) was designed as a tool to collect teachers' perception related to GIS and was taken to the teachers physically in their schools, and completed by all 100 teachers in the presence of the researcher. Electronic mail could not be used because many schools are poorly resourced in the province and do not have the necessary equipment for e-mailing and faxing. From 100 respondents only three responded through e-mail. These are the schools initially referred to as Model C schools which have better technological infrastructure in their schools.

The data was collected in an ordinal scale where answers from the respondents were prepared, on a fully anchored 5-point rating Likert type scale and was close-ended. The 5-point rating were: *strongly disagree, disagree, I do not know, agree* and *strongly agree*. Respondents indicated their preference by choosing one of the ratings. The anchored 5-point rating scale could be defined as a scale that has all the points anchored with descriptors. In anchoring, points provide references that respondents could use to direct the expression of their opinions (Johnson &

Christensen, 2014). The questions were mainly centred on the teaching and learning of GIS technology in their respective secondary schools in Limpopo Province.

Table 4.1: A district share in Limpopo Province

District	Percent (%)
Capricorn	20
Mopani	20
Sekhukhune	20
Vhembe	20
Waterberg	20
Total	**100**

Quantitative data collected was categorised into five sections, namely:

4.3.1.1 Demographic data

Data in this section entails gender, age, experience, qualifications and subjects taught by the teacher. This information is important because understanding gender and age of geography teachers in Limpopo Province enabled the researcher to understand the impact it has on the teaching and learning of GIS in secondary schools of this province. The gender of teachers is also important. Teachers teaching and learning geography are of different age bands. Teachers who trained during the nineteen eighties (1980s) and the nineteen nineties (1990s) could differ in terms of promoting the use and knowledge of Information Communication Technology (ICT) and Geographical Information Technology (GIS), as these concepts were not used then.

Teaching experience of sampled geography teachers is also important in addressing the objectives of this research study. The research study identified whether long serving teachers are available for being capacitated and skilled in GIS knowledge or not. Qualifications of teachers offering geography in secondary schools is also imperative.

4.3.1.2 Skills of teachers in GIS

This section dwells on the teachers' skills of teaching and learning of GIS in the secondary schools of Limpopo Province. The teachers' skills include basic computer skills, prior exposure to GIS before teaching geography and interest to learn GIS. The research study identified whether geography teachers are skilled enough to teach and learn GIS in secondary schools of Limpopo Province. Researchers can determine whether teachers who teach GIS in Limpopo Province possess the necessary basic skills to impart GIS in secondary schools.

4.3.1.3 Teacher's knowledge of GIS

Amongst the objectives of this research study, one is to determine the background knowledge of GIS by the geography teachers. Knowledge will among others include knowledge of GIS software, accessing free GIS software on the internet and editing of raster and vector formats in GIS. Information on this aspect indicates whether or not GIS is taught by teachers who understand it. It was argued at the beginning of this thesis that learners do not perform well in GIS. The assumption is if teachers' knowledge on GIS is poor then it will affect the performance of learners as well the results for the whole province.

4.3.1.4 Methods currently employed by teachers in the teaching and learning GIS

One of the objectives of this research was to determine the methods currently employed by geography teachers in the teaching and learning of GIS. What methods does the teacher use in teaching and learning GIS? Is the approach they are using benefiting learners? Do they have computer laboratories in their schools where they do practical part of GIS teaching and learning? Is there enough hardware and software to support GIS teaching and learning in the secondary schools of Limpopo Province? Do geography teachers expose learners to the use of instruments such as GPS when teaching GIS? Do teachers have other supporting teaching resources besides prescribed textbooks? Are the learners exposed to any form of practical

learning? The teaching and learning of GIS is new in the geography curriculum of secondary schools. GIS cannot be taught like ordinary traditional sections of geography such as climatology, geomorphology and other sections.

4.3.1.5 GIS-related infrastructure questions

Well-developed GIS infrastructure in secondary schools of Limpopo Province will have a positive influence on teaching and learning of GIS. Questions in this section involved availability of electricity in rural schools, projection screens and hardware and software that are accessible to learners in a school. Do the learners possess smart phones and tablets that could be used for teaching and learning GIS?

4.3.2 Gender and GIS technology teaching and learning in this study

A total number of 100 geography teachers from secondary schools in Limpopo Province were sampled in this research study. Figure 4.2 illustrates the gender component of the sample and number of male and female teachers teaching geography in the province. Data collected shows that there are more male teachers in Limpopo Province offering geography at the FET level than their female counterparts. Current CAPS Geography curriculum at FET level encompasses the teaching of Geographical Skills and Techniques which includes map work techniques, atlas work, Geographical Information Systems and fieldwork and other common geography sections like Climatology, Geomorphology and Human Geography. The section on Geographical Skills and Techniques, atlas work GIS and fieldwork needs little background of mathematics and computer knowledge. Some scholars show how ge
nder has impacted computer technology in terms of their usage and understanding of computers. For example, Sanders (2005) points out that the majority of studies done in the United States of America, Australia, Norway, Scotland, England, Iran and Canada show that boys have greater computer experience than girls. The author went on to say that a large number of American high school students that were sampled, belonging to both sexes, agreed that teachers, counsellors and parents believed that computers were much more appropriate for males than females. Most teachers stereotyped computing as a male domain. In countries such as Japan and

Costa Rica, teachers encouraged male students to do computer compared to their female counterparts (Sanders, 2005).

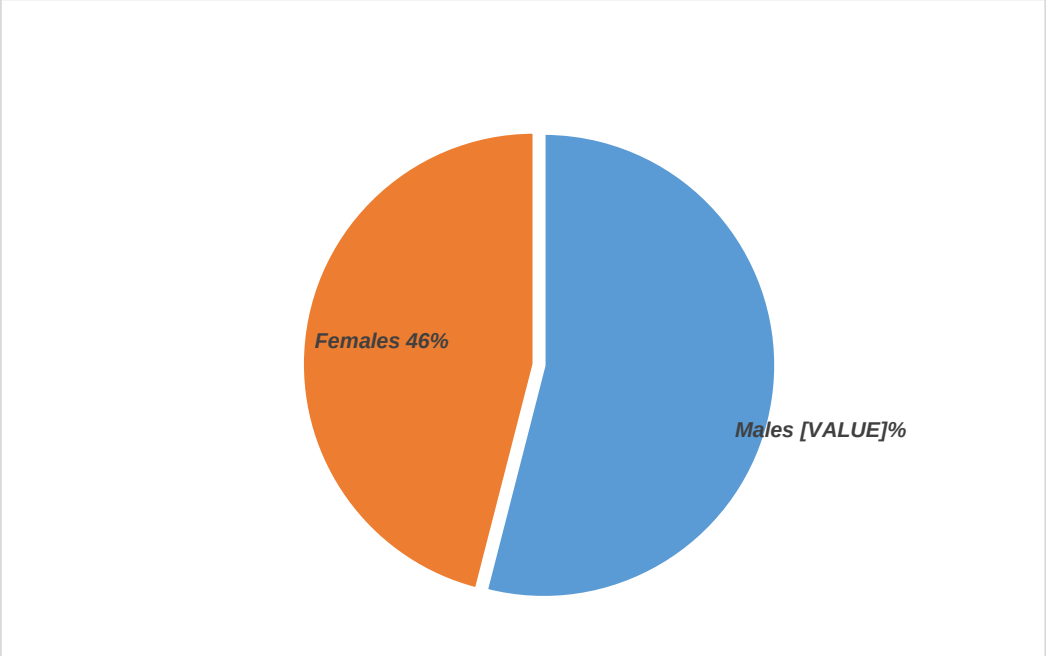

Figure 4.2: Gender of geography teachers in Limpopo Province

The survey that was conducted by Reinene and Plomp in twenty countries found that most teachers teaching computer courses were males. It further found that female computer teachers did not have confidence in their skills and knowledge (Sanders, 2006). GIS is an ICT related tool that is supported by the computer skills. From what Sanders (2006) argues, one could see how females have been disadvantaged in many fields of study all over the world. In the context of this study, it is not clear as to whether or not some of the GIS teachers currently teaching GIS were victims of these experiences cited by Sanders (2006).

Muir-Herzig (2004) and Saba (2009) cited in the literature of this research, indicate that many research studies found that when students are taught through technology they tend to develop better attitude towards learning. This research does not dwell too much with the discrimination of GIS. The researcher can only emphasise that there are an increasing number of women occupying many high positions in the field of technology. In GIS, there are women lecturers in different institutions of higher

learning teaching GIS. In the schools of Limpopo, if given training and exposure to GIS, with enough equipment, women are equally capable of teaching GIS.

4.3.3 Age-band of geography teachers in Limpopo Province

The distribution of age groups amongst geography teachers sampled in this research in the Limpopo Province, shows that 82% of the teachers teaching geography are above 40 years old of age, with only 18% of geography teachers who are less than 40 years of age. GIS is a technological tool, which needs teachers who are computer literate. Figure 4.3 (below), indicates distribution of geography teachers in the Limpopo Province according to their age-band. Many geography teachers in the Limpopo Province seem not to be computer-savvy and are unfamiliar with the related technology that is basic to GIS. As indicated in the previous chapters, GIS technology was introduced in secondary schools of South Africa in 2006. Many teachers that teach geography today were already teaching at that time and did not have any background knowledge of computers. The teachers were long qualified and understood the old curriculum. After GIS was introduced they omitted the section on GIS when teaching because they were unfamiliar with it. These are teachers who received their teacher training as geography teachers during the early nineteen nineties. Taking this factor into consideration, it is implied that teachers who completed their teacher training around the nineteen nineties were not exposed to GIS because it was not part of the curriculum. Teachers were teaching ordinary sections of geography such as Map work, Settlement Geography, Population Geography, Climatology and Geomorphology that did not need prior training and knowledge of computers.

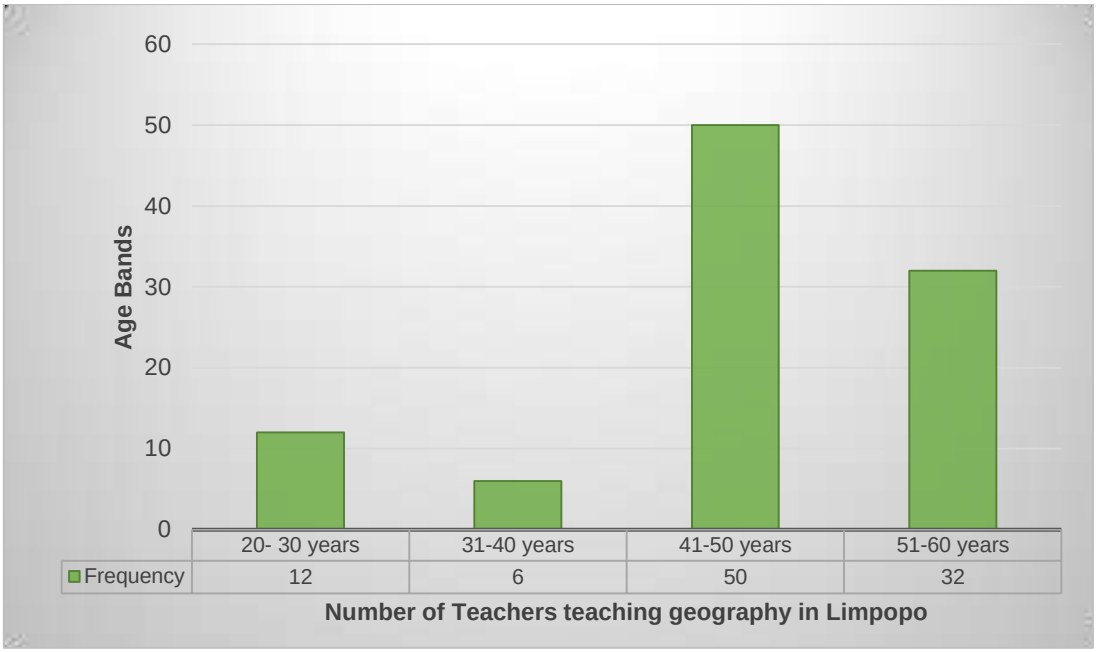

Figure 4.3: Age-band of teachers teaching geography in Limpopo Province.

Figure 4.3 further indicates that Geography teachers who are between age groups 20 and 30 years and 31 and 40 years are few, to be specific they constitute only 18% of the sampled population. These are age groups who heard about GIS while they were still training as teachers. From the research questionnaire, there are teachers in these age groups who indicated that they were exposed to GIS before joining the teaching profession. The Department of Education has a base of some teachers with GIS knowledge from which it can start because a number of these young teachers had the advantage of being were exposed to GIS previously. Amongst these teachers, there are those who did geography while studying for their undergraduate degree and were exposed to the technology at the time. These teachers registered geography as one of their majors during undergraduate studies and did GIS as one of their courses. By the time they were doing Postgraduate Certificate in Education (PGCE) they already had knowledge of GIS. These are teachers who currently play an influential role in the teaching and learning of GIS in secondary schools. The knowledge they have adds more value in the geography classroom than a teacher who was never exposed to GIS before. These teachers also understand the application of GIS software such as *ArcView* because they used it while studying GIS as one of their modules. The main challenge in schools is lack of teaching resources which hinder the smooth execution of good GIS lessons. Teaching GIS does not necessarily need a computer programmer but only a person

who understands the application of software. Furthermore, teachers in these groups are young and still eager to learn more on technology application and are not 'technologically-shy'. The future of teaching and learning GIS in secondary schools lies in investing in the young teachers who will continue with the GIS technology. These teachers do not have many problems with GIS except that their schools do not have supporting resources.

The data collected showed that most of these young teachers are available for further short term training in GIS through workshops and other extra training that could be provided. Training and providing workshops for teachers who show interest in learning GIS can be an advantage because from the information collected many geography teachers indicated that they were available for GIS training. With the basic computer skills which some of these young teachers possess, it would be easy for them to understand hardware and software related to GIS. Literature indicates that while the strategies of teaching GIS could be a challenge to any new teacher, organising good lessons and practical assessment is important (Baker, 2005). Data indicate that even teachers who had exposure to this software before teaching still face a challenge when organising GIS lessons. It is therefore important that GIS teachers in Limpopo be allotted time every academic year for short training on the presentation and organisation of GIS lessons.

GIS software are upgraded almost annually. It is important that the little infrastructure available in some schools be utilised to help other schools that are not well equipped. GIS teachers who are young in the field and have smart phones, can also explore some of the GIS software available for free on their cell phones. Some learners have similar phones and teachers can show learners some of the important features of GIS.

4.3.4 Available GIS infrastructure in secondary schools of Limpopo Province

Data collected indicate that most secondary schools in Limpopo Province do not have GIS hardware and software. The teaching and learning of GIS in secondary schools in the Limpopo Province remains theoretical. GIS teachers cannot develop a convenient method of teaching and learning GIS if necessary resources are not in

place. Almost 95% of geography teachers indicate that they teach GIS theoretically, because of lack of hardware and software. It is very important that learners get time to do the practical part of GIS on their own on hardware using relevant software available. The teaching and learning of GIS requires hardware and software because this technology is basically digital. Hardware that is available in many secondary schools of Limpopo is for administrative purposes, where a computer is only used by the school principal, his deputy and heads of departments. The hardware and software for GIS teaching and learning is not available and accessible to learners in secondary schools.

The theoretical framework of this research study is constructivism. Garbett (2011) explains that constructivism emphasises "the importance of the knowledge, beliefs and skills that an individual brings to the experience of learning". Teachers must design opportunities, activities, tools and environments for learning (Murphy, 1997). The geography teachers should create a favourable environment for teaching and learning GIS technology by providing the resources needed to teach GIS.

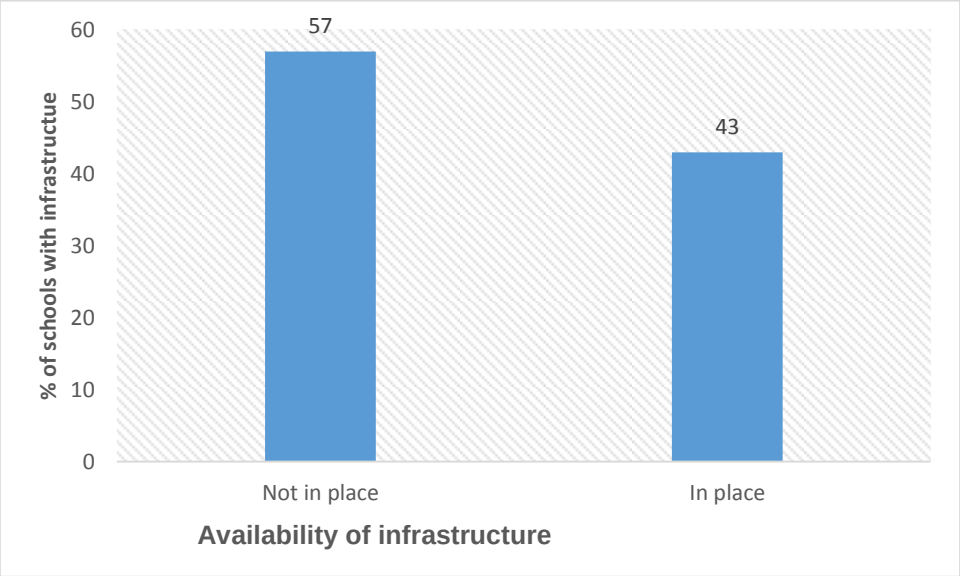

Figure 4.4: GIS infrastructure in the secondary schools of Limpopo

Constructivism dictates that teaching tools should be available to give learners the opportunity to apply their knowledge, their beliefs and their skills. Learners cannot construct maps without 'relevant tools' and 'conducive learning environment'. Relevant tools in this context refer to both hardware and software, while a conducive learning environment is a computer laboratory room. Without hardware and software it is impossible for a learner to construct a geographical product. Computer

laboratories are also important to support a situation conducive to teaching and learning GIS. For constructivism to succeed in teaching, all the necessary resources must be provided. In Limpopo Province, because most of the secondary schools do not have well-developed infrastructure for teaching GIS, learners continue to perform poorly in this technology (Figure 4.4). This seems to be one of the major barriers that if attended, could rescue the situation which most schools find themselves in.

The availability of GIS-related infrastructure could also assist in internet-based GIS mapping in support of GIS teaching and learning classes. Internet-based GIS maps are free to access only if you have the necessary infrastructure. Poorly resourced schools in the rural Limpopo Province could connect to the internet through 3-G and other means provided by different cell phone service providers in the country. Hardware and software need huge financial backing from government to invest in because of the significant role they play in GIS teaching and learning.

4.3.5 Lack of funds to support GIS development in secondary schools

One of the deterrents of GIS implementation in schools is lack of funds. Both hardware and software need substantial amount of funds that need to be invested on GIS infrastructure development in Limpopo. From the available data collected, lack of funds impacts negatively on the growth of GIS in secondary schools of Limpopo Province. Literature indicates that governments in Hong Kong, Singapore, South Korea and Taiwan (Lam et al., 2009) invested huge public money in providing their secondary schools with the necessary hardware and that has improved connectivity in schools as well. As a result of this move, the teaching and learning of GIS in these countries is taking a positive direction. Huynh et al. (2012) also cited conditions of GIS in the secondary schools of Canada. They identified funding as one of the main challenges faced by the educational authorities regarding purchasing of computers to equip secondary schools, where in the Province of Ontario alone 1 500 units were needed and the Department of Education could not afford to purchase them. This resulted in the failure of the whole process of implementing the idea of teaching and learning of GIS in Canada. Introducing GIS in their secondary schools has become a futile exercise that would not bear any fruits for the learners and teachers. Development of laboratory computer rooms is also necessary. When building

developments are planned, computer laboratories could be added in the building plans for schools. The laboratory computer rooms could also be used to teach learners other computer skills necessary for their general development. Funds should be made available to improve the situation. Schools that have surplus classrooms could convert some of the classrooms that are not in use into a computer laboratory.

The basic GIS software like Arc GIS is powerful and the most advanced software that could be used in schools. A site licence for software like Arc GIS could cost around US$700 (ZAR10150). Secondary schools in Limpopo Province cannot afford this amount. Private schools sampled also cannot afford this expensive software. Within the geography fraternity in general, there is a shortage of educational software, not only in GIS, but geography IT as a whole (Lam et al., 2009). Lam et al. (2009) go on to highlight that teachers in schools are too busy to get time to develop their own teaching software. If teachers were able to develop their own teaching and learning software, perhaps the price of software could be affordable and user friendly. Developing software locally is also limited by the technical complexity of GIS. Without good IT background knowledge, it is not easy for GIS teachers to develop teaching and learning software.

4.3.6 Teachers' development and the innovation in the curriculum

Teachers are an important key towards the implementation of curriculum changes. From the data collected, teachers seem to contribute towards the slow diffusion of GIS in Limpopo Province. When curriculum changes, the people to implement and effect changes are teachers. Commitment of teachers, their responses to curriculum changes are influenced by many factors such as attitudes, competencies in the subject and emotional weakness (Hargreaves, 2005). GIS is a new topic altogether in geography curriculum in South African education. Teachers who are nearing retirement and those with negative attitudes towards technology will be slow on the implementation of GIS. When interviewed, some teachers indicated that learning computer skills to them was like going back to school again, something that they are not prepared to do. They feel GIS is for the new generation of teachers who enjoy the use and application of this technology. The attitude of such teachers in particular,

retards the progress of the implementation of teaching and learning GIS in secondary schools.

The age band of teachers participating in this questionnaire indicates that 32% of them are above 51 years as represented in Figure 3. In terms of government standard regulations of the Department of Basic Education, teachers retire between 60 and 65 years. If a teacher is 56 years old, s/he might not be interested in pursuing training in GIS like young teachers who are still in their late twenties. The young teachers will be more interested as they still have a long way to contribute in the teaching and learning of geography. The argument here is that geography teachers who are already above 55 years, seem not to show interest in being trained in GIS. They continue to teach other sections of the geography curriculum but leave out the section on GIS because they do not know it. Learners in such schools continue to underperform and be disadvantaged in the section on GIS and end up passing Grade 12 without any knowledge and understanding of GIS. The learners who are supposed to have studied the GIS basics are deprived such opportunity due to teachers who are not knowledgeable in GIS.

4.3.7 The response of teachers to change and teachers' training in GIS

Another important aspect in the introduction of GIS is change amongst teachers from the old curriculum that did not include GIS technology to the new curriculum that includes GIS technology. Not all teachers accommodate change easily. GIS is a new technology which geography teachers should accept and teach because it is part of the current geography curriculum in the FET- level. Personal factors like beliefs, career goals, commitment and values may obstruct teachers from adapting to change (Stone-Johnson, 2016). Figure 4.5 represents the experience of teachers sampled in this project. Experienced teachers in geography teaching seem to resist change more than new geography teachers. From the data collected, geography teachers with more than 30 years teaching experience are not keen to go for short-term GIS training and workshops. The reason could be that they are not conversant with the use of computers and therefore shy from the GIS technology. Some of them feel that they are about to retire and it therefore not necessary for them to be trained on GIS technology. Some of them resist change due to other personal reasons. In

the teaching and learning of GIS, teachers who feel that they have been teaching for a long time will always feel frustrated when a new operation of doing things is introduced. Resistance will always be there from conservative teachers and most of them even opt for retirement if new methods and technicalities of doing things are introduced.

According to data collected in Limpopo Province, there are about 37% of geography teachers with less than 10 years teaching experience. Many of these teachers are the ones who indicated that they were exposed to GIS before they started teaching. In many universities GIS is offered as part of the geography module, therefore teachers who graduated some years ago, have little knowledge of GIS technology. These young teachers are mostly the ones who are prepared for change and learn more about GIS technology. They feel that knowing GIS may expose them to other job opportunities outside teaching and at the same put them on the same level with some of their teaching peers teaching geography in other provinces.

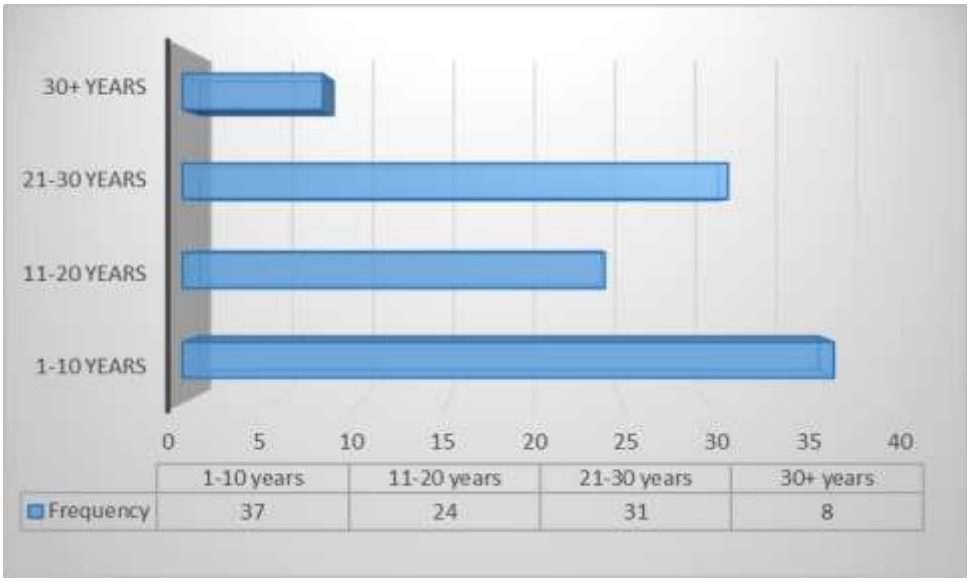

Figure 4.5: Geography teachers' experience in Limpopo Province

Figure 4.5 shows the experience of teachers teaching geography in Limpopo Province. The statistics show that there is a reasonable number of teachers who could be trained with teaching and learning of GIS technology. About 61% of teachers who have less than 20 year's geography teaching experience in Limpopo Province (24% of those of between 11-20 years added to 37% of those between 1-

10 years of teaching), are the ones which the Department of Basic Education in the province could invest in because they are young and presumably have many more years to teach geography in the secondary schools. The current state of affairs indicates that many learners will continue missing out on GIS because their teachers cannot teach it. Teachers who have been teaching for a long time and are close to retirement might not be interested in the training as indicated previously in this chapter. In the interim, the delays can result in poor performance of learners in secondary schools. The number of teachers who cannot teach GIS is still high and has to be addressed. Robust GIS training for teachers should be undertaken by the Department of Basic Education.

4.3.8 Valuing the importance of GIS by the teachers

According to Fullan (1993), teachers should be skilled in developing and applying knowledge of curriculum, instruction, principles of learning and evaluation needed to implement and monitor effective programs for all learners. Geography teachers must first value the importance of GIS, so that they can give themselves time to learn it to be skilled in its application. Many teachers in Limpopo Province cannot teach GIS and it is therefore impossible for these teachers to give themselves time to learn GIS. Geography teachers must first be exposed to the importance of GIS in general so that they can value it and develop an interest in knowing and understanding it. Lam et al. (2009) indicate three different perspectives from which the importance of GIS can be perceived:

- Its importance in the teaching and learning of geography;
- Its value in geography, and
- Its importance in the assessment in geography.

If geography teachers know the value of GIS and its importance in the teaching and learning of geography, they most probably will have the courage to study it; and this can change their views and perceptions towards the teaching and learning of GIS. It can enhance the passion towards teaching and learning of GIS. From the questionnaire conducted, many teachers believe GIS is a valuable tool that enables learners to learn about spatial relationships. The fact that geography teachers value

GIS means that they can give themselves time to be trained on GIS knowledge. Young teachers believe that the knowledge of GIS can open up other job opportunities in other sectors of the economy. They believe teaching GIS as technology in geography could give them opportunities of getting other jobs outside the teaching fraternity. One learner responded in the interview: “my father encouraged me to do geography and maths so that I can choose a GIS career when I go to a tertiary institution”.

Teachers also feel that GIS is a skill that is characteristic of geography as a discipline and should therefore be taught in schools. Incorporating GIS in the secondary school geography curriculum could elevate the academic status of geography as a subject of technology. If secondary schools in Limpopo could be equipped with the necessary GIS hardware and software they could elevate the learners’ interest in learning geography. Using Google Earth, which is one of the Open source GIS software, could assist geography learners in seeing some many places around the world that they could never get the chance to visit. This is made possible because of the GIS software used in the plotting the maps of such areas. For instance, learners could see transport network of Durban in KwaZulu-Natal on the hardware through the use of Google Earth. They could google out the map of the area in which their school is located together with the neighbourhood. These could increase their knowledge of places and make their learning interesting and meaningful. Learners’ understanding of GIS can improve and give better meaning to GIS. Making a comparison of Google Earth and an ordinary atlas, GIS Google Earth would give more a meaningful setup than an ordinary atlas. Therefore, the learners’ interest on the study of GIS can increase. One responded that “I refer my learners to use Google Earth and to check the daily weather on their cell phones and that gives them a little understanding of GIS”. From the questionnaire conducted it is the feeling of many geography teachers in Limpopo Province that GIS in secondary schools should be encouraged. Smart phones which most learners possess, have many of these open source GIS that learners could access.

4.3.9 The relationship between GIS knowledge of teachers and performance of learners

To determine the relationship between GIS knowledge of teachers and performance of learners in GIS, the Pearson's correlation coefficient was used. Correlation is a measure of the strength and direction of association that exists between two variables measured on at least an interval scale. A correlation that is -1,0 is negative while +1,0 is positive. The correlation coefficient only measures the linear relationship and determines the degree to which the two variables are related (Garren:1998). In the context of this research study, the variables are GIS knowledge of teachers and the performance of learners in the GIS test.

4.3.9.1 Explaining correlation in this research study

One other objective of this research was to determine the relationship between the background knowledge of GIS by the teachers and the performance of learners in GIS. To determine this objective, sixty learners in five different secondary schools of Capricorn District were given a GIS test to write. The test was managed in different times in their respective schools and was written by Grade 12 learners testing the basic theoretical knowledge of GIS (See Appendix E). The assumption was that a Grade 12 Geography learner who had a knowledgeable GIS teacher from Grade 10, could answer the questions very well without any problems. The GIS knowledge that a Grade 12 learner accumulated on GIS from Grade 10 allows him/her to answer all the questions well. The researcher requested the geography teachers to select twelve Grade 12 geography learners in their school to write and the researcher administered the test together with the teacher. The selection was randomly made by the teacher without looking at the performance of learners. It was a multiple choice test of twenty minutes with ten questions. A multiple answer sheet was provided and the learner had to circle the answer he/she believed is correct using a pencil.

In the questionnaire, there were questions in Section C (See Appendix C) that evaluated the knowledge of GIS by the geography teachers sampled. These questions requested the teachers to respond on whether they could edit points, lines

and polygon features using GIS software or not. The response of teachers based on that selected question to test knowledge was rated according to performance levels as illustrated in Table 4.2.

Table 4.2: Teachers' knowledge rated using performance levels

Knowledge rating (performance Levels)	**Description**
1	Poor knowledge of GIS
2	Satisfactory knowledge of GIS
3	Average knowledge of GIS
4	Good knowledge of GIS
5	Outstanding knowledge of GIS

Using learner's average performance of the test given and the teacher's knowledge of GIS, Pearson's regression was calculated using both Microsoft excel and SPSS statistical software package. The computations yielded the results below.

The analysis of the relationship between GIS knowledge of teachers and performance of learners was performed using the statistically significant Pearson's correlation coefficients (r).

H_0: There is no relationship between teachers GIS knowledge and performance of learners.

H_1: There is a relationship between GIS knowledge and performance of learners.
$\alpha = 0.05$.

Table 4.3: Pearson's correlation between GIS knowledge of teachers and performance of learners

Pearson Correlation Coefficients, N = 60		
Prob > |r| under H0: Rho=0		
		Average learners Performance
Teachers GIS knowledge rating (Level)	R	0.244116823
	P	<.0001
	R^2	0.059

The results in figure Table 4.3 shows that there is no correlation between the performance of learners and the knowledge of teachers. The correlation coefficient yielded, R^2 = 0.059. The result indicate that there is no correlation between the average performance of learners in GIS and teachers knowledge of GIS. This shows that learners' performance on GIS does not necessarily rely solely on teacher's knowledge, in other words teachers knowledge is not a good predictor of student performance in this study. This is because a geography teacher can have good knowledge of GIS but can be limited by lack of the necessary equipment such as hardware and software. In this case the knowledge of the teacher is limited by lack of resources. A former Model C teacher in Mopani District who has equipment for teaching GIS, confirmed that his learners always do better in the GIS section than schools in the township and rural villages. He attributes this achievement to the GIS equipment he has in his school. To support the latter statement, Innes (2012:103) indicated that "lack of access to the necessary hardware and software required to teach GIS effectively", limits its deliverance in secondary schools of South Africa.

Figure 4.6 represents the relationship between the two variables: average learner's performance in GIS and the knowledge of teachers. The knowledge of teachers was rated in numbers rated from 1 to 5 where one is poor knowledge while 5 represents the best knowledge. From the line indicating the average performance of learners, one could read that instead of the line rising up with knowledge of teachers it does not follow that pattern. From level 1 to 2 it shows performance average of learners at 63% going up to 68% where the teacher's knowledge is at point 2, but immediately thereafter it drops to 57%, hence the rating of the teacher is at level 3. This indicates a weak relationship between the two variables.

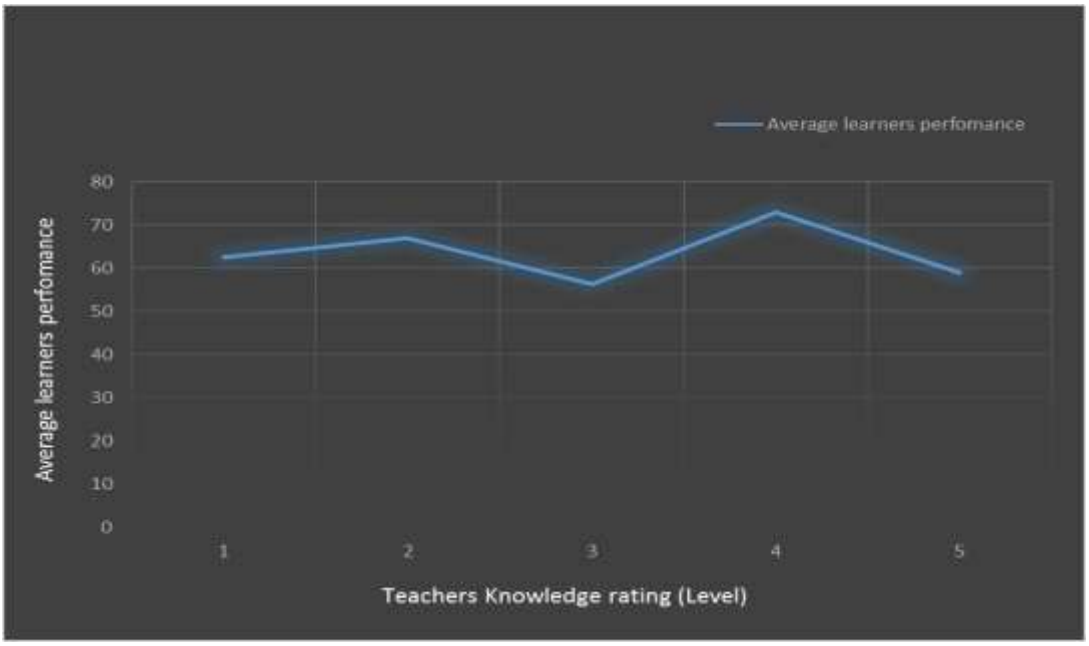

Figure 4.6: Average performance of learners on GIS test and GIS knowledge of teachers

The performance of learners does not correspond well with the knowledge of GIS. The fourth respondent indicates an average of 73%, which tell us that the learners' understanding of GIS is high and again at the 5th rating the performance of the learners drops to around 58%. The normal pattern of relationship in this context should have been that the knowledge of teachers should grow constantly with the average performance of learners. This would imply that when the knowledge of the geography teacher in GIS is rated high, one would expect learners to perform well in GIS. The practical norm would be that good performers of GIS learners will be expected in schools where the teacher is more knowledgeable in GIS rating 5 on the rating scale, than the one who is not knowledgeable, rating 1 on the scale. The school rated 4 on the collected data is a semi-urban school, while school 5 is an urban school popularly known as former Model C School. It is surprising that school such as 4 can perform better than school 5, while the expectations were that school 5 would perform better than school 4 because it is well structured and equipped with moderate GIS infrastructure . This is the school one could expect to have an average of more than 80% performance because their learners are mostly from middle class families. They have computers in their homes, have smart phones, are urbanites and are exposed to many more technological entities than learners in rural schools.

Good and modern structures of a school does not imply that the school will produce good results in GIS. The situation of the school seems not to have influence on the performance of learners in GIS. Knowledgeable teachers in GIS does not imply that their learners will perform well in GIS. In teaching and learning of GIS available equipment plays key a role in making learners understand it. Learners must be given activities to do by themselves on the hardware that has relevant software. As indicated earlier in this research study, a constructivist theoretical framework best suits teaching and learning of GIS. Through activities given to learners they can learn on their own through the guidance and supervision of the teacher and produce an end-product of their own making. Matoti and Lekhu (2008), argue that constructivism is a "learning process of constructing meaning derived from the learner's action in the world or a process of knowledge construction."

4.3.10 Subjects geography teachers have done during teacher training

Geography teachers in Limpopo Province went through different teacher training institutions to qualify as teachers. Data collected indicate that there are those who did post-matric teacher's diploma, those who did four years Bachelor of Education degree and the last group that did a post graduate teacher's diploma. Many teachers in this research have Bachelor's degree that was done jointly with a teacher's diploma. There are some who did a teacher's diploma first and later pursued their Bachelor's degree studies with local universities; either on full time basis or part time with institutions like University of South Africa (UNISA). The combination of their major teaching subjects, which most of these teachers did while doing teacher training, is of concern. Geography is classified as both a social science and science subject. In many tertiary institutions, a prerequisite for registering a Bachelor's degree with geography as major, requires Grade 12 Mathematics Level 4 (UL School of Agricultural and Environmental Sciences Calendar, 2016). The study of GIS requires a background of mathematics from a tertiary institution. The combination of geography with science subjects makes it convenient for teachers to develop an interest in GIS. Teachers that have done mathematics cope well with GIS than those who did not attempt it.

Most teachers sampled in the questionnaire have combined geography with either English or Sepedi, which are languages as their major teaching subjects. Figure 4.7 indicates other subjects which geography teachers have done while training as teachers. The percentage of geography teachers who studied geography and languages is higher than teachers who have combined it with mathematics. There are some teachers that have studied it with History, as both are grouped as social sciences in terms of the secondary school curriculum. Only a small number of geography teachers in Limpopo have a combination of mathematics and geography. Learners would continue to underperform in GIS because their teachers are more in languages than in science. This research study does not undermine languages but argues for the importance of combining subjects that have some links in terms of interests. The combination of the Bachelor of Education programme in the School of Education of the University of Limpopo also does not have a combination of Geography and Mathematics/Physical Science/Life Sciences/Technology. In the Department of Geography and Environmental Studies, at the University of Limpopo, it is a prerequisite that students who register for their GIS programme should have passed Grade 12 mathematics. GIS is a technological field of study which needs support of subjects with a science background.

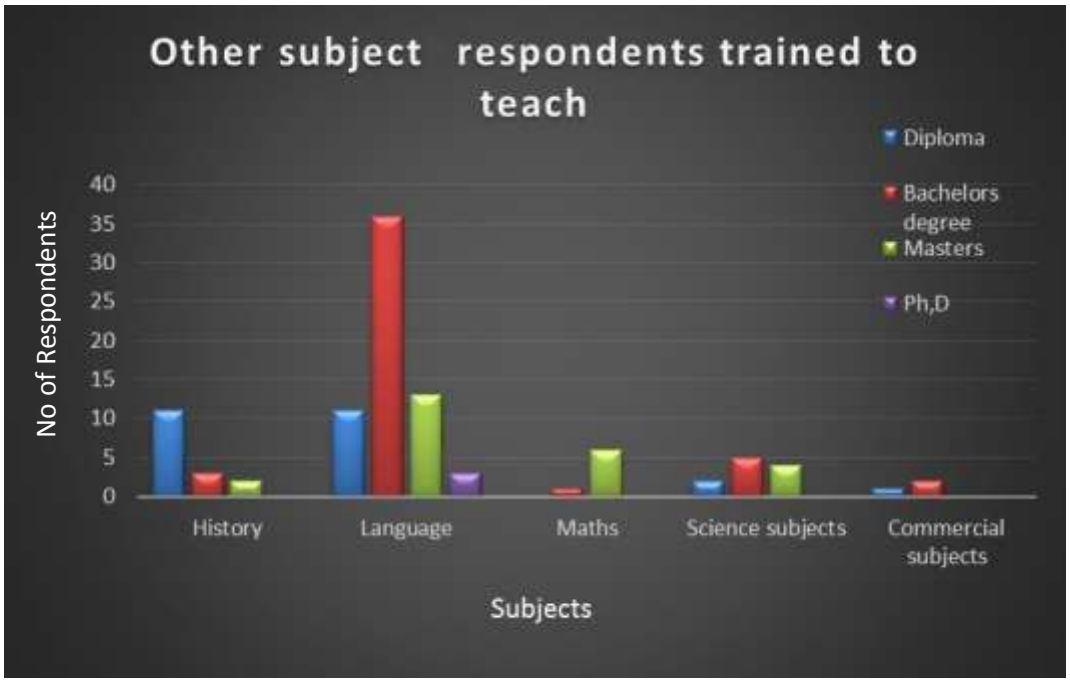

Figure 4.7: Qualifications of geography teachers and other subjects which they have trained in.

Sections of Human Geography like Settlement, Population, Political and Economic Geography may not warrant mathematics when studying them, but GIS technology can be used as a tool to solve some problems related to all these sections. If for example, one wants to represent population distribution of South Africa on a map, GIS knowledge is required. In order to produce a quality map, GIS background and knowledge is necessary. A database needs to be built on all population characteristics related to South Africa which shows all the nine provinces separated, and one joint map indicating the distribution of population in all the provinces. Representing economically provinces in South Africa on a map is also part of GIS knowledge. Showing different functional zones in a particular settlement area will require GIS application. The argument here is that, in essence, GIS knowledge is a prerequisite in all geography disciplines. People who wants to teach and learn geography should have done mathematics up to Grade 12 as one of the subjects. Students who did mathematics, and are interested in pursuing a teaching career in geography will find it convenient when teaching and learning GIS. The interest of teaching and learning GIS-related content will in many cases, likely develop among teachers who specialized in mathematics than those who have done languages. The data collected for this research indicates that most teachers in Limpopo did geography and language as teaching subjects. The combination of Geography and languages does not encourage teachers with poor technological background to opt for voluntary personal upgrading in GIS. Most of them perceive GIS as being 'another animal' that is going to take them back to school where they will have to learn everything from again.

4.3.11 Teaching experience vis-à-vis displaying variety of vector and raster formats

The fundamentals of GIS at the Grades 10 – 12 levels are centred on the understanding of how vector and raster formats are stored. Data collected shows that geography teachers with more experience and those with little experience in the profession, have different knowledge in displaying a variety of vector and raster formats. Figure 8 indicates that teachers with less teaching experience know how vector and raster formats can be displayed in GIS. These are young teachers who happened to get exposure to GIS while studying for their undergraduate degrees.

Because they were exposed to this technology, they seem to understand vector and raster formats. With relevant software, they can also display them on hardware. Another reason may be that some of the teachers currently graduating from different universities learnt GIS when they were in Grade 12. They are already familiar with the terms, vector and raster formats. Most teachers who had long service of teaching ranging from more than ten years and upwards could not display vector formats on a computer, even with the available software. Young teachers can do the displays of these vector formats.

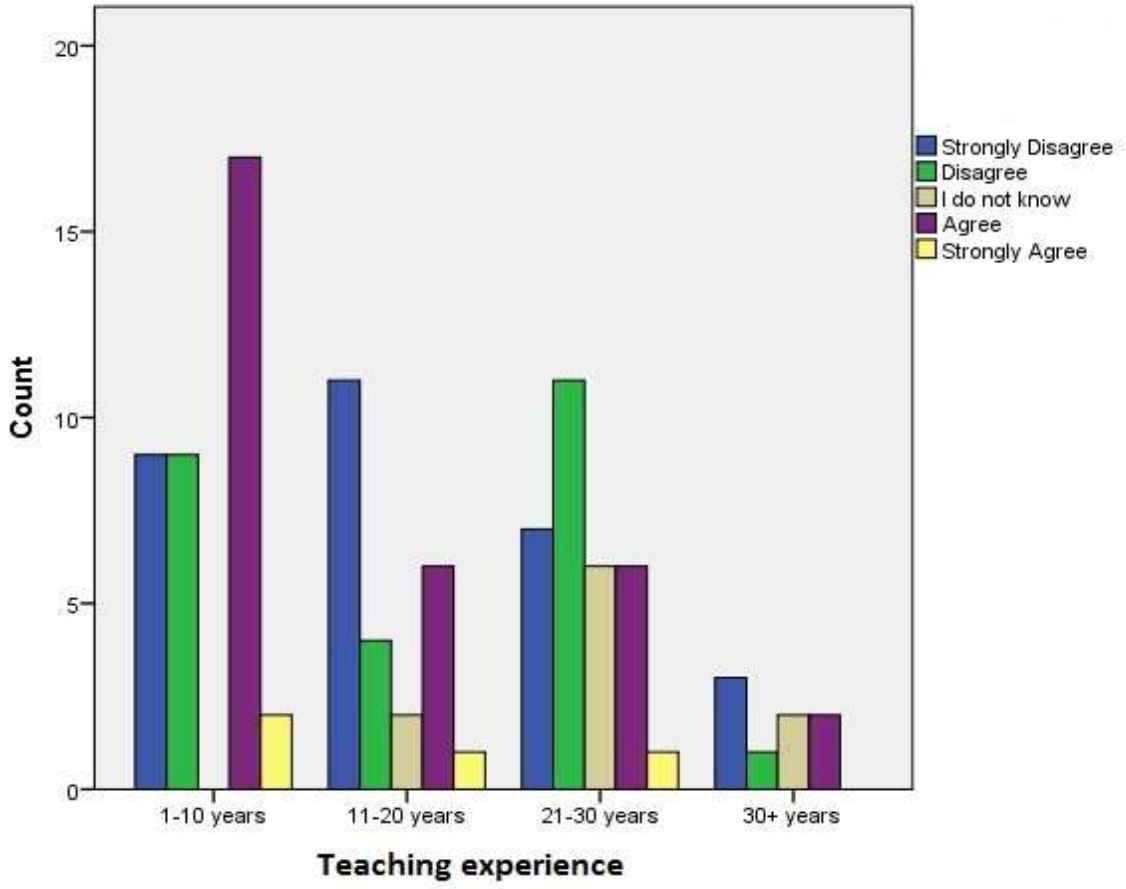

Figure 8: Teachers who can display vector formats using GIS

For the general questions on GIS, most of the respondents indicated they find it difficult to teach and learn GIS but contradict themselves by saying that they enjoy teaching the section on GIS. This is an indication that some geography teachers wish to understand GIS so that they can deliver it without problems. Furthermore, most teachers responded that they are prepared to work with GIS. It rests upon the Department of Basic Education to take some serious steps to capacitate them with

the necessary GIS knowledge that they could employ to teach GIS in the secondary schools of Limpopo. Willingness to know more about GIS teaching and learning prevails among geography teachers. The department needs to give support to teachers to improve their knowledge and skills to teach GIS.

From the teachers sampled, there were a few teachers with more than 30 years teaching experience who indicated that they can display vector formats. Perhaps these teachers may have achieved this through personal experiences they received from colleagues or from doing GIS diploma on their own, these need to be investigated further through qualitative investigation. Possibilities of having computer gurus within the teaching fraternity is also a possibility. In general, most geography teachers cannot teach and learn vector formats practically, they only know the theoretical explanation. The possibility of teachers in Limpopo Province continuing to avoid teaching GIS section is still a challenge, which needs to be addressed.

4.3.12 Coefficient Alpha – Measuring the consistency and reliability of the questionnaire

The measurement of internal consistency of the questionnaire is referred to as coefficient alpha. Cronbach alpha developed by Lee Cronbach in 1951, was used to measure the consistency, validity and reliability of the questionnaire used in collecting the quantitative data of this research. When evaluating the measurement instrument used in this research study, validity and reliability are fundamental (Tavakol & Dennick, 2011).

Internal consistency describes the extent to which all items in a test measure the same concept and hence is connected to the inter-relatedness of the items within the test. In this research, the concept measured is the teaching and learning of GIS in the secondary schools of Limpopo province. The items under different themes of the questionnaire were directly related to the topic. The number of test items interrelatedness and dimensionality affect the value of alpha. The acceptable values of alpha ranges from 0.70 to 0.95 (Tavakol & Dennick, 2011).

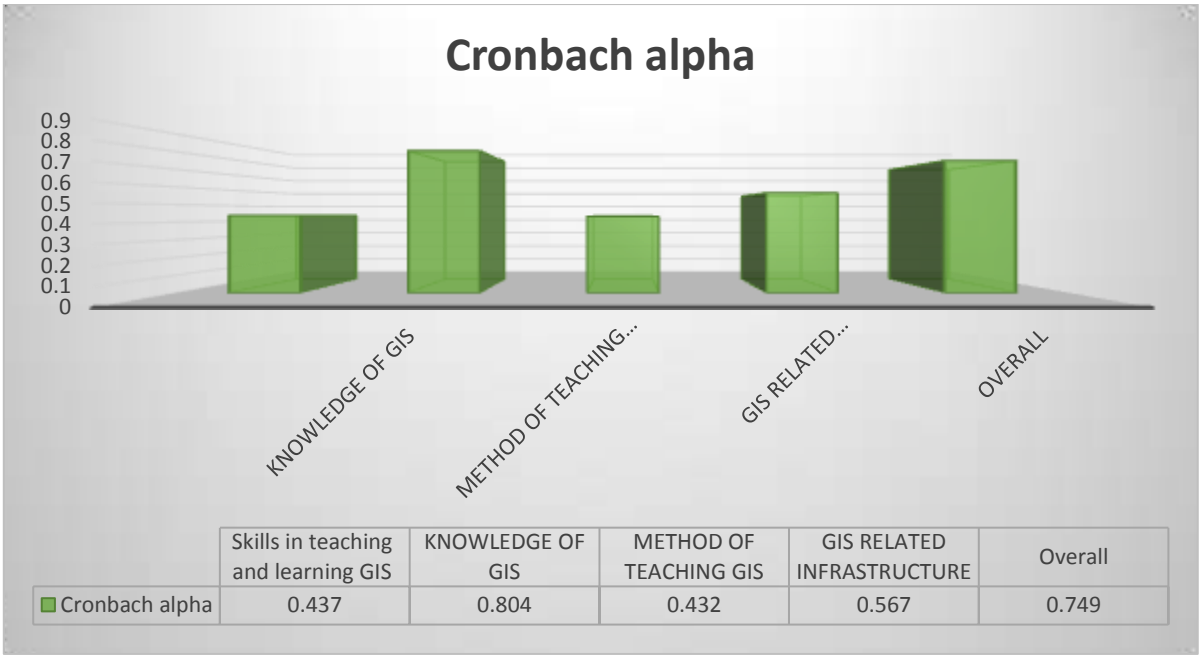

Figure 4.9: Measuring validity of the questionnaire using Cronbach Alpha

The questionnaire used in the collection of this research was categorised into five themes, namely personal data of teachers sampled, their skills in the teaching of GIS, their knowledge of GIS, methods they use in teaching GIS and the GIS related infrastructure available in their schools. The questionnaire in this research used a Likert Scale of five ratings, a multiple-item rating scale. Multiple rating scales provide more reliable scores than single-item rating scales. Figure 4.9 above illustrates the Cronbach alpha statistical results for each theme and the overall value thereof. The overall Cronbach alpha of the questionnaire is 0.75 which makes the questionnaire used in this research to be valid and reliable. The individual alpha value of each of the themes was not considered, it is only the overall value that was considered because the validity and reliability of the whole questionnaire was under examination. Validity mean the extent to which an instrument measures what is intended to measure and reliability mainly looks into the ability of an instrument to measure consistently (Tavakol & Dennick, 2011). A research tool or instrument used in collecting data cannot be valid if is not reliable.

4.4 QUALITATIVE ANALYSIS OF THE DATA COLLECTED: FINDINGS

In the research methodology chapter of this study, it was outlined that the study followed a mixed methods approach where the quantitative approach and qualitative approach were used to understand the methods employed by the geography teachers when teaching and learning GIS. Documents in the form of an open-ended questionnaire was used as tool to collect qualitative data (See Appendix C, Part 2). It was supported by structured and semi-structured interviews where selected geography teachers were interviewed on questions related to GIS teaching and learning. Grade 12 end-of-the-year geography examination reports from the Department of Basic Education in Limpopo, compiled by the examiners, were also used as documents collected. Observations on geography focus groups in Mankweng Circuit and geography learners in GIS discussions in schools, field notes, informal and formal interviews were used in the collection of qualitative data in this research study.

Interim analysis was also used in this research study "because qualitative researchers usually collect data over an extended time period and continually need to learn more about what they are studying during this time frame" (Johnson & Christensen, 2014:58). Interim analysis can be defined as a recurring way of collecting and analysing data, collecting additional data and analysing it as well, during a single research study (Johnson & Christensen, 2014). In this study, qualitative data was applied several times as an interim analysis. The questionnaire was composed of two parts where part one was quantitative and part two qualitative. Part two had five questions that were of open-ended type (qualitative questions). Data on open-ended questions were also collected from 100 (hundred) teachers sampled in the study.

When collecting the qualitative data, teachers were visited individually in their respective schools to complete the questionnaire while others met as a group of geography teachers. Each time before the teacher could start with the completion of the questionnaire, the researcher would explain the purpose of the research project. Geography teachers shared their problems of teaching GIS informally with the researcher. A summary of some of the informal responses is as follows:

- Department of Basic Education failed to expose them to training in the teaching and learning of GIS in their schools.
- They lack teaching and learning equipment to teach GIS well in schools.
- Geography subject advisors seem not to understand GIS.
- No initiative is taken up by the DBE to give them quality support by arranging with a local university for short GIS training.

Below are some quotes from these discussions:

- Teacher A commented that “since GIS was introduced in the geography curriculum in 2006, they were never given training on it. I think it is because our geography subject advisors do not understand it”.
- Teacher B remarked that “the local University of Limpopo has GIS laboratories but the DBE does not even bother to arrange short GIS training programmes with the university authorities”.
- Teacher C also commented that “my school does not even have a single GIS equipment like a computer. I only have my own laptop”.

All these comments indicate how basic infrastructure of GIS is still lacking in schools. These will obviously have a negative impact on the teaching and learning of GIS.

In Vhembe District, the researcher met with a group of 35 (thirty five) geography teachers who discussed Grade 12 Half-yearly Geography Examination Memorandum. The researcher was allocated one hour (1 hour) to get the comments of teachers and distribute the questionnaires for completion. Teachers echoed problems they encountered in the teaching and learning of GIS. All their views were noted as part of the qualitative data for the study. Information related to their personal challenges of ignoring their training in this regard dominated the talk. The researcher explained the purpose of the research and how they should go about completing the questionnaire. Whatever they said was noted in the researcher’s record book. In qualitative research it is important to keep track of ideas you get from respondents and to record your insights as they unfold to avoid relying on memory later on when writing up (Johnson & Christensen, 2014).

Information collected was classified into different types. This is referred to as typology. Typology can be simple or complex depending on the data the researcher

has collected. In this research, typology was simple because the researcher looked mainly at the methods teachers use in the teaching and learning of GIS and the reason for using such methods. There are a variety of teaching methods and these methods had to be classified into different types. Grouping information in analysis could help one in avoiding mixing up information in the analysis. Responses were related to the different methods teachers employ on the teaching and learning of GIS in their respective secondary schools; the workability of the methods used; what teachers wanted to learn in GIS; what the Department of Basic Education should do to improve the teaching and learning of GIS in secondary schools and how teachers motivate their learners in the use of GIS.

4.4.1 Findings from documents analysis and focus group interview

The findings from the following documents were analysed: Grade 12 Final Examination Geography Reports of 2009 – 2012 from the Department of Basic Education; open-ended questionnaire from geography teachers in Limpopo Province; focus groups of geography teachers and learners interviewed and transcripts from taped interviews of geography teachers in Limpopo Province.

4.4.1.1 Examiner's report on geography marking of Grade 12 final examination papers

Document analysis is a type of qualitative research where a researcher interprets documents to give them voice and meaning around a particular research topic. In this research, the researcher wanted to give meaning from the documents collected in teaching and learning of GIS. From the Limpopo Department of Basic Education Geography Chief Examiner's report on marking Grade 12 Final Examination of November 2011, the examiner reported that:

> *"Learners performed poorly in this question (GIS questions). Most teachers don't know and don't understand GIS, hence it is a problem teaching it to the learners. There is no specific textbook for GIS, learners from rural areas do not have access to computers.I think we should be provided with guidelines as to what we are supposed to teach to the learners because GIS is too broad. The question on*

resolution and megapixels was difficult for learners, especially those who come from deep in the rural areas of Limpopo Province".

The above excerpt from the report explains the findings that was identified by the examiner when analysing the end-of-the-year geography examination marking. There was a big challenge for teachers regarding the teaching and learning of GIS in secondary schools. The above statement shows the seriousness of the problem of GIS that prevails in the secondary schools of Limpopo Province. The problem starts with the teachers who do not understand GIS, and yet the department expects the learners to pass it. The findings support what this research study presented in the quantitative analysis. In the quantitative analysis, it was highlighted how most teachers lack skills and knowledge in GIS. The examiner's reports also support this limitation which affects the performance of learners. Both analyses support each other another. It is critical that the Department of Basic Education attend to this. It is surprising that the examiner reported on this shortcoming in 2009, 2010 and 2011 final year geography examination and the Department has not made any move to correct this. There is enough evidence from the learners' final year performance that GIS is still a problem. Previously in the quantitative analysis, it was found that teachers do not have knowledge of GIS and that lack of equipment in the schools is also deterrent factor.

The question of textbooks is also cited in the report. According to the examiner, textbooks also seem not to carry enough information. In fact textbooks are theoretical and GIS needs practical involvement of both the teachers and the learners. One respondent indicated that the textbooks have a lot of information that cannot be covered within the specified time prescribed by the syllabus. She proposed that if GIS was an independent subject, perhaps teachers would be able to cover the information detailed in the curriculum. In the opinion of the researcher, the content on GIS seems to be basic and suitable for the learners at the level of FET in schools.

Constructivist theory which this research is argued, emphasises that learners must construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. Every time that learners encounter new knowledge in GIS, they must reconcile it with the previous ideas and experience they have, for example, with map study. This could encourage learners to change from

doing or drawing maps by hand and start to use computers to draw maps. One should also take into cognizance that we are creating our own knowledge every day when interacting with the objects in the world. To do this, it is right to ask questions, explore, and assess what we know.

4.4.1.2 Methods used by teachers in the teaching and learning of GIS

a. Introduction

The didactical method is critical when formal teaching and learning takes place at any given time. Data collected outlined different methods geography teachers engage themselves in when teaching and learning GIS in their respective schools. It is important that methods used by individual teachers be analysed in detail to find out whether they fit well in the teaching and learning of GIS or not. The researcher would argue that as long as the method of teaching GIS does not involve relevant equipment, it will always fail to deliver a successful lesson. Methods used must give room for practical engagement of learners, otherwise GIS will continue to be another difficult subject to understand within the geography fraternity.

Qualitative responses from different geography teachers were also analysed as part of documents. Teachers explained methods they use in class when teaching and learning GIS and the reasons of employing such methods. From the responses most teachers use the textbook method, question and answer method, narrative method while few present through PowerPoint using data projector. Profiling the geography teachers, it shows that most teachers sampled teach in rural schools, some in semi-urban and some in urban schools. The profile of these teachers ranged from teachers teaching in well-equipped schools in towns to poor schools in rural settings. Learners in both urban and semi-urban areas were much easier to communicate with as their language was more proficient than those in rural schools. The quality of interview also differed. Those in urban and semi-urban schools are fluent in English and are not shy.

b. Textbook method in teaching and learning GIS

Findings indicate that most teachers use the textbook method to teach GIS in secondary schools in Limpopo. The textbook method is a method where a teacher reads the content and explains to the learners sentence by sentence. The textbook method in content subjects like geography is used by teachers who are not familiar with the subject matter. Learners could be referred to the textbook when the geography teacher wants to show them diagrams or an activity to work on as classwork or homework. Teachers who are not conversant with the subject matter would usually resort to this method to support what they are teaching. If a teacher does not know the subject matter well, reading from the textbook with learners and explaining sentence after sentence becomes the method of choice. This becomes a problem when learners do not have textbooks.

Reasons for using textbook method is that they lack related resources to impart GIS efficiently. GIS is an ICT related part of geography which could be taught well when the school is equipped with hardware and software. Alibrandi and Palmer-Moloney, (2001) state how difficult it is to teach technology without necessary equipment like hardware and software. This was when they were involved in the training of students on how to integrate technology in the teaching of GIS in North Carolina State University. They categorically stated that GIS cannot be taught without hardware and software. GIS is a practical discipline as this research highlighted in the previous chapters. How will the teacher show learners what a polygon is if he does not have a hardware? How does one demonstrate the development of a polygon while there is no hardware in place? In the absence of equipment, teaching GIS becomes a myth.

Another reason for resorting to the textbook method is because they do not “know” GIS. They read from the book with learners, explaining from the context of the text book. When a teacher knows the subject matter, he or she is not be expected to use text book method. The method could only be used when reference to a particular illustration in the book is explained. Reading from the textbook does not bear good results in GIS teaching. Learners would end up memorising without understanding important facts on GIS. GIS needs theoretical explanation that should be supported by practical teaching. Where learners are exposed to the practical GIS, learning it becomes easier and progressive than a situation where learners only hear from the teacher about GIS. Learners must learn GIS through doing the practical component.

When teachers were asked what they want to learn in GIS, they indicated that they would like to learn the following:

- Practical usage of the computer
- To build a GIS data base
- Practical applications
- To know and understand GIS
- Generating data using GIS software
- To master teaching with the assistance of a computer
- Use of GIS software
- Data collection, analysis and display.

The above themes demonstrate that most teachers are not familiar with GIS and therefore find it difficult to teach. Some teachers indicated that they need more capacity building workshops in GIS. For the question that determined their skills in GIS, more than 70% indicated they strongly agree with being capacited on this. A teacher indicted that even if his school was equipped with computers he will not use them to teach GIS because he knows nothing about it. It is imperative that the training of teachers on basic computer skills be considered. The textbook method will go on dominating in secondary schools of Limpopo due to lack of computer skills and knowledge.

Respondent 1, who is attached to an urban school in Polokwane City (former Model C school), on the question of teaching method, stated that she uses the textbook method and PowerPoint presentation she got from the internet, prepared by the geography teachers in the Western Cape Province. She combines both methods because the PowerPoint has some basics of GIS which is supported by the information in the textbook. This teacher has an advantage because her school is equipped with a data projector which she connects to her laptop and teaches the GIS lesson. The teacher mainly uses the textbook for referral purposes. When asked whether this method worked for her, she explained that the method work for her learners although they have problems in understanding terms such as ‘buffer zone’. Learners imagine this to be something that perhaps has to do with ‘some fencing

around it'. Due to lack of necessary equipment, learners will always imagine instead of seeing what a real buffer zone is.

c. Narrative method of teaching

Another method that is used by geography teachers is the narrative method. Some respondents referred to this method as the traditional method of teaching because it has been the dominant method used in teaching and learning. Butcher (2006) illuminates this method as a story telling method which dominates in language teaching. Interjecting is not common when one narrates and one can only be given a chance to intervene at the end of the talk where questions could be raised and issues be clarified. This research argues that GIS is not a language but a technology of resolving spatial problems and should therefore be practical. In GIS teaching and learning, the focus is not on storytelling and story listening but on doing as championed by constructivist theory. Narrative method according to Butcher (2006) is good for teaching adults especially in correctional activities or services. Secondary school learners are not yet adults, they enjoy a situation where they discover solutions by themselves. The reason for using this method is because of lack of teaching resources. The narrative method is traditionally a theoretical method of teaching where a teacher tells while learners listen. In essence, the narrative method is a theoretical method where practical or demonstration work is very minimal. Teachers prepare from the textbook and narrate without engaging any form of practice. GIS as indicated before, involves doing while teaching and learning, not listening. It involves activity instead of passiveness. Teaching and learning apparatus are necessary in GIS teaching and learning, therefore the narrative method does not seem to fit well with GIS.

Data collected indicated that narrative method is used in many schools in Sekhukhune and Mopani districts. Some of the school refer to it as theory method of teaching. This is because teachers do not have anything in the form of hardware or software that could be used to aid the GIS lessons. A respondent from Sekhukhune district said he used narrative method "because of lack of teaching resources". Another respondent from Mopani cited that he uses narrative method because of

“lack of computers”. The two responses are the same. Teaching resources are therefore critical in the teaching and learning of GIS.

From the findings of this study, teachers resort to this method because they do not have the necessary hardware and software required in the teaching and learning of GIS. In one recorded interview, a geography teacher indicated how she tried to improvise with her single laptop to show learners a map that she downloaded. Showing the map to a class of forty geography learners, on a laptop, in groups of three is not effective at all. It consumes more time and ends up rendering the whole exercise boring without achieving the intended results. Her school does not have a data projector which perhaps she could connect and show the whole class at one time. The use of this method is dictated by lack of resources; that is hardware and software. Lack of resources in schools of the Limpopo Province is a huge challenge.

d. Question-Answer Method in teaching GIS

Geography teachers in some schools indicated that they use the question-answer method in teaching and learning GIS. The question-answer method is also referred to as Socratic Method of teaching because it was developed by one of the greatest Greek philosophers, Socrates. This is a method where subject matter is transferred through questioning and answering questions asked by the teacher. It is an important method as it reflects on the learners’ background and attitude towards the topic you are teaching on. The method is also important as it checks on prior knowledge of the learners about the topic discussed. It can also be helpful in mobilising existing knowledge and experience so that new knowledge can be formed.

GIS is a new concept in the teaching and learning of geography. Using this method may have less impact because learners do not know much about the GIS technology at all. If teaching resources are available, the question-answer method could be relevant because a teacher would ask questions related to the use of those resources, for example, why do learners think hardware is important when GIS technology is taught? GIS is new concept which learners need to interact with through the technological aids such as computers, laptops and smart phones that

are available. Geography teachers cannot ask learners GIS related question if they do not know anything about GIS and learners cannot on the other hand ask questions on GIS which they never studied before. Teachers indicated that the reasons for using this method is that they want to measure knowledge of learners in GIS. A responded indicated that she use question-answer method because “learners are afforded the opportunity to ask questions”. Another respondent said that he uses question-answer method because he is able to ask learners questions on what they see from their textbooks and maps”. How much do the learners understand about GIS? Asking learners at this level about GIS might not be feasible because they were never exposed to it.

e. Lecture Method in teaching GIS

The lecture method was also mentioned as a method used by some teachers in the teaching of GIS. This is one of the oldest methods of teaching used in educational institutions of higher education. It is a one way channel of communicating information and is normally used in large classes. Learning material is not necessary in this type of method because the lecturer can use a PowerPoint presentation or chalkboard. The students’ main duty is to listen and pen notes when the lecturer gives a lesson. One respondent reasoned that he resorted to this method because he does not have computers in his school. The teacher use this method out of frustration of not having resources at his disposal. The lecture method is not good for secondary school learners because no learning materials are involved. The presenter does not have time to find out whether the learners understood. Learners with poor listening skills will be left out during the lesson. This method does not suit the teaching and learning of GIS.

f. Using technology: Projector connected to a laptop

The qualitative data collected indicated that few teachers use ICT equipment as a means of teaching and learning GIS in their schools. Secondary schools with such equipment are the former Model C schools located in the urban area and private schools. The ordinary public schools in township and surrounding rural areas do not have such equipment. They resort to methods such as using textbook and narration which are not effective in the teaching and learning GIS. This thesis highlighted in

the beginning that the theory for this research is constructivism. Using equipment like laptops, data projectors when teaching and learning GIS will definitely make its delivery, convenient and easy for learners to understand. The following table represent the types of teaching methods used in teaching GIS from twenty schools sampled in Capricorn District.

Table 4.5: Different methods of teaching GIS in schools in Capricorn District

Type of method used	**No. of schools using the method**	**Type of school**
Narrative method	05	Public Schools
Textbook method	10	Public
Question and Answer method	02	Public
Using ICT equipment method of presentation	03	Former Model C & Private Schools
TOTAL	**20**	

4.4.1.3 Critical Analysis of methods used in GIS teaching and learning in the Secondary Schools of Limpopo Province

Data collected indicates that the majority of geography teachers in Limpopo Province use the textbook method for teaching and learning GIS. The geography teachers using this method cited reasons of having shortage of hardware and software. GIS is an ICT-related programme and without engaging some sort of equipment learners, are not able to understand it. Reading from a text book and explaining everything theoretically without the practical involvement of learners, will not engage with the technicalities involved in GIS. Learners must be given projects to do using hardware

and software, which can be referred to as GIS learning. One respondent explained how she used the textbook method with the support of a data projector. In this case, learners only see the modus operandi of GIS on the screen while they are not actively involved in doing it. This lesson only makes learners understand the theory of GIS operations. In GIS teaching and learning, the focus should be on doing to get solutions to whatever spatial problem one intends to solve.

The narrative method of teaching also does not seem to fit well in the teaching and learning GIS. This method could be suitable for teaching other sections of geography, like in geomorphology with teaching sections on features associated with inclined strata. GIS teaching and learning cannot be narrated like one telling a story, it needs to be done practically with the involvement of the learners.

Another method popularly mentioned from the data collected about the teaching and learning GIS, is the question-answer method. Question-answer method could be relevant when asking learners questions related to the previous lesson to determine whether they understood it or not. It can also be used in linking what they did previously with the new lesson. In the teaching and learning GIS, this method did not suit the presentation of the GIS lesson. The GIS teacher cannot ask learners questions on subject matter that the learners do not know. Knowledge in GIS teaching and learning can only be proven by the end product constructed by learners through using available resources.

The lecture method is also cited as one of the methods used in teaching and learning of GIS in Limpopo secondary schools. This method is irrelevant in terms of teaching this part of the curriculum in geography. It is a method that is relevant for teaching in tertiary education, for example in Universities and Colleges. In lecturing, the lecturer only talks without much interference from students or learners. Students take notes when the lecturer gives out the lecture. There is little time to pick up on slow learners and give them support. It was indicated earlier that no teaching apparatus are involved in lecturing. The lecturer does not care much about less-gifted students. Even after writing tests, there is no time for the lecturer to reflect back on the problems encountered by underperforming students. There is no time for remedial work that could support students who failed the assessment.

Innes, (2012) argued in the literature that for South Africa to produce Geographical Information scientists, the first step will be to acquire map skills. The author went on to say that these skills can only be attained in a classroom. Technological skills training need practical involvement of individuals. Theoretical perspectives in teaching and learning GIS cannot benefit this technology. Innes's (2012) argument supports the ideology of this thesis that for learners to learn map skills well, it is critical that schools have equipment that will facilitate good GIS teaching and learning.

The above four methods outlined do not promote GIS skills development. There are other methods mentioned by respondents such as observation, chalkboard, discussion, and paper-based notes which they are using. To the researcher, these do not seem to be methods of teaching and learning; they are supporting aids and means that could make learners understand GIS technology. GIS learners could first observe how to follow the operations of GIS hardware in downloading images using a particular software. Chalkboard can never be a method of teaching and learning GIS. The chalkboard is a traditional teaching aid where the teacher writes down notes when teaching. It is referred to as traditional teaching aid because there is traditionally no classroom without a chalkboard or whiteboard (in current classrooms).

Discussion is also not a method of teaching. It is another way of learning. In a class, a teacher could divide learners into groups and give them a topic to discuss for later presentation. In GIS teaching and learning, discussion cannot be a method of teaching. Discussion takes place anywhere in teaching and learning. It can be both formal and informal. None of the methods that were discussed above qualify to be methods that could be applied in the teaching and learning of GIS. It is surprising that some of the respondents indicated that these methods do work for them. These teachers believe that the methods work for them because they make learners memorise for examination purposes using questions from previous years. What is important in GIS teaching and learning is doing – doing as you learn.

Mdlongwa (2012) argues how most schools in South Africa are still using the traditional methods of teaching and are not even trying to convert to methods that are ICT inclined. He emphasised that the use of ICT is only found in schools that are located in urban areas and that the rural schools still have a challenge of electricity. The data collected indicates that many rural schools have been electrified but many teachers still cannot take advantage of this to use technological related methods when teaching. Very few schools have projectors but the researcher believes most schools can afford to purchase these from their school budget.

4.4.1.4 Private Schools and Public Schools in teaching and learning GIS

Limpopo Province has secondary schools that are private and public. Private schools (also referred to by the DBE, as independent schools) are expensive and only well-to-do families afford to enrol their children in such schools. Private schools are owned and operated by trust, church or community, or by a for-profit organizations or companies. Government do give private schools grants, depending on the community they serve. Since they are expensive, it is expected that they have enough resources for teaching and learning in all subjects. Private schools are expected to have well equipped science laboratories and good, well-resourced sporting facilities. It is also presumed that these schools have the capacity to hire teachers who can teach GIS well and make an impact on its teaching and learning.

On the other hand, public schools are owned and maintained by the Department of Basic Education. The department maintains school grounds, administrative costs, salaries, books and other educational materials. Extramural activities are also taken care of by the DBE. Some public schools supplement the government grant with school fees paid by parents; fundraising activities organized by schools and lobbing for donations from corporate institutions. Grants paid by the government to public schools is determined by the poverty level of the community in which the school is located. The unemployment rate and general education level of the community are also taken into consideration. The grant paid is determined by the number of learners registered in that particular school. Obviously, the school with higher

enrolment of learners gets a higher grant than the school with lower enrolment of learners.

Schools that are located in the more affluent areas can raise money from other sources to sustain the level of education of the school. Schools in South Africa located in affluent areas have a much higher standard of education than areas that are less affluent. Urban schools in Limpopo Province have a higher standard of education than those in rural areas, regardless of whether they are public or not. Public schools in less affluent areas do not collect school fees from learners. The government uses ‘quintile’ of schools to fund schools. Quintile 1 is the poorest where each child is subsidised by R807.00, while the subsidy deceases as quintiles goes up until quintile 5 (the richest) which get about R134.00 per child per year (DBE, 2012).

In terms of GIS teaching and learning, private schools and affluent public schools have made efforts in equipping their schools with hardware and affordable software. Private schools sampled in this research study have laptops and projectors and a room used as laboratory in which GIS lessons are held. The teacher connect laptop to the projector so that learners can follow what she is teaching on the screen. After demonstrating to learners what she teaches, she then gives learners a project that they must to do as group. Every year her learners have to complete a GIS-based task. The end-product produced after their assignment becomes the work of their own. After completing the assignment, learners are well prepared to endeavour in any university GIS programme because of the background given at the secondary school level. In School B, which is found in the city, the school cannot afford hardware and software that could be used in the teaching and learning of GIS. The geography teacher uses her own laptop to teach GIS. Fortunately the school has a projector which she connects the laptop to and she teaches. Constructivist theory emphasises that learners must do. The teacher’s duty is to control the situation so that order can prevail. GIS teaching and learning include inter alia that learners should be given tasks which they complete by themselves. In this way they come up with an end-product that is meaningful.

An affluent public secondary school in Waterberg District, indicated how their school is struggling to get donors from the corporate sector who can at least donate 10

computers to their school. The teacher is worried that she cannot make teaching of GIS in her school possible because of lack of hardware. She is quoted as saying that "*the theoretical method I am using is not sufficient in the teaching of GIS and I use this method because there are no computers in our school".* Government-run schools cannot afford to supply all secondary schools with computers because they do not have enough financial backing. One would expect affluent secondary schools to have better facilities than public schools in rural areas. Data collected shows that in terms of GIS equipment, the affluent secondary schools do not differ much from the rural schools. The only equipment common in the affluent schools is a data projector and most teachers in such schools are encouraged to present lessons using their personal laptops.

One of the findings of this research is that not all private schools have GIS equipment. A private school located in a semi-urban area, which is not affluent area, situated twenty five kilometres outside the city of Polokwane, does not have a single projector. The geography teacher in this school does not have GIS knowledge and she uses the textbook method when teaching GIS. A private Moslem high school in the city with a qualified GIS teacher, does not have equipment for teaching GIS. He cited the reason for this, that it is expensive to equip the school with necessary hardware and software needed for GIS teaching. From the discussion of findings above it is clear that introducing GIS in many secondary schools requires a lot of financial backing. This research study also found that is not all private schools that are well equipped with GIS resources. Data collected indicate that some private schools are struggling to equip their schools with the required teaching resources like computers, data projectors, and other related modern facilities. Table 4.4 show the availability of GIS

Table 4.4: Availability of equipment in private schools of Limpopo Province

	Urban	Rural
Computers for learners	Yes	No
Software	No	No
Projector	None	None

Laboratory	None	None

When asked whether they enjoy teaching the GIS section in geography, most teachers teaching in the private schools and the affluent schools indicated that they do enjoy teaching GIS. This is because most of the teachers were exposed to GIS before and their schools are partly equipped with GIS hardware and software. Majority of the teachers from public schools also indicated that they do enjoy teaching GIS. These are teachers who initially indicated that they could not teach GIS due to less knowledge they have in GIS, now responded differently to say that they enjoy teaching GIS. This is in contrast with their initial response. They went on to mention that they like working with GIS while they previously said they do not know it. These contrasts indicate that some of the geography teachers who were interviewed, were confused.

On the question of implementing GIS in secondary schools, teachers in private schools supported the idea while most of teachers in public schools did not support the idea. Teachers in private schools and other affluent secondary schools who were interviewed, indicated that they already using technology when presenting lessons. This does not only apply to geography lessons, but to other subjects. Schools lack computers to teach and learn GIS, but they do have laptops and I-pads that they use when teaching and learning other subjects. The problem is that in a school of twenty teachers, they have to share five school laptops. Some teachers end up using their personal laptops to teach because such schools have projectors which they use when presenting lessons. The teachers in secondary schools have realized that GIS teaching and learning involves usage of hardware and software which adds value to their need for more technological teaching aids in schools.

Teachers in private and affluent schools have an advantage over ordinary public schools in rural areas because they have equipment and they teach learners who are acquainted with technology due to their family background. Most students in urban schools are from affluent families who come to school already knowing what computer is and how to operate it. This background knowledge gives the learners an advantage compared to learners living in rural areas. The GIS teacher can then base the teaching on the already existing GIS knowledge of the learners.

In conclusion, GIS teaching and learning in both private and public secondary schools of Limpopo Province do not differ much in terms of equipment. Equipping schools with relevant hardware and software is still a big challenge in many schools. The Department of Basic Education should consider moving secondary schools forward in terms of technology. GIS technology must be considered as the only way to bring real GIS teaching and learning in the secondary schools of Limpopo and South Africa at large. Private schools should also connect to the cooperate world so that they donate hardware and software that could be used in the teaching and learning of GIS.

4.4.1.5 Qualitative analysis of responses from GIS learners in secondary schools

Qualitative data regarding the understanding of GIS by learners was also collected to back quantitative data collected in determining learners knowledge of GIS measured from the test. Class meetings were held with GIS learners in two different groups; winter school learners at the University of Limpopo and Capricorn High School learners. The purpose of these meetings as to establish their feeling towards GIS. During this time, learners got a chance to air their views and perceptions regarding GIS teaching and learning.

a. Background

Geography learners doing GIS in secondary schools of Limpopo Province were also allotted an opportunity to give their perspective on GIS. Open-ended questions were used to collect the information. Learners, who were earlier given a test to write were also sampled to answer the open-ended questions. Five questions that were asked ranged from what they learnt thus far from GIS (See Appendix E); uses of GIS; their views about GIS and its relevance in everyday life. Learners were also asked to explain why GIS is important in the modern world; as well as its value to us. A question asked was related to their cell phone usage, where learners were asked to

indicate whether they are aware that navigation on their cell phones was part of GIS? Learners should be made aware of some of the free GIS software that they could download through the apps and use them in learning GIS. The researcher also had an opportunity to share GIS knowledge with Grade 11 learners of a school in a 30 minute GIS talk. Learners' response were recorded and shared with the researcher concerning interesting things they believe they could learn in GIS. One learner explained how his father told him about the opportunities of GIS as a career. Seemingly a friend to his father is a GIS-user. He confirmed that he was encouraged by my visit to their school, but disappointed that the schools were not fully equipped with equipment for teaching and learning GIS. He indicated his intentions of pursuing a GIS career after matric.

Another group of learners sampled in this research, were Grade 12 geography learners who were attending a winter school at the University of Limpopo during June-July vacation. Learners who registered, were from different schools in the province, both rural and urban. There were a few learners from Mpumalanga and Gauteng Provinces as well. Sixty eight learners registered for geography and the researcher randomly selected 30 of them.

b. Analysing learners qualitative responses

Learners in Grade 12 were asked open-ended general questions related to GIS (See Appendix E). The questions were based on the GIS knowledge they accumulated since they started doing it in Grade10. When methods used in teaching GIS were analysed, it was realised that most methods applied by GIS teachers were not relevant. Dominantly methods used were theoretical and could not fit well in the teaching and learning of GIS. Learners are taught without any form of hardware and software. Teachers need to have teaching resources that could support their teaching and learning of GIS. Analysing responses from learners provided data on whether the methods used by geography teachers in teaching and learning GIS, had the necessary impact on learners.

The first question needed a learner to tell what he or she learnt about GIS thus far. These learners had been doing GIS since Grade 10 and they were in Grade 12, their

final secondary school year. The question intended to find out what the learners knows about GIS. One learner respondent explained that he/she learned that "*GIS is a digital collection of information used as a system to capture, store and gather information. I have learnt that in GIS there are five key components, namely hardware, software, methods, data and people."* From this quote, it is clear that this learner has a theoretical perspective of what GIS is about. He knew the theory behind GIS and that without these mentioned components, GIS will not operate. The integration of these components fulfils the requirements of a practical GIS. This learner with this rich explanation, finds himself in a school that does not have any hardware and software for GIS. The school does not even have a qualified GIS teacher who knows methods that could be applied in manipulating any spatial data available to complete a project. This learner is a product of a teacher who uses the text book method in teaching GIS. The teacher makes learners to memorise the definition of GIS without exposing learners to real practical GIS teaching and learning situations.

Another learner from the same school responded by saying that "*GIS is a computer system that is tailor-made to use spatial and attribute data in an integrated manner, in order to give quick answers on the where, what and how much questions geographers have asked over centuries".* The learner knows that GIS is 'a computer system' which means that he is aware that hardware is necessary. He went on to say that it is tailor-made, which signifies the use of software together with the hardware, to guide one in producing a GIS-end-product. The integration between the two can give quick answers to the geographical questions which are posed everyday by geographers. The learners referred to some research that needs to be done to answer some questions regarding geographical problems. In this case GIS is used as a tool to get answers to the research questions. The learner have a good idea on how GIS operates. Fulfilling the obligations of GIS teaching and learning, it would be ideal to have this equipment on site in schools to give meaning to GIS teaching and learning.

One Grade 12 learner, when responding about what he learnt in GIS, indicated that *"GIS is helping us to understand the earth better and to apply geographical knowledge to many human activities. Applying GIS and geographic understanding together is a new way of thinking, solving problems and managing our planet."* The

learner explained how GIS can assist in solving problems confronting us in the management of the planet, making us understand the world better so that our geographical knowledge can be applied better and relevantly in the modern world. Today there are problems with global warming which are a threat to human life on the planet. GIS could be used as a tool to resolve some problems related to this. He went on to add that "*GIS have come up with a new way of thinking and solving our problems in the world and all these will assist in managing our planet."* The learner understands the use of GIS and how this technology can help in solving the problems encountered on this planet. All this information is learnt from the text book without any support from hardware and software. One could imagine how such learner could perform if given an opportunity to be exposed to the computer. Currently the learner is attached to a school that does not even have a single computer. His teacher uses the textbook method to teach GIS. Learners can learn all GIS information from the textbook without any engagement with hardware and software. The learner's inputs with regard to what he theoretically learnt in GIS shows that this learner has knowledge about GIS.

Learners had to respond on the uses of GIS in their daily experience. From their responses, it is evident that they lack practical perception of how GIS can assist in their daily lives. Responses from the learners was superficial. The learners cannot relate well their experiences in GIS because they do not have practical experience of GIS. However, response from one learner was that *"GIS makes me understand local and global environment, find my car in a parking lot or building. Know where places of recreation can be found. Learn where local malls, schools and super markets are found."* This response demonstrates that this learner has practical exposure to GIS. This is how a learner who has practical experience in GIS should respond. The respondent shows that he has practical knowledge in GIS. The respondent above shows that he knows that using the GPS on a cell phone, could help in locating malls and schools.

On the question whether GIS is important in the technological world, all learners sampled responded that *"Yes"* it is important. Learners had to give reasons for the answers they advanced. One of the learners gave a reason that has to do with remote sensing. The learner indicated that *"GIS is important in the technological*

world because with GIS, one can get images without any physical contact." The information explained by the learner is correct, but this is not GIS. Remote sensing is another field of study that is independent of GIS. Aerial photographs are a good example of remote sensing and provides data that could be used in GIS. Remote sensing is another way in which GIS data is tapped for GIS purposes. When a helicopter captures an image of any phenomenon, no physical contact is made. From the pictures, GIS comes in, where some features are identified and overlaid in different themes. Another learner who also supports the idea that GIS is important in the technological world, indicated that *"GIS could help during investigations."* The learner could not specify what type of investigation was being referred to. It is true because in policing and investigation of cases, GIS is used. It is therefore important that GIS is introduced in schools. Some learners could in future be hired as detectives investigating serious cases, using GIS as a tool to attain their objectives. With the help of GIS, some cases could be resolved and the crime level can be reduced. Learners who are still at the secondary school level could identify the importance of GIS and technology in general. Secondary schools in Limpopo Province need to have hardware and software that could support teaching and learning of GIS in their respective schools because learners are already showing the significance this could bring to society.

Generally, the learners who participated in this research showed an understanding of what GIS is. Their responses indicate that they have a theoretical perspective on how GIS operates. Teachers teaching GIS in secondary schools in Limpopo, though hindered by lack of hardware and software, try their best to make learners understand what GIS is all about. Learners' theoretical knowledge in this regard lacks practical exposure to the GIS. The theoretical knowledge could be a good foundation for building the practical knowledge of learning GIS. The fact that most teachers show interest in the teaching and learning of GIS in school could force the Department of Basic Education to consider making provisions to fill this gap. Secondary schools that are located in the affluent areas of Limpopo Province could also look into how to raise funds that could be used in schools to purchase hardware and software.

On the question of whether learners think it is good to learn geography through computers, most learners responded that it was good to use computers and they gave different reasons for this. Some learners indicated that *"it will be simple to learn GIS"* for the obvious reason that one would have the basic knowledge of how a computer operates. GIS, as mentioned in the first chapter, is an ICT-based concept which cannot be applied without the use of hardware. From these responses learners realised how difficult it is for them to learn GIS without computers in their schools. Learners originating from urban schools gave responses that indicated that they were conversant with GIS application, to a certain extend. The reason for this is because most learners are from families where parents are having such equipment in their homes. When these learners come to school, they already know how a computer is operated. Some of these learners possess I-pads and can run some of the GIS applications. This is different for some learners from rural areas who cannot even switch on a computer because they were never exposed to such hardware.

c. Conclusion

Responses from learners indicate that geography learners in the secondary schools of Limpopo province have an interest in learning GIS. Their responses demonstrate clearly that most of them have an idea of what GIS is. One could also gauge that their teachers in particular are making an effort in the teaching and learning of GIS even without the necessary equipment to make this an achievable goal. The use of the textbook method when teaching and learning GIS demonstrates that the Department of Basic Education still has a lot to do in equipping schools in the Limpopo Province and South Africa as a whole.

From this research, it was evident that in many secondary schools in the Limpopo Province, geography learners have theoretical knowledge of how GIS operates and what GIS can achieve. This is not enough in terms of the constructivist theory of learning. All components of learning must be available to make the goal of teaching and learning of GIS achievable. Once one component is not available within the teaching and learning milieu, a lesson cannot achieve its objective. In the context of this research, teachers and learners are available and ready to teach and be taught,

but the teaching and learning tools are not available. Hardware and software are the cornerstone components in teaching and learning GIS, whether it is at the secondary school level or at a higher learning institution. Innes (2012) reported on the spatial competencies conducted by State Information Technology Agency (SITA) in all nine provinces of South Africa. They used data from Grade 12 Examination Paper 1 (Practical Paper) collected between the years 2000 and 2007. The Limpopo Province got the lowest scores when compared to other provinces. Lack of hardware and software in this province worsens the situation in terms of the learners' understanding of spatial features done in GIS. Serious steps are necessary before conditions can deteriorate further.

4.5 SYNTHESIS OF DATA PRESENTED IN THIS CHAPTER

When triangulating the data collected quantitatively during this research, the results show that there is still a lot more to be done to assist the secondary schools in Limpopo Province in teaching and learning GIS. Most teachers offering GIS in the secondary schools are not well skilled to teach GIS. Innes (2012) notes that GIS teaching needs more specialised skills than when teaching ordinary content of geography. The statement itself implies that the GIS section of geography is unlike normal sections of geography, instead it needs some sort of extra skills which one should have to be able to deliver it. This tells one that it is not every geography teacher who can teach GIS, but those who have undergone some specialised training in this regard. To have some specialised skills means one should be able to use hardware with relevant GIS software where one can produce a meaningful spatial feature, depending on the objective of the project. If one is equipped with these skills then one is able to teach GIS. The question of practical knowledge of GIS is very important as was argued earlier in this research study that GIS teaching and learning needs practical exertion. Many schools do not have equipment to teach and learn GIS. It is critical than the Department of Basic Education get funds to assist in this endeavour. Mah (2012) states that the introduction of GIS in the United States of America's secondary schools was possible because computers are not as expensive as before. Furthermore, he indicates how connecting to the internet is no more difficult because learners come to class with internet-enabled smartphones and tablets through which the internet could be accessed. The Department of Basic

Education can budget for equipping schools with, for example, tablets. One respondent in the qualitative method commented that “in Gauteng Province, the Education Department supplied secondary schools with tablets. The process is said to have been brought to a halt due to criminal elements who break into schools to steal the equipment. The department is currently looking into some measures to beef up security in schools”.

The quantitative data collected has shown that geography teachers offering GIS in secondary schools do not have required knowledge to teach GIS well. In the questionnaire, teachers were asked questions that determined their knowledge on GIS and most of them responded in a way that shows their lack of knowledge on the technology. The quantitative data showed how geography teachers are unable to display a variety of both vector and raster formats. The question itself indicated that teachers do not have knowledge of GIS. A number of teachers accepted that they lack knowledge and indicated that they are prepared to be trained if given an opportunity to do so. In the qualitative data, GIS teachers indicated that they would prefer to be taught GIS either in a form of short term course organised during their vacation with local university or ordinary workshops where teachers could be shown how GIS operates. They have indicated that they would like to be exposed to the practical part of GIS. The two research methods support one another. Through the qualitative design, GIS teachers specified exactly what they wanted to be trained on. One respondent indicated that he wants to be taught basic concepts on GIS and computer skills which can help them in assisting learners when working on GIS. In the quantitative analysis, researcher only identified that teachers do not know GIS but in the qualitative analysis teachers specified exactly where their problem is. It is from triangulation of the two designs that researcher can identify the GIS challenges facing teachers. It is in the context of this argument that the two designs are seen to be complementing one another.

The researcher initially believed that teachers teaching geography in urban and former Model C schools were knowledgeable about GIS teaching and learning. There is only one geography teacher, in a former Model C School located in an urban area in Mopani District who indicated that he studied GIS and can teach it well. His school is well equipped with computers that according to him are enough

for his learners. The teacher had offered to extend his GIS knowledge freely to other geography teachers from less-equipped schools around his vicinity, to GIS teaching and learning. He used equipment in his school to render this service to assist neighbouring colleagues. Most schools around the area where his school is situated, do not have facilities and knowledgeable teachers in GIS. He was disappointed because the response from geography teachers and Department officials attached to the circuit where his school is situated was not as positive as he expected. There were signs of resistance from teachers and geography subject advisers who insisted that they do not have time to attend extra classes after school. To quote the teacher in his words, "I invited secondary school teachers from the surrounding schools several times so that I could expose them to GIS in my equipped school but to no success". Mah (2012) and Scheepers (2009) cited that introduction of GIS will always experience resistance. According to Mah (2012), even in the United States of America when GIS was first introduced in secondary schools, it was met with challenges such as resistance from other quarters within the geography teachers. It was not smoothly accepted as one could expect. The process met with challenges such as resistance of the new technology. The resistance came mainly from experienced teachers with long service in the teaching and learning of geography.

From the quantitative data collected, geography teachers who have been teaching for more than twenty years, and who are in the age group 51–60 years, seem not to have interest in GIS technology. These are teachers who have a good reputation in the teaching of geography at secondary level. To them, when you tell them of GIS, it is like telling them to go back to school again. If one considers their remaining years in the service, they do not deem it necessary for them to study GIS. In the interviews, one teacher in Mopani District indicated that personally, she cannot use a computer and always requests assistance from the family members and staff to type question papers for her. She further said that she would soon be retiring and therefore it is not necessary to study GIS. Studying about computers and GIS, in her own words "*would be like going back to school again and I am not ready for that."* This qualitative remark from interviews, corroborate well with quantitative data collected to support the idea that there is a relationship between age and GIS teaching and learning in secondary schools. Younger teachers who are technologically inclined in terms of computers, smart phone, I-pads and other modern media equipment usage,

are interested to know and understand GIS technology. Teachers who are said to have been 'born before technology', struggle with the use of technological equipment in teaching and learning, compared to younger ones who enjoy using them. Triangulating the two methods validates the analogy that age in Limpopo Province, to a certain extent, influences poor performance of learners in GIS teaching and learning. This is because older geography teachers are not prepared to go for GIS training because they are close to retirement.

Younger teachers indicated in the quantitative design that they are interested in going for vocational workshops on GIS teaching and learning. The qualitative responses from these young geography teachers support the idea that for the Department of Basic Education (DBE) to improve teaching and learning of GIS, it should organise workshops. These workshops should offer enrichment programmes for GIS teachers in the form of tertiary programmes offered by universities. GIS teachers who are keen to teach this topic, might propose the content of topics they would prefer to be covered. The two designs close the gaps left by each other and in this case, most young teachers teaching geography are keen to be trained in GIS. It is therefore important that young teaching who were never exposed to GIS before, be trained so that learners' performance can improve.

From the transcripts collected through recorded tapes, one geography teacher indicated how department officials were disappointing teachers in terms of taking them to workshops. He indicated that he himself is 'shallow' in the knowledge of GIS because GIS is new concept to him. He remarked that officials are not doing anything to support the geography teachers in capacitating them with GIS knowledge. In his words he said that, "*officials have not yet even started to train us on GIS".* The teacher was referring to organization of workshops at circuit level. Teachers proposed to the officials to request assistance from the local university, but officials were reluctant to organise it. From the quantitative data collected, teachers indicated that the Department of Basic Education never organised GIS workshops for them. GIS was first included in the curriculum in 2006 and ten years down the line teachers still complain about being capacitated in GIS teaching and learning.

When triangulating the two designs, it is obvious that information collected qualitatively from geography teachers through interviews, is validated by the information collected through quantitative questionnaire. From the quantitative data, teachers also indicated that they would need to attend more workshops on GIS so that they could be able to teach it. From the questionnaire where teachers responded to the question regarding what the Department of Basic Education does to improve GIS teaching in schools, many teachers recommended that workshops and short courses need to be organized by the department. This indicates a gap which, if closed, could bring positive results towards the teaching and learning of GIS in secondary schools of the Limpopo Province. The two designs have validated the need for workshops and other measures and interventions that could help in the elevation of this part of the syllabus.

Geography teachers also responded on how learners, through the use of Global Positioning System (GPS) could be exposed to practical fieldwork experiences in GIS. GPS is global navigation satellite system that provides geolocation and time information to GPS receiver, in all weather conditions, anywhere on or near the earth where there is an unobstructed line of sight to four or more GPS satellites. The GPS system operates independently of any telephonic or internet reception. GPS provides critical positioning capabilities to military, civil and commercial users around the world. This system was created by the government of the United States of America who maintains it and is accessible to anyone with GPS receiver. The US government has the power to deny access to the system. Most teachers strongly agree that using GPS can expose learners to GIS practical fieldwork experience. Table 4.4 hereunder, supports what the researcher argues.

Table 4.5: The use of GPS in GIS teaching can expose learners to practical fieldwork experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Agree	3	30.0	30.0	30.0
	Strongly Agree	7	70.0	70.0	100.0
	Total	10	100.0	100.0	

From the questionnaire, most teachers responded that there are hand-held devices that could be used by learners for GIS learning. One of the devices referred to here is GPS. In the qualitative responses, on the question of how do they motivate learners on the use of GIS, geography teachers said that they expose learners to technology by encouraging them to use devices such as tablets, cell phones and GPS. There are teachers who can use GPS device. Triangulating this understanding, the researcher could deduce that geography teachers are aware that in making learners to understand the position of any spatial feature, it is important that one should have GPS device. All places on earth have a position that is determined by longitude and latitude lines. Where those lines interact, the feature will be found at that point. In GIS, co-ordinates are important because they represent existing spatial features that are part of the earth and they all have a position where they are found. Both the quantitative and qualitative designs support one another that GPS is important in GIS and its usage can motivate the learners in the teaching and learning of GIS. By using both methods, the researcher established how some teachers view GPS as an important device in teaching and learning GIS. Teachers who take their learners out for field trips, use a GPS device to locate the area they going to.

4.6 CHAPTER SUMMARY

The use of mixed methods design in this study had a great impact on the analysis of data in this study. Collecting data from geography teachers teaching in secondary schools of Limpopo Province in both rural and urban schools, as well as from private and public schools was effected by triangulating the data analysed in this research. Simultaneous application of both quantitative and qualitative designs in the research study benefitted it positively. If one method in this research study was employed, it would not have validated some of the findings of the research. When two designs are applied, they are able to show where data converges or diverges and filled in the gaps left by the other method. Johnson and Christensen (2014) argue that findings do not necessarily have to converge when one triangulates, but they can also diverge. They further indicate that this should not be a problem at all, as it can be useful and important to look at the objects of the study differently and perhaps start to look at the study from different perspectives.

The research also collected data from learners using both quantitative and qualitative methods. Responses from learners doing geography had to be compared with the responses from their teachers in order to understand the cause of poor performance in GIS. Interviews from learner focus groups doing geography in secondary schools was very critical. Learners from different schools attending Grade 12 Winter School at the University of Limpopo gave their own perspective regarding problems they are confronted with, in their respective secondary schools. Learners in former Model C schools, located in affluent areas of the province were also involved in the research. The use of triangulation design assisted in validating data from the different methods used. The use of the quantitative method to test the same question, was done in order to validate the information and data collected using a different method. As cited by Johnson and Christensen (2014), there are four strategies in triangulation, namely, the use of multiple resource data, multiple research methods, multiple investigators and multiple theoretical perspectives. In this research only two strategies were used; multiple resource data, and multiple research methods.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The aim of this study was to investigate the teaching and learning of GIS in secondary schools of Limpopo Province with the intention of proposing how best this technology can be taught. To investigate the problem scientifically, the study examined the methods currently used by teachers to propose methods that could be used in GIS teaching and learning. The study also established the availability of hardware and software in secondary schools of Limpopo, which are critical in GIS. The research further determined the teacher's knowledge of GIS *vis-à-vis* the performance of the learners in GIS. In this chapter, the key findings are summarised

and recommendations of the study also outlined. Further research on GIS in secondary school is recommended to investigate other related issues on this technology.

5.2 SUMMARY OF RESEARCH FINDINGS

Teaching and learning of GIS in South African secondary school curriculum of geography was introduced and implemented in 2006. In the same year, GIS was introduced in Grade 10, the following year Grade 11 and grade 12 in 2008 (DoE, 2008a). Today, ten years later, GIS teaching and learning is still a challenge in the secondary schools of South Africa. This research focused on Limpopo Province. Grade 12 learners continue to leave out questions on GIS when writing their final year geography paper, because teachers do not teach it on the basis that they do not understand it. The following findings were identified during the analysis of the data collected.

i. Teachers' knowledge of GIS is still lacking and this contributes towards poor performance of learners on this section in particular during their end of year Grade 12 Geography Examination. From the test given to sixty learners in selected schools in the Capricorn District of Limpopo, learners whose teachers indicated that they did not know GIS, performed below average, and those who performed better were from schools where the teachers indicated that they had little knowledge of GIS.
ii. Many schools do not have both hardware and software for teaching and learning GIS in their schools and this contributes adversely towards the teaching and learning of GIS. GIS is a hands-on discipline, and cannot be taught without supporting resources.
iii. Schools that are in urban areas (former Model C schools) and located in areas that are said to be affluent and schools categorised as quintile 1 and 2, together with well-established private schools, do not have GIS computer laboratories as expected.
iv. The Department of Basic Education in Limpopo Province does not organise workshops where qualified GIS trainees can engage secondary school teachers on some basics of GIS.

v. The Limpopo Department of Basic Education (LDBE) office does not utilise facilities available at the two local universities in the province: University of Venda and the University of Limpopo. The two institutions offer full programmes on GIS and have well equipped GIS laboratories which local secondary school teachers and learners could utilise.

vi. Learners continue to learn GIS theoretically because of lack of equipment in their schools. GIS is a practical field of study which is ICT related.

vii. Geography Subject Advisors appointed by the Limpopo Department of Basic Education do not know the content of GIS and cannot organise qualified people from institutions of higher learning in the province, who can assist in closing the gap by offering introductory training on this technology.

viii. Most teachers use the text book method when teaching GIS due to shortage of GIS equipment. The textbook method is a theoretical method because the teachers read directly from the textbook and explain what is meant to the learners.

5.3 RECOMMENDATIONS OF THE RESEARCH STUDY

The use of geographical information in decision making and problem solving has become very popular in government administration offices, municipalities, businesses and many other related institutions. The development of spatial literacy will include the availability of computer-based tools like GIS which will allow learners to interact with data, manipulating it and reflecting critically using the geographical approach. Introducing GIS at secondary school level gives learners a good foundation to understand the digital representation of spatial phenomena, while still at lower levels of study. Training learners at this lower level prepares them for future professional careers which South Africa needs in especially management positions.

This research emphasises that a GIS teaching and learning framework integrates inquiry and problem-based learning. Kinniburgh (2010) indicates that GIS teaching and learning in the new revised curriculum of New Zealand sees inquiry learning as an effective learning method. Learners are encouraged to become lifelong learners

with emphasis on student autonomy. This is a constructivist approach of learning, which is emphasised in this study.

In view of this background, the following recommendations are proposed:

5.3.1 Support of GIS teaching and learning from the Department of Basic Education

The education system in South Africa is under the control of the Department of Basic Education and it is therefore very critical that the DBE takes the lead in the implementation and support of GIS in schools. The government gazetted the encouragement of use of technology in the teaching and learning of subjects such as Maths, Life Sciences, but does not practise the principles gazetted. This is a big challenge on the part of the department. The use of ICT in the teaching of geography could also be prioritized so that GIS can become s focus. The government, through the Department of Basic Education, must influence teaching and learning in schools. Policy related issues must be pushed and implemented by government. The DBE must see to it that teachers implement whatever the policy dictates to them to do.

5.3.1.1 GIS and education policy

In accordance with Government Gazette Volume 540 Number 33283 of 2010, effective implementation of e-education implies substantial investments in suitable infra-structure for ICTs and in appropriate equipment. The document indicates that 70% of schools do not have computers for teaching and learning. As mentioned before in this study, GIS and ICT are related disciplines. The educational policy states clearly that the department should provide ICT infrastructure in schools. The DBE continues to fail secondary schools by ignoring this part of the policy as stated in the Government Gazette. The DBE should prioritize the development of ICT infrastructure in the secondary schools of South Africa.

Prioritizing it will mean that after the development of infrastructure, the department must train teachers who will operate the hardware. The department must provide security for the computers in schools to avoid burglary by criminal elements. This is one weakness on the part of the department. They must account for reasons why these computers are not supplied in secondary schools. It is imperative that government should budget for developing and improving ICT infrastructure in secondary schools.

When collecting data for this research, the researcher found one secondary school in the rural Sekhukhune District that could not use computers because the principal feels that they are not safe. About thirty computers are locked in a 'safe room' which is not accessible to anyone. The department and school do not take an initiative of providing security so that computers can support teaching and learning in that school; not only in GIS teaching, but also in other needy subjects. The future of learners cannot be held to ransom because of failing to provide security in schools. It should be considered that if a computer is not used now, in four to five years, new software will not comply well with this computer. The department and private donors waste money if computers in a school are stored without being used for the purpose they were supplied for. This study recommends that the department must consider providing trained and armed security to all secondary schools in South Africa. The National Department of Basic Education should look into financing this endeavour to create a good teaching and learning environment for GIS technology.

5.3.1.2 Training unqualified teachers to teach GIS

The study revealed that most teachers who were sampled do not have knowledge of GIS. This forms technical, material and pedagogical obstacles for the teaching and learning of GIS in the classroom. To change this landscape, this study proposes that the Department of Basic Education (DBE) should organise GIS courses for geography subject advisors and geography teachers in Limpopo Province. In Taiwan, in 2009, over 1 000 geography teachers attended GIS workshops to make sure that spatial information and GIS teaching are standardized (Kerski et al., 2012). In Limpopo Province, this could possibly be scheduled during the winter vacation with credited institutions like University of Limpopo and University of Venda because these institutions offer GIS as a course. The universities can issue out certificates to

those attending such courses. The certificates will also encourage teachers to attend even further GIS courses with other institutions of their choice. Collaborative face-to-face teacher training will add more value towards improving the GIS knowledge and skills in Limpopo Province. Both universities could also provide pedagogical and didactical help through providing ready-made sequences and tutorials to work with other geo-tools such as Google Earth, Virtual Earth, Esri software and others available. GIS cannot be taught like other geography sections; it needs a special approach. Engaging GIS teachers in this project can assist them in the application of better methodologies of presenting GIS which they could use in their schools. Teachers should remember that GIS is a technological part of geography which differs from other sections. GIS teaching and learning involves doing while you learn.

5.3.1.3 Requirements of teachers to teach GIS better

The findings of this research study revealed that many geography teachers and the geography subject advisors cannot use and work with ICTs. The DBE do not have any strategy or consistent attempt to train secondary school geography teachers in GIS. Workshops are not organized to get some qualified GIS professionals who can train teachers in Limpopo. The department officials are aware of the problem, but they do not even make an attempt to approach people who can provide the necessary assistance. Running GIS workshops should not consist of traditional academic “vector/raster” training that has little relevance to secondary school teachers and which lacks inspiration. The courses should not be barriers to GIS teaching in secondary schools.

These teachers must be trained and the courses must be prepared by people who will consider the background of these teachers. Organizing GIS classes for teachers who never worked with ICT and who never taught ICT, must be introduced with caution to avoid disaster. Introducing teachers to GIS courses without taking their background into consideration might turn out to be a big hurdle. Since these teachers lack GIS skills, it would be advisable to provide them with teacher training and easy access to the course using software that is user-friendly. The teachers will need software, data and teaching materials adapted to their educational context.

Since GIS software and teacher training is expensive, it would be advisable for the DBE to collaborate with universities to cut costs. Universities, as part of their community engagement initiative, can train them at lower costs and utilize institution's hardware and software to train them. Teachers could also be exposed to open source GIS software that can be downloaded freely from the Internet and be used without any costs incurred. Teachers can also be shown the GIS Apps available on their smartphones and tablets. Some learners in schools have these instruments which can be used as teaching aids for GIS teaching and learning. Two important needs are GIS tools and geographical data that can be used when engaged in GIS assignments and exercises. Tools here refer to both hardware and software required for running GIS applications.

5.3.1.4 Funding challenges for the implementation of GIS in schools

The teaching and learning of GIS in secondary schools of Limpopo Province remain a challenge in as far as funding is concerned. Access to the internet should be given priority in secondary schools where schools could be given free access to free Internet usage both in rural and urban schools. Municipalities could collaborate with the DBE to make this possible. In his State-of-the-province speech, Gauteng Premier David Makhura announced that Tshwane Metropolitan Municipality is to launch Free Access Wi-Fi in April 2015 (Sapa, 2015) to supply free Internet bundles to the whole area falling under its jurisdiction. Free Wi-Fi facilities are freely accessible to citizens in that municipality. Schools, universities, business and ordinary civilians have access to this free service. This will ensure that all schools have broadband internet access. Other municipalities should start to follow this approach used by Tshwane Metropolitan Municipality.

Concerning the supply of hardware and software, the department should consider a staggered approach. If schools cannot be supplied with many computers at the same time, the Department can start with the supply of at least 1 computer/ 5 learners /secondary school. The government could sign an agreement with secondary schools and the hardware and software suppliers. This research study has emphasized that GIS teaching and learning cannot take place without hardware and relevant software. This is a practical area of study. Learners must do as they learn.

Teachers are expected to show the learners how to access the software and how to apply it. Learners are expected to work on their own as they learn.

5.3.1.5 Sources to support GIS in secondary schools

Secondary schools in Limpopo Province do not have anything in place that could assist in the teaching and learning of GIS. The proposal on the purchasing of hardware has already been made, however, the hardware needs appropriate software and qualified individuals who will operate it. This study proposes software that is relevant for Grades 10 - 12 learners and which the DBE and some schools in affluent areas can afford. Secondary school can take the offer by ESRI: K-12 package: ArcGIS with 5 hardware keys for 500 computers. Schools and youth clubs throughout the world are learning the benefits of including GIS in their lessons and other after school activities related to GIS. Learners in Limpopo and South Africa at large could gain skills which they can use for further education and employment in other sectors of the economy. The background knowledge learners will gain from this programme, together with the analytical skills will enable them to tackle both local and global challenges. This package is offered free of charge online to schools. The Department of Basic Education could enter into an agreement with ESRI, on behalf of schools in South Africa. For this to succeed, schools must first be equipped with hardware. The DBE should consider purchasing I-pads for secondary schools in the country. The Provincial Education Department in Gauteng initiated a programme of supplying schools with I-pads, but were stopped because of criminal elements who were breaking into school buildings to steal these gadgets.

In South Africa, data is available from Statistics South Africa (SSA), which is a government controlled institution. SSA has provincial offices that could assist schools with data that they could use in their schools for different types of projects that could take forward the teaching of GIS in secondary schools. The DBE can negotiate on behalf of schools, with SSA, so that schools can access data at discounted prices or for free for GIS assignments. The DBE should also collaborate with government institutions that have data so that schools can have access to data which secondary school teachers and learners could utilize in the teaching and learning of GIS.

It must also be taken into cognizance that GIS taught in schools currently should be revised. The Department of Basic Education need to get experts who can develop curriculum that has GIS for education. GIS is broad and discussing topics that are of tertiary standard at secondary level will not benefit learners. ESRI South Africa can assist the DBE to come up with GIS content and activities that is suitable for secondary learners because they are experts in this field. Klonari (2009) cites that ESRI France was responsible for proposing tools for education in secondary schools in France. They also proposed four modules that could be taught to teachers interested in learning how to teach GIS in secondary schools. ESRI France also helped the ICS-School in La Ville du Bois, which is involved in the European IGUESS project and offers technical support in the training of GIS teachers and offer free licences to students. This is possible for South African GIS curriculum development in secondary schools. What needs to be developed is GIS for Education, which will mainly be education-based.

5.3.1.6 Time required for learners' practical's work and for training teachers on GIS

Training teachers on GIS needs sufficient time. GIS teachers need sufficient time to be trained and learners also need sufficient time to be taught GIS. The traditional period times allocated for each subject on the school time table will not be sufficient for teaching and learning GIS in a secondary school. In a GIS computer laboratory where learners have to participate in hardware operations, a period of about 45 minutes is considered minimal. The GIS teacher must be prepared to offer GIS lessons after normal teaching hours. This will in turn given the learners enough time to do their projects and exercises on their own. Baker (2005) hints that the required commitment in terms of time on the side of the GIS teacher, is beyond the control of schools, for adoption of GIS into their teaching curriculum. He goes on to indicate that if the teacher uses Web-based GIS applications, teachers can avoid time barriers. In the context of schools in the Limpopo Province, the Web-based GIS application has not been thought of yet because schools do not have computers yet. Norwegian high schools have managed to adopt GIS without spending a lot of money on computer resources and much time to master the technology because

they adopted GIS-based Web applications (Rod et al., 2012). If the GIS infrastructure was well developed in the secondary schools of Limpopo Province, perhaps this could be the best approach to use.

Previously under recommendations, this study proposed that teachers attending GIS training courses should do so during winter vacations. GIS learning needs enough time because one learns by doing. The facilitator needs to involve student-teachers in practical projects which need enough time to complete. This study maintains that GIS teaching and learning involves “doing”. If teachers want to learn GIS, they must have working hardware. The facilitator would want to see each of the student-teachers doing practical examples.

GIS programmes should not be relegated to after school when teachers are tired and on their way home. This is one part of the curriculum which needs budgeted time. One cannot do it at home because one might not have hardware that is loaded with the necessary software. To attend full training on GIS, the learner must be in the computer laboratory where a facilitator uses a projector to lead the trainee. With enough time allocated, more responsibilities would be expected from GIS student-teachers to attain a productive teaching-learning environment. It is necessary that enough time is allocated to this type of training for it to deliver good results.

5.3.1.7 Using a data projector as a teaching aid for teaching GIS in secondary schools of Limpopo Province

Secondary schools in Limpopo Province can afford to purchase data projectors that can assist in the teaching and learning of GIS. The geography teacher with his/her laptop can connect to it and conduct a GIS lesson while all learners in a class are watching on the screen. Even if learners do not get an opportunity to operate the laptop on their own, the researcher believes it will benefit learners in secondary school of Limpopo Province because they do not have facilities in their schools yet. Learners in such lessons can be afforded an opportunity also to operate the computer, while their peers are watching on the screen. The teacher could use these type of presentations to engage learners and to give them an opportunity to suggest spatial projects that the class could do. The teacher could bring a recorded GIS

lesson downloaded from the Internet to use in the teaching and learning of GIS and present it using a data projector in class. This study proposes that the Provincial Education Department provides each secondary school with a data projector and a laptop. In the interim, GIS teachers who are GIS literate could use these technological tools to teach GIS to learners. Before the DBE looks into the bigger picture of supplying computers and software to secondary schools in this province, some form of interim intervention needs to happen. Many secondary schools are electrified and data projectors and laptops can really assist to reduce the impasse.

A data projector can even be rented for a period that the school may require. It is very important that if the school does not have good security where these tools could be safe, it will be better if the school rents. Geography teachers who own laptops can use them to teach learners. Educational videos that are on GIS lessons could also be rented or ordered. The video content needs to be checked first by the teacher to find out whether the lessons are relevant to the secondary school level or not.

5.4. CHALLENGES IN THE IMPLEMENTATIONS OF GIS IN LIMPOPO PROVINCE

This section of the study addresses barriers or difficulties that the secondary schools are encountering with the implementation of GIS. Obstacles for teaching and learning GIS could be encountered by teachers, department officials, learners and parents. The barriers can be at school, circuit, provincial or national level. The study examined possible barriers that could be encountered when rolling out GIS training and implementation.

5.4.1 Teachers and use of current technologies

Teachers who are not comfortable with technology often oppose the introduction on new innovations. In the analysis of data, teachers who are in the category of between 50 and 60 years of age, showed lack of interest in terms of introducing GIS into secondary schools. There are different reasons for this action. Some of them do this because they believe it is of no use to embark on learning about this technology when they are about to retire. Some teachers view training on computers as another

way of getting back to school, where studying is involved and do not really want to see themselves going back to that situation. Rolling out GIS teaching and learning in secondary schools will always encounter resistance from some teachers.

Some teachers do not have any interest at all. They believe GIS is not going to change anything in the geography knowledge. One responded teacher indicated that whether GIS is introduced or not, climatology will remain climatology. This respondent does not value, for example, how through the use of technology, the weather data can be captured easily today to provide updates on every occurrence that takes place in the troposphere and that impact this has on our daily life in terms of the weather. Komlenović et al., (2013:100) maintain that “although computers are considered to be widespread and are irreplaceable means of communication in the computer era, their use in schools is still not frequent enough for the purposes of education”. If modern geography teachers can start using computers when presenting lessons and applying GIS in secondary schools, it will definitely change the mind-set of many teachers, regardless of age.

5.4.2 Lack of awareness of spatial thinking and analysis

Spatial thinking can only be taught and learnt in a geography class. Beside the fact that many teachers indicated lack of hardware and software as being a challenge in moving forward with technology in schools, societal issues are also a great constraint in embracing GIS as a required tool in education. Communities need to be aware that spatial thinking and analysis are very important in education and the society in which that education serves. GIS lies within geography like in many other countries, such as Norway, United States of America and United Kingdom, to name some few. In countries such as Turkey, geography is a compulsory subject from Grade 9 to 12 and the emphasis is on project-based learning (Kerski et al., 2012). In the United Kingdom, geography is also compulsory from the ages 5 to 14 years. This assists learners in thinking spatially and in learning how to analyse phenomena in space. This is an important element in geography teaching and learning. No other subject can take the space of geography education in terms of teaching spatial issues. In South Africa, geography is not compulsory and is not given priority like Mathematics, Physical Science, Accounting and Life Sciences. The education policy

in South Africa does not really define the importance of geography to learners. Geography is categorised as a Social Science instead of a pure Science, where it belongs. GIS itself needs learners who will be able to think critically and such skills should be embedded within the curriculum. The use of GIS in secondary schools makes learners develop spatial thinking and analysis that will make geography a unique discipline.

5.4.3 Provision of affordable hardware and software

It is obvious that the development of technological infrastructure in secondary schools could have a positive impact on the delivery of GIS teaching and learning. Hardware and software are expensive and not easily afforded by schools, and have proven to be a limiting factor in GIS teaching and learning in secondary schools. It is therefore very important to negotiate for less expensive computers with computer manufacturers. South Africa should initiate a “One Laptop per Child” school programme that would enable every learner to possess a laptop or to have a computer at school. If the DBE could achieve this in Limpopo Province and all provinces in South Africa by 2030, GIS teaching and learning will cease to be a problem in secondary schools. In the prediction of the future of GIS teaching and learning in many countries which still have infrastructural challenges, Kerski et al. (2012) predicts that the landscape of GIS in education will change “dramatically” with regard to software. Web-based GIS will solve many challenges of GIS teaching and learning in many schools throughout the world. They predict that Web-based GIS can be used entirely online with a Web-browser thereby discouraging software installation and a lot of work with schools’ IT staff. The Web-GIS solutions is where learners could save their spatial data and assignments (projects) on the servers. This will be a welcome move from the current desktop-based paradigm of teaching that is still being used today. It is anticipated that many analytical capabilities of the desktop will migrate to the cloud.

The general aims of the South African Curriculum states that one of its aims is to facilitate the transition of learners from educational institutions to the workplace [DBE, Curriculum and Assessment Policy (CAPS), Geography Final Draft, 2012]. The GIS industry has made a positive impact on the economies of different countries

and its future cannot be undermined. Industry must look into its software costs as its prices continue to be above the reach of secondary schools. The price of ArcView, which is said to be the best software in the GIS industry globally, is far above the affordable level. Secondary schools cannot afford it. This is viewed as one of the impediments that bar secondary schools from moving forward with the smooth introduction of GIS. Software prices should therefore be re-examined for smooth future implementation of this technology.

5.4.4 GIS publicity in schools, circuits, districts and provinces

Geography teachers, with the support of the provincial office of the DBE, should publicize what they are doing in their respective schools. Teachers must make the communities know about exemplary GIS projects that they carry out in schools. Communities do not know what teachers are doing in schools. Circuit managers and school managers should organize exhibition days in which GIS products and other related features could be shown to the communities they are serving. Posters could be shown to parents and the community where the school is located on parents' day. School administrations can organize such events where local businesses and people are invited to raise money that could be used in purchasing computers for GIS teaching and learning. When such events are organized, local media could be invited to publicize the event and to drive GIS awareness messages to the people. Such events will attract local business people who can donate capital that could be used in purchasing computers. Schools could open Facebook, Twitter, Linked-In and other social network accounts which can open up links between the school and the community. Alumni who are already working could help in supporting such fund-raising events. Many schools in Limpopo Province do not organize such activities. For GIS knowledge to diffuse, publicity is very critical.

5.4.5 Disparity of resources in South African schools

Schools in Limpopo Province continue to show a great difference in terms of resource allocation. More than twenty-two years after the inequalities in education were phased out, most schools in rural areas Limpopo Province are still under resourced. A number of secondary schools are still without electricity. Some schools

have been electrified, but they cannot maintain the electricity bill because the schools are serving poor communities who are exempted from paying school fees. They rely on the quintile funding from the Department of Basic Education. Even if such schools can be supplied with computers, they will not be able to use them because of the unavailability of electricity. This is a serious barrier that needs serious intervention from the DBE. Schools that are located in towns and cities of Limpopo Province reflect a different perspective when compared to those in rural areas. Inequality continues to affect the learners negatively in rural schools of Limpopo Province. Authorities could allocate more budget in rural-based school to address this problem.

5.5 GENERAL CONCLUSIONS

The teaching and learning of GIS in the secondary schools in Limpopo Province is confronted with problems. Professional development in GIS is still a difficult issue for many teachers teaching GIS in secondary school of Limpopo. GIS teachers in Limpopo Province are still in need of training that could give them a foundation of what GIS is about. School Governing Bodies need to be educated priority in terms of purchasing teaching resources that could support the teaching and learning of GIS. The Limpopo Department of Basic Education should come up with a strategy of training teachers in the teaching and learning of GIS in the province. The research has revealed problems related to the poor performance of Grade 12 learners in GIS in the secondary schools.

In any form of teaching and learning, the teacher is the central driver who must ensure that the objective of the lesson is achieved. Geography teachers are developed professionally to teach and supervise the teaching and learning milieu in class, but lack pedagogical approaches to teaching and learning GIS. GIS cannot be taught like language, for instance. When teachers teach GIS, they must support the learners instead of controlling them. Learners must have time for practical experience in GIS, and that is possible if the school has hardware and software. Teachers must receive pre-service training on GIS before teaching it. The data collected indicated that teachers are prepared to be trained but the Department of Basic Education does not provide this training. Schools in Limpopo Province are not

well equipped to teach and learn GIS. Teachers have positive attitudes about GIS, but are discouraged by lack of hardware and software in their schools.

This research postulates that GIS teaching and learning in South Africa is at a crossroads. The Department of Basic Education needs to give support to teachers, otherwise GIS teaching and learning at the FET level will fail. GIS has a role to play in the future generations. GIS will open up avenues for current geography learners to become future researchers. Literature on teaching and learning of GIS in secondary schools and global reports indicate that GIS has been moving slowly in many countries of the world, South Africa inclusive. Komlenović et al. (2013) indicate that only few secondary schools during the 1980s, recognised GIS as a new teaching aid in the geography classroom. It was later in the 1990s, ten years later, that many developed countries introduced GIS in their secondary schools curricula (Bednarz, 2004; Kerski, 2003; Scheepers, 2009). The diffusion of GIS in secondary continues slowly in the less developed countries and the main barriers are funds to buy equipment that will assist in its teaching.

Komlenovic et al. (2013) illustrate on the table below, when GIS in secondary schools of different, selected countries of the world was introduced.

Table 5.1: Selected countries that have introduced GIS in Secondary Schools

Country	**Year of introducing GIS in schools**	**School level**	**Actual use of GIS in the classroom**
South Africa	2006	Secondary school level (Grade 10, later in Grade 11 and 12	Not widely spread

USA	1996	US National Scientific Education Standards	Wide use of digital maps, but small number of schools adopted GIS
Turkey	2005	National curriculum for secondary schools (9^{th} – 12^{th} Grade)	At the beginning of GIS adoption in schools
England and Wales*	1991; 2000	National Curriculum programme of study (KS3, KS4 and A level)	GIS has been compulsory in Geography teaching since 2007
Norway	2006	Secondary school level (upper level, 16-19 years old)	Advanced use of digital maps and GIS
Finland	2003	National Frame Curriculum for the upper secondary school, GE4	Not widely spread in schools, except at GE4 level
France	2000 – 2002	Secondary school level (only in the tutorials for history/geography teachers)	No general use of GIS in schools, except in individual cases
Germany	1998 – 2001	Secondary school level (GIS is included in several different curricula)	Remarkable progress in using GIS in schools in the last five years
Belgium**		Secondary school level (only the Flemish community in 3rd grade	GIS is only mentioned in the Flemish curriculum

Source: Komlenović et al. (2013)

*Obligation to use it from 2007

** The situation in Belgium is different for the two communities, Flemish and Trench; no data about the time of introduction of GIS in schools.

From the table, it is evident that mainly developed countries have introduced GIS in their curriculum except South Africa which is still developing.

When South Africa is compared with other countries in terms of introduction of teaching and learning of GIS in secondary schools, it is on the same level with other developed and developing countries. Looking at the table, one could appreciate that South Africa is not left behind other countries and this is indeed commendable. South Africa is certainly moving at the same pace with other countries of the world. Some South African scholars such as Scheepers (2009), Breetzke et al. (2011) and Innes (2012), have also published on GIS teaching in secondary schools in South Africa. The table further shows that countries such as Norway, Turkey and France are almost on the same footing with South Africa. According to Klonari et al. (2009), many subject areas will benefit from learning GIS technology because it leads to many more types of careers and professional activities that involve GIS. If the Department of Basic Education can fully support GIS in secondary schools it could certainly open gates to many learners' future careers. GIS cannot be singled out from other ICTs as being the most mentioned education technology. In Limpopo Province, only a few teachers have the knowledge and skills to apply this technology in practice. The Department of Basic Education took on informed decision by introducing GIS at the secondary level because GIS applications can range from crime to landscape management, and from business analysis to modelling of the environment. It is therefore a relevant and appropriate field to have been introduced. If required resources could be provided in teaching and learning of GIS, future generations could benefit and this can have a positive impact on the economy of South Africa.

5.5.1 Suggestions for future research

The aim of this research study was to investigate the teaching and learning of Geographical Information Systems (GIS) in secondary schools of South Africa using Limpopo Province as a study area. Data collected for this study was on teaching and learning of GIS in the secondary schools of Limpopo Province and South Africa at large. GIS teaching and learning in secondary schools of South Africa and the world at large is a new initiative. Challenges confronted by both teachers and learners in GIS teaching and learning are in existence and need to be investigated. This

research study identified some hindrances that deter the smooth introduction of GIS teaching and learning in the secondary schools. One of those deterrents is the lack of knowledge of GIS by the teachers. Another question that was investigated was whether teachers with GIS knowledge, if placed in schools where equipment is not available, can geography learners do better in GIS? Are both components, the qualified teacher in GIS and the presence of hardware and software necessarily needed to make a learner understand GIS? Beside the theory of constructivism that was applied in this research study, is there perhaps another alternative theory that could be used in the teaching and learning of GIS? These are some of the questions that other GIS scholars can research on going forward. Teachers in Rwanda managed to train each other through the 'snowball effect', where initially in the pilot, ten teachers were trained in using GIS in their teaching at secondary school level, and each of them had to train three teachers from the surrounding schools (Forster, 2008). The programme rolled out in such way that every time after the three were trained, in the next year each of them would train three more around them (Forster, 2008). Can GIS teachers in Limpopo Province resort to this type of programme? Can it really work? Other researchers should look into other ways of teaching and learning GIS in secondary schools of South Africa. It is imperative that other avenues that could ease the teaching and learning of GIS in secondary schools be looked into.

Hardware and software are expensive and they impede the progress of teaching and learning GIS in secondary schools in South Africa. This study suggests that other researchers look into developing software that could be for secondary school teachers and learners, software that could be affordable to the department and secondary schools. The software should specifically be for geography education. Software like ArcGIS, is not for geography education per se, but it is for all data that one wants to run. Kerski et al. (2012) propose that GIS in education should have its own approach which is different from other perspectives.

The geospatial competence of all nine provinces in South Africa is not the same. Innes (2012) showed provincial scores for matric geography examination paper on topographical maps and orthophoto readings for the period 2000 to 2007. Western Cape followed by KwaZulu-Natal and Northern Cape performed better as compared

to North West and Limpopo, which were at the bottom of the table. Using this approach, this research study suggests that all the nine provinces be compared in terms of GIS performance, and the reasons for the differing performances be investigated. Western Cape and Gauteng Provinces may reflect a different scenario because they are urban and lead in the matric results performance every year. If their geospatial competence is not the same, what is it that is done in the provinces with high competence which is not done in other provinces? Can one argue that spatial vocabulary and understanding of concepts are key to spatial thinking?

Understanding GIS begins with understanding of map reading. A teacher cannot teach a learner how a map is read without having a map to read. According to Innes (2012), many schools do not have adequate resources for teaching map use. Policies promoting the use of IT in education are in place, but there is no national rollout of teaching resources that could make the use of GIS in geography education accessible to all learners in the country. In most of the rural schools in Limpopo Province, which are highly under-resourced, geography education is under threat because of the introduction of GIS in the curriculum of geography. Some schools opt not to offer geography any longer because of including GIS in the geography curriculum (Innes, 2012).

5.6 CONCLUSION

This research study investigated the problems encountered by teachers in the teaching and learning of GIS in South African secondary schools. Introducing GIS at the secondary school level is an initiative that deserves to be applauded for it takes the use of technology in geography to a higher level. The Department of Basic Education in South Africa is moving at the same pace with other countries of the world in terms of the geography curriculum. GIS was technology that was taught only at institutions of higher learning, and it is pleasing that today it is taught at the secondary school level as well. Its impact on the economies of different countries cannot be ignored.

Cell phones today are not only used as instruments for making calls, but also as an instrument that is loaded with GPS essential for showing us positions of places. As

travellers, is not necessary to purchase a map that could direct you when driving in an area that you not familiar with. Your smart phone could assist you in this regard if it is GIS compliant. The fact that one cell phone can provide all these services it means that it is loaded with GIS software. The cell phone has got the maps of all the countries, all cities and towns of the world, and all streets of the world and much more. This is the GIS which some people do not realize exists. It is therefore critical that this knowledge be taught in secondary schools so that future generations can develop even more advanced GIS software that the ones currently in use.

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APPENDICES

APPENDIX A: APPLICATION LETTER FOR PERMISSION TO COLLECT DATA FROM SCHOOLS IN LIMPOPO PROVINCE

UNIVERSITY OF LIMPOPO

Turfloop Campus

Faculty of Humanities

School of Education

Private Bag x 1106

Sovenga

0727

SOUTH AFRICA

Tel: 015) 268 3176

015)268 2928

Fax: 015)268 3533

11.07.2012

The Director – Examination Section

Limpopo Provincial Department of Education

POLOKWANE

0700

TO WHOM IT MAY CONCERN

This communication serves to confirm that **Mr. P.J Sefara** is a fully registered Ph.D Geography Education candidate in the **Department of Curriculum Studies** in the School of Education at the University of Limpopo. The title of his thesis is: **Developing Models of Teaching Geographical Information Systems in Secondary School of South Africa.** He is currently collecting data as part of the research.

The supervisor will be grateful if Mr. Sefara is provided with the assistance he requires in order to complete his research.

Thanking you in advance for your assistance.

Sincerely,

…….

Prof. M.J. Themane

HOD: Educational Studies

,

APPENDIX B: APPROVAL FROM LIMPOPO EDUCATION DEPARTMENT

LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF EDUCATION

Enquiries: Dr. Makola MC, Tel No: 015 290 9448. E-mail: MakolaMC@edu.limpopo.gov.za.

Private Bag x1106

SOVENGA

0727

LIMPOPO PROVINCE
DEPARTMENT OF EDUCATION
2012 -07- 18
H.O.D'S OFFICE
PRIVATE BAG X9489 POLOKWANE 0700

Dear Sefara P.J

RE: Request for permission to Conduct Research

1. The above bears reference.
2. The Department wishes to inform you that your request to conduct a research has been approved- **Title: DEVELOPING MODELS OF TEACHING GEOGRAPHICAL INFORMATION SYSTEM IN SECONDARY SCHOOLS OF SOUTH AFRICA.**
3. The following conditions should be considered:

   3.1 The research should not have any financial implications for Limpopo Department of Education.

   3.2 Arrangements should be made with both the Circuit Offices and the schools concerned.

   3.3 The conduct of research should not in anyhow disrupt the academic programs at the schools.

   3.4 The research should not be conducted during the time of Examinations especially the forth term.

   3.5 During the study, the research ethics should be practiced, in particular the principle of voluntary participation (the people involved should be respected).

Cnr. 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X9489, POLOKWANE, 0700
Tel: (015) 290 7600. Fax: (015) 297 6920/4220/4494

The heartland of Southern Africa – Development is about people!

3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.

4. Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.
5. The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.

Thamaga MJ

Head of Department

2018/07/27

Date

APPENDIX C: QUESTIONNAIRE FOR COLLECTING DATA

THE TEACHING AND LEARNING OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS) IN SOUTH AFRICAN SECONDARY SCHOOLS – A CASE OF LIMPOPO PROVINCE

Secondary School Teacher's Questionnaire Code……

BRIEF EXPLANATION ABOUT THE RESEARCH PROJECT

The aim of this study is to develop a model of teaching and learning GIS in South African Secondary Schools. I would like to ask you questions regarding the status of teaching GIS in your school. This is not a test and there are no wrong or right answers, choose only those suitable for you. Respond to the best of your knowledge. Your responses will make valuable inputs in the use of GIS in the teaching and learning of Geography. If you do not understand any of the questions, be free to ask the researcher for clarification. All responses will be confidential, so do not write your name.

Thank you.

PART 1

SECTION A: PERSONAL DATA AND TRAINING EXPERIENCE OF TEACHERS

1	Gender?	1. Male	
		2. Female	
2.	What is your age band?	1. 20 - 30 years	
		2. 31- 40 years	
		3. 41-50 years	
		4. 51-60 years	
3.	How long have you been teaching geography?	1. 1 - 10 years	
		2. 11 - 20 years	
		3. 21-30 years	
		4. 30+ years	
4.	What qualification do you possess?	1. Diploma	
		2. Bachelor Degree	
		3. Postgraduate Degree	

		4. Other	
5.	What other subjects have you trained to teach?		
6.	Fill in the Grade (s) and subject (s) you teach.	Grade (s)	
		Subject (s)	
7.	Is your school rural or urban?	1. Rural	1. Urban

SECTION B: SKILLS IN GIS

This section asks questions about skills in teaching and learning GIS. Indicate to what extent you agree with the following statements

(Check your answer in the correct box)

	Strongly Disagree	*Dis-agree*	*I do not know*	*Agree*	*Strongly Agree*
1. Basic computer skills are necessary for teaching GIS technology in secondary schools ……	☐	☐	☐	☐	☐
2. GIS is a valuable tool that gives learners necessary skills to conceptualize spatial information	☐	☐	☐	☐	☐
3. GIS requires learners' basic computer skills	☐	☐	☐	☐	☐
4. GIS improves cartographic skills ……	☐	☐	☐	☐	☐
5. GIS improves learners' spatial-related problem-solving skills ……	☐	☐	☐	☐	☐
6. GIS improves geographic research skills ……	☐	☐	☐	☐	☐
7. Relevant hardware and software equipment are necessary to teach and learn GIS skills effectively……	☐	☐	☐	☐	☐

8. The Department of Education work shopped me on skills of teaching and learning with GIS ……. ☐ ☐ ☐ ☐ ☐

9. I have been exposed to GIS technology before teaching in secondary school…… ☐ ☐ ☐ ☐ ☐

10. I need more capacity building workshops on GIS ☐ ☐ ☐ ☐ ☐

SECTION C: KNOWLEDGE OF GIS

This section asks questions about knowledge in teaching and learning GIS. Indicate to what extent you agree with the following statements

(Check your answer in the correct box)

	Strongly Disagree	***Dis-agree***	***I do not Know***	***Agree***	***Strongly Agree***
1. GIS is a system in which spatial information may be stored, manipulated and displayed ……	☐	☐	☐	☐	☐
2. A map is a key tool in the study of spatial relationships	☐	☐	☐	☐	☐
3. I believe GIS is a valuable tool that enable learners to learn about spatial relationships……..…	☐	☐	☐	☐	☐
4. I have enough knowledge about how to incorporate technology into my geography teaching……	☐	☐	☐	☐	☐
5. I know at least one GIS software…… ……	☐	☐	☐	☐	☐
6. I can display a wide variety of vector formats using GIS software.....	☐	☐	☐	☐	☐
7. I can display a wide variety of raster formats using GIS software……☐	☐	☐	☐	☐	☐
8. I can edit point-, line-, and polygon features using GIS software ……	☐	☐	☐	☐	☐
9. GIS can be a powerful tool in efforts to enhance					

education in geography …… ☐ ☐ ☐ ☐ ☐

10. GIS pulls together elements of other subjects in the school curriculum such as mathematics, biology and statistics…… ☐ ☐ ☐ ☐ ☐

SECTION D: METHODS OF TEACHING GIS

This section is about your experiences in teaching and learning GIS.

Indicate to what extent do you agree with the following statements

(Mark your answer with a cross on each line)

	Strongly Disagree	*Dis-agree*	*I do not Know*	*Agree*	*Strongly Agree*
1. GIS in your school is taught with the aid of computers.	☐	☐	☐	☐	☐
2. In your school GIS is mainly taught theoretically…...	☐	☐	☐	☐	☐
3. Lack of computers disadvantages the practical teaching and learning of GIS in my school……	☐	☐	☐	☐	☐
4. Lab-based GIS teaching method excites learners to develop interest in GIS technology ……	☐	☐	☐	☐	☐
5. The Internet-based GIS is an efficient method for collecting huge geographical data for classroom use	☐	☐	☐	☐	☐
6. Lab-based GIS teaching methods are impeded by lack of funds ……	☐	☐	☐	☐	☐
7. In GIS teaching and learning, theoretical approaches are more efficient than practical approaches..……..	☐	☐	☐	☐	☐
8. Our current curriculum emphasizes GIS theory teaching and learning method more than application method	☐	☐	☐	☐	☐
9. Integration of remote sensing in teaching and learning					

GIS can improve learners' understanding of geospatial information…… ☐ ☐ ☐ ☐ ☐

10. The use of GPS in GIS teaching and learning can expose learners to practical fieldwork experience ☐ ☐ ☐ ☐ ☐

SECTION E: GIS RELATED INFRASTRUCTURE

Indicate to what extent do you agree with the following statements?

(Mark your answer with a cross on each line)

	Strongly Disagree	*Dis-agree*	*I do not Know*	*Agree*	*Strongly Agree*
1. Electricity is essential in the implementation of GIS in schools ……	☐	☐	☐	☐	☐
2. My school has an operational computer lab ….	☐	☐	☐	☐	☐
3. Learners in my school have access to computers	☐	☐	☐	☐	☐
4. Rural schools are more disadvantaged in relation to GIS equipment than urban schools ……	☐	☐	☐	☐	☐
5. Lack of funds impede implementation of practical computer-based GIS teaching in our school …	☐	☐	☐	☐	☐
6. Projection screens in secondary schools can help with the teaching and learning of GIS……	☐	☐	☐	☐	☐
7. My school has a computer lab technician to support the use of GIS……	☐	☐	☐	☐	☐
8. Open source GIS software can help with the implementation of GIS in secondary schools……	☐	☐	☐	☐	☐
9. Smartphones and tablets can be used alternatively to run GIS apps which can be used by learners….	☐	☐	☐	☐	☐

SECTION F: GENERAL QUESTION ON GIS

This section want to find out about the general knowledge of teachers towards GIS teaching and learning.

(Mark your answer with a cross on each column by choosing YES or NO)

	YES	NO
1. Are you interested in vacation workshops on GIS?		
2. Do you find GIS difficult to teach and learn?		
3. Do you enjoy teaching the GIS section in geography?		
4. Do you think GIS technology can be easily implemented in secondary schools?		
5. Do you think GIS technology is effective enough to replace analogue paper map teaching in secondary schools?		
6. Do you like working with GIS?		
7. Do you have maintenance support for your computer systems?		
8. Do you think hand-held devices can be used by learners for GIS learning?		
9. Do your learners have hand-held devices such as cell phones and tablets?		

PART 2

1. **What methods do you use when teaching GIS in your school?**

   ……

   ……

   ……

   Explain the reasons why you use that method?

   ……

   ……

   ……

   ……

2. **Does this method work?**

   ……

   ……

   ……

   Why do you think so?

   ……

   ……

   ……

3. **What would you like to learn about GIS?**

   ……

   ……

   ……

4. **What should the Department of Education do to improve the teaching of GIS in secondary schools?**

   ……

   ……

……

……

5. **How do you motivate your learners to use GIS?**

……

……

……

……

APPENDIX D: CLEARANCE CERTIFICATE FROM TURFLOOP RESEARCH ETHICS COMMITTEE

University of Limpopo
Department of Research Administration and Development
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2212, Fax: (015) 268 2306, Email:noko.monene@ul.ac.za

TURFLOOP RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

MEETING:	**06 July 2015**
PROJECT NUMBER:	**TREC/61/2015: PG**
PROJECT:	
Title:	Teaching and Learning of Geographical Information Systems (GIS) in South African Secondary Schools – A case of Limpopo Province
Researcher:	Mr PJ Sefara
Supervisor:	Prof RJ Singh
Co-Supervisor:	N/A
Department:	Curriculum Studies
School:	Education
Degree:	PhD in Education

PROF TAB MASHEGO
CHAIRPERSON: TURFLOOP RESEARCH ETHICS COMMITTEE

The Turfloop Research Ethics Committee (TREC) is registered with the National Health Research Ethics Council, Registration Number: **REC-0310111-031**

Note:

i) **Should any departure be contemplated from the research procedure as approved, the researcher(s) must re-submit the protocol to the committee.**

ii) **The budget for the research will be considered separately from the protocol.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX E: LEARNERS TEST AND QUALITATIVE QUESTIONNAIRE FOR LEARNERS

THE TEACHING AND LEARNING OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS) IN SOUTH AFRICAN SECONDARY SCHOOLS – A CASE OF LIMPOPO PROVINCE

LEARNER'S QUESTIONNAIRE **SCHOOL NO: ----------**

BRIEF EXPLANATION ABOUT THE RESEARCH PROJECT

The aim of this study is to develop a model of teaching and learning GIS in South African Secondary Schools. I would like to ask you some questions regarding your learning of GIS in your school. It is my wish that you respond to the best of your knowledge. Note that there is no wrong or right answer. Your responses are very valuable to me and I would appreciate if you answered all the questions. All the responses will be confidential.

Instructions:

1. **Read all the questions carefully before you shade the Multiple Choice Answer Sheet (MCAS).**
2. **Read the instructions on the MCAS.**
3. **Shade your MCAS properly lest it becomes rejected during marking.**

---

1. The concept GIS stands for ……..
    a. General Information Systems.
    b. Geographical Information Systems.
    c. Geographical Internet System.
    d. Geographical Information of Schools.

2. What are elements necessary for GIS?
    a. Staff and information.
    b. Hardware and software.
    c. Hardware and computer.
    d. Computer and process.

3. +Remote sensing is:
    a. The way in which aircraft and satellites collect data about features on earth without coming into contact with them.
    b. The way in which a truck collects data about features on the earth.
    c. The way an aircraft and satellite collect information in the atmosphere.
    d. The way information is collected by GPS.
4. Resolution is
    a. The darkness of the image,
    b. The length, breadth and width of an image.
    c. The brightness of the image,
    d. The sharpness of an image displayed by dots per inch, pixels per line, or lines per millimetre.
5. Spatial data can be defined as
    a. Data /information that identifies the geographic location and boundaries of features on earth.
    b. Data/Information that explains the relief of the land.
    c. Data/information that describes the natural phenomenon.
    d. Data/information that describes the man-made phenomenon.
6. Descriptive information about spatial objects is called
    a. Spatial data.
    b. Primary data.
    c. Attribute data.
    d. Secondary data.
7. Data that is fed into the GIS is stored in one of two different ways:
    a. Polygon format or grid format.
    b. Vector format or raster format.
    c. Spatial format or attribute format.
    d. Spectral format or temporal format.
8. The raster format is best for showing
    a. Numerical values,
    b. Points and lines,
    c. Polygons to define data,
    d. Databases,

9. The vector format is best for showing
    a. detached features like location of customers,
    b. attached features like number of places,
    c. simple GIS analysis,
    d. remotely sensed data,
10. GPS stands for
    a. General Post Stand.
    b. Global Positioning System.
    c. Global Proof of System.
    d. Good Pool System.

LEARNERS QUALITATIVE QUESTIONS

EXPERIENCE YOU GAINED THROUGH THE STUDY OF GIS

1. **What have you learnt about GIS?**

    ……

    ……

    ……

2. **What are the uses of GIS in today's life?**

    ……

    ……

    ……

    ……

3. **Do you know that navigation of your cell phone is GIS?**

    ……

    ……

    ……

4. **If you agree can you explain why it is so?**

    ……

    ……

    ……

Thank you for your cooperation.

University of Limpopo
School of Languages and Communication Studies
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 3069, Fax: (015) 268 2868, Email:Lukas.Mkuti@ul.ac.za

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To : **Prof J. Singh**
DVC: Research, Innovation and Partnerships

From : **Dr L.D. Mkuti**
Department of Languages

Date : **1 June 2017**

Subject : **EDITING LETTER FOR MR P. J. SEFARA (8201121)**

This letter serves as proof that I edited the thesis of Mr P. J. Sefara entitled ***"TEACHING AND LEARNING OF GEOGRAPHICAL INFORMATION SYSTEMS (GIS) IN SOUTH AFRICAN SECONDARY SCHOOLS: A CASE OF LIMPOPO PROVINCE".***

Kind regards

DR L.D. MKUTI
HEAD OF DEPARTMENT: LANGUAGES