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University of the Witwatersrand
School of Geography, Archaeology & Environmental Studies

Assessing the depth of Geographical Information Systems for teaching and research within the undergraduate Geography curricula of three South African universities

by

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Ethical Clearance Protocol Number: GAES 5-2018-0012

A research report submitted to the Faculty of Science, University of Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Science in Geographical Information Systems and Remote Sensing

Johannesburg, South Africa

DECLARATION

I, **Miyelani Owen Maswanganye**, solemnly declare that this research report constitutes an original work prepared in partial fulfilment of the Master of Science in Geographical Information Systems and Remote Sensing (Coursework and Research report). I further declare that I have never submitted this research report to any other university. I further declare that I have not committed any plagiarism, therefore the use of ideas from other scholars and people were properly referenced in line with the reference guide of the School of Geography, Archaeology and Environmental Studies at the University of Witwatersrand.



Signed and dated: 29 May 2019

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I acknowledge everyone who played an important role during the course of my study, this could have been directly or indirectly. Most importantly, I convey special thanks to the following people:

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- Ms Vongani Sonsy Masonto. You were not just my woman during the course of my study, but someone who showed me a great support and understanding. I want to thank you for the role you played. I found studying being easy because you motivated me.
- Family and friends. Studies made me to be in social quarantine at some times, but you always showed me love and confidence.

DEDICATION

It is a great honour and appreciation for me to have come to achieve this prestigious academic qualification, Master of Science in GIS and Remote Sensing. I thus dedicate this achievement to my entire family, especially my kids (Hlulani, Blessing, Rivoningo and Lwandle). To my father- Yuza Robert Maswanganye, my mother- Lucy Patron Baloyi, my surviving grandmother- Nyanisi Khubani Maswanganyi, and lastly my belated grandfather- Masenyani Ben Maswanganyi; this academic achievement is in honour of all your love, sacrifices and care which you demonstrated to me during my upbringing.

It was not an easy task, but I strived to achieve this Masters qualification through hard work and sacrifice. This is my second master's degree, as I have completed Master of Public Administration with the University of Pretoria in 2016. I decided to embark on this postgraduate study as an effort to improve my knowledge and skills in the field of my speciality. In the course of doing so, I therefore used the study opportunity as an effort to inspire home, confidence and inspiration to anyone who is related to me in life. To this end, this achievement should not only inspire my kids to do more academically, but should also encourage any person who sees me as a role model. Dedication, zeal and commitment always yield good results

ABSTRACT

Geographical Information Systems (commonly known as GIS) is a concept that was coined around the 1960s, firstly as a computer system needed to make accurate, fast and automated measurements from maps and a tool that would be able to carry large numbers of disparate data sets (Goodchild, 2013). It evolved worldwide into a software application that was adopted widely, which has now become a multidisciplinary research tool applied in many research projects that involve a spatial component (Cilliers, 2013; Coppock & Rhind, 1991; Goodchild, 2010; Longley, Goodchild, Maguire, & Rhind, 2011). This research report deals with the use of GIS for teaching and research within undergraduate geography curricula of three different universities, namely, University of Witwatersrand, University of Limpopo and University of North-West. A different approach is used by all three universities under study that use the teaching of GIS within their curricula. Generally, the use of GIS is not entirely to prepare students for a vocational skill and this should be a concern to most universities taking into cognisance the prevailing need of graduates with GIS skills. Again, it is to the benefit of geography as a discipline if GIS can be regarded as one of the catalysts in making sure that the geography discipline remains relevant and competitive in the modern eras characterised by an increase in the use of information technology.

While it is acknowledged that to date GIS has developed into a separate discipline called Geo-Informatics, it remains to be seen if the integration of GIS within geography could be regarded as something of the past that has now become obsolete. This is so because GIS has always been a natural partner to geography and both influence the growth of each other in an insurmountable way (Zietsman, 2002: 30; Longley, 2000). This study has contributed to this debate by emphasising that indeed geography and GIS are intrinsically related to one another. Attempting to teach GIS alone as a technology is inadequate, since it may only prepare students with the technical application of the tool but fails to provide students with sufficient knowledge that can underpin the geographical knowledge such as spatial thinking, spatial variability, spatial connectivity, spatial relationship of objects and all other geographical aspects which are essential for high-level GIS analysis.

While accepting the debate that geography is a logical home for GIS (Hill & Nell, 1996: 150, Society for South African Geographers [SSAG], 2003: 109), the challenge however becomes the manner in which a GIS curriculum is designed and taught within the discipline of geography. There is little doubt that the demand for GIS has increased worldwide, but the challenge is the quality of output which geography graduates possess after completion of their studies. The majority of geography graduates are seen to be ill prepared to perform various GIS functions in the work place.

It is clear that GIS has the power to unify both physical and human environmental aspects using geographical analytical methods. The reality that in the 21st century, there is advancement of technology, GIS had made it easy to perform some geographical processes such as environmental impact assessments, pollution analysis and mapping, et cetera. In accentuating the preceding argument, scholars argue that there should be a balance between research on GIS concepts and principles as well as the GIS applicability in solving practical problems (Nellis, 1994:37). Kemp et al. (1992:189) argued, though, that a geography curriculum development at institutions of higher learning should provide for a clear consensus on content or an appropriate pedagogical approach; including provision of details on the content, sequence, clarification of course objectives as well as striking a balance between education, training and technology. This is lacking in South African geography curricula.

This research uses both qualitative and quantitative research approaches in order to complement the weaknesses associated with each method when used separately. The multi-institutional case study approach supported by a snowballing sampling approach was used for data collection. The standardised questionnaire was developed to collect Likert-scale data from students in three different universities under study. The study also relies on the use of thematic study on content analysis. In doing so, lecturers were asked a set of interview questions aimed to solicit answers intended to validate the responses given by students. The approach proved useful for this study because answers from open-ended questions were analysed and triangulated to verify the similarities and differences. The course outline of each GIS module was also analysed to establish aspects that were covered. The literature review (in this case, studying of course

contents) helped to validate the responses given by students on the standardised questionnaire.

Although the study has its inherent limitations which include lack of representativeness due to having a varying number of students from all participating universities, the findings are of paramount importance.The study has revealed many challenges across three universities; such as lack of resources to teach GIS, lack of sufficient time to conduct practical work, lack of GIS lecturers, high number of student enrolment that makes it difficult to teach GIS within geography, lack of teaching GIS on other geography modules. While these challenges are concerning, the study established some positive outcomes, wherein it was found that University of Limpopo which was a previously black university is performing well on some aspects of GIS compared to the University of the Witwatersrand and the University of North-West.

Students in three universities proved to be familiar with the use of GIS software packages, although they raised concerns about their limited exposure. Students from all three universities showed a strong desire to work in the field of GIS as well as to pursue GIS research. This revelation, therefore, calls for a revision of geography curricula in order to broaden aspects of GIS teaching in South African universities. Again, in South Africa, a GIS job entry requirement is a National Qualifications Framework (NQF) 7 which is a Bachelor's degree, Advanced Diplomas, Post Graduate Certificate and Bachelor of Technology. So, it is important that universities take advantage of GIS market needs in order to train students appropriately. Funding is another challenge that needs to be addressed by universities to ensure that geography degrees take advantage of GIS in order to continue attracting more students as well as to remain a subject of choice to many.

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LIST OF ABBREVIATIONS AND ACRONYMS

BoK	Body of Knowledge
BSc	Bachelor of Science
CD: NGI	Chief Directorate: National Geo-Spatial Information
CSG	Chief Surveyor General
DRDLR	Department of Rural Development and Land Reform
ESRI	Environmental Systems Research Institute
GAES	School of Geography, Archaeology and Environmental Studies
GI	Geographical Information
GIS	Geographical Information Systems
GISc	Geographical Information Science
GISSA	Geo-Information Science of South Africa
GPS	Global Positioning System
GRASS GIS	Geographic Resource Analysis Support System
NRC	National Research Council
NSIF	National Spatial Information Framework
PAIA	Promotion of Access to Information Act
PU	Potchefstroom University
QGIS	Quantum Geographical Information System (GIS)
RS	Remote Sensing
SAGC	South African Geomatics Council
SDI	Spatial Data Infrastructure
SGB	Standards Generating Body
SGSS	School of Geo- and Spatial Sciences
SPLUMA	Spatial Planning and Land Use Management
SSAG	Society of South African Geographers
UCGIS	University Consortium for Geographic Information Science
UL	University of Limpopo
UNISA	University of South Africa
UP	University of Pretoria

NWU	North-West University
UWE	University of West England
USBQs	Unit Standard Based Qualifications
Wits	University of Witwatersrand

CHAPTER ONE

INTRODUCTION AND BACKGROUND TO THE STUDY

1.1. INTRODUCTION

There is a growing demand for Geographical Information Science (GISc) knowledge and skills in South Africa as evidenced by the survey studies conducted in 2014 and 2016. In 2014, Coetzee, Eksteen and Roos (2014) published results of a survey study aimed at gaining insight in the members of the GISc community in South Africa as well as the nature of work that they do. The study reveals that members of the GISc community are experiencing challenges for registration with the SAGC due to the inconsistencies of the academic qualifications against the requirements for Council accreditation. The study further reveals that participants were from different settings, including Environmental Management, Information Technology and Urban and Regional Planning as the three top industries that use GIS on a daily basis (Coetzee et al., 2014).

In 2016, a GISc demand of knowledge and skills survey was conducted through joint collaboration of the University of Pretoria Department of Geography and Geoinformatics, Geo-Information Science of South Africa (GISSA), and Directorate: National Spatial Information Framework (NSIF) of the Department of Rural Development and Land Reform (DRDLR). The survey results revealed that data acquisition, data management, data analysis and interpretation, coordination, visualisation and mapping, as well as training in both the public and private sector are the most common skills that are required. Other GISc related activities are still performed, but they amount to less than 30% of the work. The less than 30% GIS demand of knowledge and skills include system analysis, research, project management, policy development or governance, database administration, management, marketing and development.

The 2016 GISc demand of knowledge and skills survey further revealed that geospatial data, visualisation and mapping also account for more than 50% of work done in both the public and private sectors. Data manipulation and analytical methods are mostly applied but declined to near 40%, whereas data modelling, design aspects, GIS and society fell

below 30%. The GISc knowledge and skills that are not commonly required include physics which fell below 10% in both the private and public sectors, followed by conceptual foundations, Geocomputation, mathematics and statistics and organisational and institutional aspects that fell short below 20% of application. Interestingly, both 2014 and 2016 surveys' results revealed that data acquisition (primary and secondary) is the most actively performed in both the public and private sectors.

Geographical Information Systems is a concept that was coined around the 1960s, firstly as a computer system needed to make accurate, fast and automated measurements from maps and a tool that would be able to carry large numbers of discrete datasets (Goodchild, 2013). It evolved worldwide into a software application that was adopted widely, which has now become a multidisciplinary research tool applied in many research projects that involve a spatial component (Cilliers, 2013; Coppock & Rhind, 1991; Goodchild, 2010; Longley, Goodchild, Maguire, & Rhind, 2011). Longley (2002: 37) argues that GIS is regarded as an umbrella term that is used to embrace all technology that has successfully been utilised for the creation, management and analysis of spatial data (Longley, 2002: 37). Geographic Information Science (GIScience or alternatively GISc) is regarded as the science in which GIS is located. Bolstad (2008: 12) defines GI Science as a theoretical foundation upon which GIS is based. For that reason, Bolstad (2008:12) argues that GI Science is primarily interested in how geographic information is conceptualised.

The words *"geographic"* and *"geographical"* are adjectives that are somewhat used interchangeably as the prefix to both the above-mentioned concepts and they simply refer to something "relating to geography" (Concise Oxford English dictionary, 2004). For instance, GIS (i.e. Geographical Information Systems or Geographic Information Systems) and GISc (i.e. Geographical Information Science or Geographic Information Science). For the purpose of this research, Geographical Information Systems (GIS) and Geographic Information Science (GISc) are adopted for clarity and consistence. Again, it was observed that both GIS and GISc are sometimes used interchangeably to refer to one thing, but they have different meanings as alluded to in the above definitions.

Goodchild (2009: 1037) defines geographic information *"as instances or aggregations of primitive atomic tuples of the form where x defines a location on or near the Earth's surface, and may include the temporal dimension, and z defines one or more attributes of that location."* Geographic information is somewhat referred to as spatial information**.** In a South African context, spatial information is defined as information about spatial objects or features and their attributes (*Spatial Data Infrastructure Act*, 2003, (Act No. 54 of 2003)), hereafter referred to as the SDI Act. In essence, geographic information relates to objects, either discrete or continuous, located on or near the earth's surface described by using coordinates**.** These objects are recorded spatially with associated attributes. There are also "systems" that form part of the GIS concept. *"Considering the importance of spatial information and SDIs to government, SDI concepts are an important ingredient of GISc education and training at institutions of higher education"* (Coetzee, Rautenbach, & du Plessis, 2015:8).

1.2. RESEARCH PROBLEM, AIMS AND OBJECTIVES

1.2.1. Research Problem

Notwithstanding the issues raised in the section above, institutions of higher learning in South Africa seem to struggle to meet the demands of GIS knowledge and skills and as a result they continue to provide inadequate training for geography graduates on GIS and other geospatial technological aspects. This is evident by high numbers of geography and environmental management graduates who are being declined a professional registration with the South African Geomatics Council (SAGC) in different GISc professional categories. Previously, SAGC used to accept geography graduates who possessed a three-year qualification for a GISc technician, but that has since changed following the introduction of the new GISc academic model which was recently adopted.

1.2.2. Aims

This project investigates the GIS curriculum at three different South African universities' geography departments with the aim to examine the link between the academic discipline of geography and the professionalisation of GIS as a vocational training.

1.2.3. Objectives of the study

The objectives of the study are to:

- Conceptualise GIS within the discipline of geography;
- Explore the similarities and difference of three different South African universities' geography curricula in teaching GIS and other geospatial technologies;
- Examine the strength and weakness of teaching GIS and other geospatial technologies within the three different South African universities' geography curricula;
- Explore the readiness of undergraduate geography students in performing GIS and other geospatial technological jobs available in the industry.

1.3. ETHICAL CONSIDERATION

This research project is conducted as part of the Master of Science in GIS and Remote Sensing (RS) coursework for students enrolled with the University of the Witwatersrand (commonly known as Wits). Therefore, this research report remains the property of the aforesaid university. Efforts were made to ensure that this study adheres to Wits' ethical clearance before the data could be collected (refer to ethical clearance, annexure D). The privacy of data collected was dealt with by maintaining strict confidentiality and the preservation of records to ensure privacy (Tolmie, Muijs & McAteer, 2011: 60). The informed consent form was given to all participants prior to the completion of the students' questionnaire and answering of lecturer's interview questions. The requests to conduct research at the North-West University (NWU) and the University of Limpopo (UL) were made and approvals were granted as such (refer to Annexure E and F, respectively). The collected data were used only for statistical analyses purposes and results are presented in chapter four and chapter five of this research report. The presentation of the results ensured that no data could be traced back to any individual respondent. All the records of lecturers' interviews and students' questionnaires were handled with utmost care in order to avoid accidental loss and unauthorised access.

1.4. OUTLINE OF CHAPTERS

Chapter one of this study provides an introduction and background to the research project. Chapter one starts by giving an introduction which outlines the background of the research problem as well as to provide clarity on the concepts of GISc and GIS and how they influence each other. Chapter one further outlines the research problem, the aims as well as the objectives. As outlined in the preceding sections, this research project aims to investigate the depth of GIS used for teaching and research within an undergraduate geography curriculum at three different South African universities. The research further seeks to examine the link between the academic discipline of geography and the professionalisation of GIS as a vocational training. In doing so, the objectives of this study focus on conceptualising GIS within the field of geography, exploring the similarities and differences of GIS teaching within an undergraduate geography curriculum of three different universities. The weakness and strength of each university's geography curriculum in teaching GIS and lastly, the readiness of geography graduates in performing GIS related jobs offered by the industry, is investigated.

Chapter two deals with the review of literature. This chapter provides a detailed and critical review of available published literature with regard to the teaching of GIS within a geography curriculum. This chapter does not attempt to provide an account of all published literature in GIS teaching within the geography discipline; it aims to ensure that this research does not reinvent the wheel on the already available literature, but focuses on the area that needs consideration or on gaps in the existing knowledge. Thus, it is the purpose of this research to investigate the use of GIS teaching within the geography curricula of South African universities as an effort to add new ideas to the already existing academic debates

Chapter three is geared towards discussing the methodological approach adopted for the purpose of this research. This is a multi-institutional case study with the aim of fathering similar variables from different environments. The qualitative and quantitative methods were both applied for the purpose of this study. A standard student questionnaire was distributed to a group of GIS students in all three universities under study. Answers from open-ended questions were analysed using a qualitative analytical approach, where

answers gathered from close-ended questions were analysed by using simple percentage graphs based on rating scale and an advanced statistical analytical approach using the Mann-Whitney U Test. The use of both the qualitative and quantitative approach helped to eliminate the weaknesses associated with each method when used alone. The data analysis and presentation are divided into two chapters, namely chapter four and chapter five.

Chapter four focuses on presenting and analysing data using a basic statistical approach. In this chapter, the percentage of distribution of respondents on each question were presented and analysed accordingly. **Chapter five** focuses on presenting and analysing data by using an advanced statistical approach in the use of the Mann-Whitney U Test. The significant level is 0.5% for statistical analysis.

Chapter six focuses on the discussion of the main prominent points, gaps and similarities as well as to offer recommendations aimed at improving the teaching of GIS in geography curriculum for both research and vocational skill. This chapter reiterates the aim and objectives of the study and provides information on whether GIS teaching in geography has indeed provided students enough knowledge for vocational training.

1.5. CONCLUSION

This chapter has suggested that as GIS has evolved from early attempts to work with spatial data to become a cutting edge application in many industrial fields, so the teaching of GIS in South African universities has not always responded to the industry requirements. The use of GIS in geography has been researched extensively, but there are still some challenges in South Africa since the geography curriculum of different universities seem to integrate GIS within the teaching very differently. To this end, this study aims to investigate how GIS is being used within the undergraduate geography curriculum in South Africa. The objectives include among others to examine the extent of how geography graduates are prepared to embark on the GIS profession. This chapter gives a framework of the entire research report in a nutshell.

CHAPTER TWO

LITERATURE REVIEW

2.1. INTRODUCTION

This chapter considers theoretical debates taking place within the broad spectrum of the field of GIS, as well as the integration of GIS within the domain of geography at institutions of higher learning. The main focus is to study the role that GIS plays in contributing to the growth of geography as a discipline and in turn, the role of teaching GIS as both a vocational skill and a tool for research within the domain of geography per se. The following section provides a critical review of the literature.

2.2. THE RELATIONSHIP BETWEEN GEOGRAPHY AND GEOGRAPHIC INFORMATION SYSTEMS

This section provides a historical perspective on the relationship between GIS and Geography. The use of GIS for teaching and research within geography curricula has been researched extensively (Kemp et al., 1992; White & Simms, 1993; Shaw, 1993; Nellis, 1994; Longley, 2000; Wiegand, 2001; Zietsman, 2002; Alyson et al., 2002; Brown, 2004; Sinton, 2009; Whyatt et al., 2011; Piróg, 2014; Martí et al., 2014; Şeremet & Chalkely, 2015; Berman et al., 2016). Little doubt exists that GIS has a profound influence on society and in fact to a discipline of geography per se (Zietsman, 2002: 30). Sui (1995) and Longley (2000) held a view that GIS and geography have always been natural partners because they influence each other.

In support of the above assertion; the geography discipline is seen to be the logical home for GIS precisely because the technology is spatially orientated, employs geographical analytical methods and has the capability to unify both physical and human environmental aspects (Hill & Nell, 1996: 150, Society for South African Geographers [SSAG], 2003: 109). Kemp et al. (1992), argue that geographers who are trying to analyse spatial information by using GIS must research extensively all questions around data collection, compilation, accuracy, display and analyses. Furthermore, Nellis (1994:37) elaborates that when designing a geography curriculum, the balance between research on GIS concepts and principles as well as GIS applicability to solve practical problems should be

upheld. A geography curriculum should embody clear consensus on the content or an appropriate pedagogic approach which includes providing details on the content, sequence, clarification of course objectives as well as strike a balance between education, training and technology (Kemp et al. 1992: 189).

During the early years of development, geography has had strong ties with astronomy, land surveying and mapping technologies that assisted with the accurate location and organising of the subject matter with which it had to deal (Zietsman, 2002: 32). Zietsman further argues that geography has had a long tradition of providing descriptions of the earth and explanations relating to observed spatial patterns, processes and relationships between phenomena (Zietsman, 2002: 32). Nowadays, GIS has made it easy to describe the earth and provide explanations with regard to spatial patterns, processes, and relationships between phenomena. The earth's description and explanations of patterns, process and relationships of phenomena have always resorted under the discipline of geography (Zietsman, 2002: 32).

The aforesaid view is supported by the work of Bearman, Jones, Andre, Cachinho & DeMers (2016: 395) who argue that geography degrees are in fact in an ideal position to provide spatial literacy training, of which GIS forms a key component. Geography provides insight into the knowledge and understanding of spatial phenomena and processes as well as the meaning of spatial units from global scale to the micro-local (Berman et al., 2016: 395). GIS is therefore assisting in integrating the various scales related to phenomena, process and meaning (Berman et al., 2016: 395). Geography as a subject provides a good setting for GIS because it offers the basis for developing the interconnections among different speciality domains (e.g. housing, geomorphology, hydrology, etc.) (Berman et al., 2016: 395; SSAG, 2003:109).

2.2.1. The opportunities of using GIS for teaching and research within geography curricula

Kemp, Goodchild and Dodson (1992) suggest that the rationale for teaching GIS within the higher education curriculum rests on four ideas - namely; the recognition of geography as a home discipline of the technology (GIS); the teaching of GIS as a collection of marketable skills; the recognition of GIS as an enable technology for science; and lastly,

the recognition of GIS as an intellectual theme within the discipline of geography. In addition, Wiegand (2001:70) argues that "GIS offers a one-off opportunity for geographers to demonstrate unequivocally that they can offer students technological capability for real-world problem solving through the use of data analysis, modelling and presentation tools."

Wiegand (2001: 70) further accentuates that GIS is regarded as a valuable component of professional geography. Consequently, if GIS is not incorporated as part of the core geography curriculum, the geography domain runs the risk of failure to survive in the wake of the curriculum competition between business studies, science, information and communication technology (Wiegand, 2001: 70). The following subsection will therefore provide an in-depth review of the role of GIS in geography.

2.2.1.1. GIS and spatial thinking

There is no clear consensus that exists regarding the definition of spatial thinking, but it is an interdisciplinary subject that ranges from psychology and the pedagogy of GISc (Wakabayashi & Ishikawa, 2011: 305). Spatial thinking as defined by Wakabayashi and Ishikawa (2011) relates to "a constructive amalgam of three elements; concepts of space, tools of representation, and processes of reasoning." National Research Council (NRC) (2006: 12) in the United States defines spatial thinking as "a collection of cognitive skills comprised of knowing concepts of space, using tools of representation, and reasoning processes." Jo, Hong, and Verma (2016) state that empirical studies are still required to elucidate the "potential of GIS as an instructional tool to support spatial thinking in order to formulate geographical courses." This recommendation is useful in making sure that GIS is integrated in the teaching of geography broadly.

Wakabayashi and Ishikawa (2011: 309) argue that an increase in rapid growth, the widespread availability and use of geospatial technologies has undoubtedly led to an increase in the need for teaching and learning about spatial thinking. Spatial technologies such as GIS, remote sensing and Global Positioning Systems (GPS), among others, transform our ability to understand the geographical processes and improve how we think geographically (Jo et al., 2016; Nellis, 1994). For this reason, spatial technologies should be embedded in the curriculum to enhance geographical education (Nellis, 1994: 36). In

support of the above argument, Sinton (2009) states that GIS has the power to influence spatial thinking. A new understanding, narration or solutions to a problem can be derived through the use of a map, precisely because it adds to the abiity to expand a frame of reference, something that has been noted as a basis for spatial relations and spatial cognition (Sinton, 2009: 9). “There is little doubt that in-depth understanding of the spatial concepts behind GIS is important for appropriate use of geospatial technologies (Wakabayashi & Ishikawa, 2011: 309).

Figure 1: A conceptual schema for spatial thinking and related terms

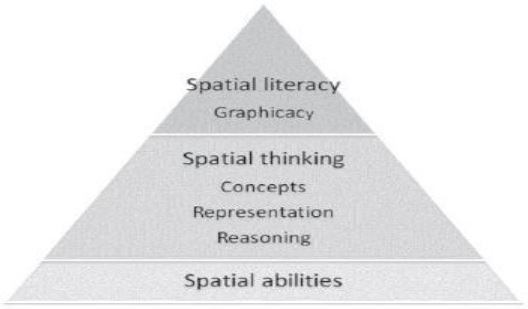


Fig. 1. A conceptual schema of spatial thinking and related terms

Source: Wakabayashi & Ishikawa (2011)

With respect to GIS education, there are two distinct approaches in teaching about GIS and teaching with GIS and they both represent different perspectives and purposes (Jo et al.; 2016; Bednarz & Ludwig, 1997; Sui, 1995,). “To teach about GIS concentrates on GIS technology itself with an instructional focus on training. To teach with GIS focuses on applications of GIS with an instructional focus on education” (Sui, 1995:581). For this reason, the role of GIS in spatial thinking can be examined based on these two perspectives; notably, “(1) the effect of learning about GIS (e.g. GIS coursework) on the development of students’ spatial thinking skills and (2) the effect of learning with GIS (e.g. using GIS as a learning tool in courses other than GIS).” (Jo et al., 2016: 442).

Empirical studies conducted before proved that learning about GIS has a positive effect in improving students’ spatial thinking. Based on a study conducted by Lee and Bednarz (2009), they had a pre- and post-spatial skills test administered to a group of students in a college and they found that there is a significant difference between the performance of

students with a GIS academic background and those without. The students who participated in the survey having done GIS courses scored higher than those who did not have a GIS background on the pre- and post-spatial skills test. The authors further explain that high scores of students on the survey were attributed to the nature of GIS course topics and activities that helped them to increase their knowledge of spatial relationship.

A stand-alone course focusing on both spatial thinking and geospatial technologies also proved to yield positive outcomes in increasing students' knowledge of spatial thinking skills (Nielsen, Oberle, & Suguraman, 2011). The concept of spatial thinking in this regard, was taught through an integration of class readings and discussions. Geospatial technologies are then taught to students through performing various activities using GIS, GPS and remote sensing techniques and the evaluation showed that students' spatial thinking skills were increased in this regard. Conversely, teaching with GIS offers the potential and benefits of utilising GIS as an instructional tool to support different numbers of educational goals (Goldstein & Alibrandi, 2013; Tsou & Yanow, 2010; Sinton, 2009). Evidence shows that GIS has been widely used for both undergraduate research projects (Nyhus, Cole, & Firmage, 2007) and for problem solving across the curriculum (Drennon, 2005).

2.2.1.2. GIS and vocational training

An empirical study was conducted by Piróg (2014) under the theme *"Do geography degree programmes facilitate a smooth transition to the job market? Reflections of working and job seeking graduates in Poland*." The study outcome reveals that GIS courses are most prominent and should be included in the teaching of undergraduate geography degrees. The survey study further reveals that the majority of university graduates experienced continued periods of unemployment and that the predicament includes those from geography (Piróg, 2014: 155). The failure of graduates to enter labour markets does not only cause negative psychological, economic and social consequences to the students per se, but it affects the image and credibility of the discipline of geography (Piróg, 2014: 155). There is a significant risk of lowering the status of the discipline if its graduates cannot succeed career-wise.

Another survey study was conducted by Brown (2004) focusing on former students of the University of West England (UWE) who were drawn from undergraduate and honours degrees at the school of Geography and Environmental Management. The survey study focused on those students who did GIS and remote sensing modules from both physical and human geography. Furthermore, the study also made use of interviews with potential employers in order to gain an understanding on the employability of geography graduates. The study reveals that geography graduates who have good knowledge and skills in spatial data analysis and have a good skills base have higher chances of finding jobs in GIS and Geographical Information related fields (Brown, 2004: 18). The study further reveals that geography graduates reading for "non-vocational degrees" sometimes find it difficult to secure employment in line with their qualifications and skills (Brown, 2004: 18). The most important reason why GIS should be taught at undergraduate geography level is to ensure that graduates who prefer to go the vocational route rather than research are able to find jobs after completion of their undergraduate study. In elucidating the preceding point, Brown (2004: 18) states that institutions need to consider how they train graduates because most of these graduates may not have the capacity and capability to further their studies, hence the need to be aware of labour market demands.

Whyaat, Clark and Davis (2011) conducted a study under the theme *"Teaching Geographical Information Systems in Geography Degrees: A critical Reassessment of Vocationalism."* The study reveals that there are more GIS jobs in some economic sectors than others. While some students have indicated that GIS did not have much effect on their jobs, other alumni proved that GIS shaped their career. Furthermore, it was stated that specific GIS skills were more required at an entry or junior level, but changed while the career of a person progressed, making the later value to be indirectly vocational (Whyaat, 2011: 242). Although vocationalism looks great, it also then leads to challenges. More details will follow in the forthcoming subsection.

2.2.2. The challenges of using GIS for teaching and research in the geography curriculum

Among other challenges, the teaching of GIS within geography curricula seems to step around the structure of content. Kerski (2008:331) states that "today's main challenges

lie not with the hardware or software, but with the structure of educational systems. With web-based GIS and free and low cost school site license options, cost is often the least of the concerns." This argument is true looking at an increased rapid and widespread online software to teach GIS and remote sensing nowadays. For instance, R Studio is a statistical statistics software that can be applied to perform both GIS and remote sensing functionalities. There is also Quantum GIS (QGIS), Geographic Resources Analysis Support System (commonly termed GRASS GIS) among other online software platforms. The challenge however, as alluded to by Kerski (2008), will be on the availability of competent lecturers who can impart both theoretical and practical knowledge to students in a more effective way.

Meeting the demands of the ever-changing market seems to be a bottleneck in the supply of skills by universities, in particular when it relates to GIS. Whyatt et al. (2011: 237) states that "a specific claim for the additional vocational qualities for GIS modules (beyond the higher education experience in general) will be easier for staff to sustain, if there is continuity in employers' demands."

There are authors who argue that the syllabus can be tailor-made to suite the sector's needs. The challenge however, as the authors have alluded to, is that it will be harder for universities to respond to the needs when the demands per sector vary and if those demands keep changing over time. "The more quickly industry's needs change, the more difficult that alignment will become and the greater the need for universities to be able to forecast correctly the changing set of vocational needs or to focus their teaching on only the longer-lasting basic principles of GIS." (Whyaat et al., 2011: 237).

The authors further accentuate that the dynamism on GIS labour market has an inverse proportional effect on the demand side, thus giving a clear sign that GIS is not an easy field to satisfy. The employability aspect of graduates with GIS skills makes it essential to consider the extent in how geography could harness such benefits. The aforesaid assertion was also embraced by the Society for South African Geographers (SSAG), where the body noted that in order to design a balanced curriculum, there is a need to investigate the level of the GIS market in the society and the level of training that is required for each niche in the market (SSAG, 2003: 106).

2.3. THE ORIGIN AND GROWTH OF GEOGRAPHICAL INFORMATION SYSTEMS IN SOUTH AFRICAN UNIVERSITIES

In South Africa, the application of GIS in research dates back to the 1980s, (Cilliers, De Klerk & Sandham, 2013: 70). The advancement in the use of GIS in South Africa gained impetus around the 1990s, with the incorporation of GIS in a number of Organs of State such as the Chief Directorate: National Geo-Spatial Information (CD: NGI, previously known as Survey and Mapping) and the office of the Chief Surveyor General (CSG) (Breetzke, 2006). The arrival of personal computers and software packages and the increase in the availability of data in early 1990s provided further increase in the widespread adoption of GIS in many settings (Breetzke, 2006).

During early 1990's, South African universities started to realign their geography curricula to incorporate aspects of environmental studies and computer based training (du Plessis & Van Niekerk, 2012) and, to teach GIS within geography curricula (Zietsman, 2002). Around 2000, GIS had already evolved and become an important research tool and its teaching spanned across many disciplines (Zietsman, 2002). By 2012, GIS had evolved to become an independent teaching field, separate from the discipline of geography, possibly due to the rising demand of professionalisation of the discipline (Cilliers, De Klerk and Sandham, 2013).

In 2013, the Geomatics Profession Act, (Act No. of 2013) was introduced to regulate the Geomatics profession, where GISc is included. Members of the public with qualifications in different branches of Geomatics are required by Law to register with the Council, known as the South African Geomatics Council (SAGC). The Geomatics Profession Act, 2013 repealed the South African Professional and Technical Surveyors Act, 1984 (Act No. of 1984) that was previously regulating surveying activities, where GISc was also incorporated. With the professionalisation and certification of GISc in South Africa, it is now mandatory that any one applying for a government tender that requires GIS services should furnish a registration certificate of a membership in good standing. Due to professionalisation, it remains to be seen whether those students who are graduates from different disciplines such as geography with inadequate training in GIS will still find it easy to be accepted for registration by the relevant council.

Furthermore, du Plessis and Van Niekerk (2014) published an academic study which was part of Doctoral studies focusing on developing a new GISc framework and competency set for curricula development in South Africa. Du Plessis and Van Niekerk (2014) highlight the commonalities and inconsistencies that exist in three different models namely, the Body of Knowledge (BoK) as developed in the United States, Unit Standard Based Qualifications (USBQs) and the South African Geomatics Council (SAGC) Accreditation Model used in South Africa for professional registration. The Geographical Information Science and Technology (GI S&T) Body of Knowledge (BoK) was initiated in 1997 by the University Consortium for Geographic Information Science (UCGIS) to provide a framework for the assessment of GI S&T curricula as a means to solve an educational challenge faced by them (Kemp & Wright, 1997).

The USBQs was established in South Africa around 2004 following the professionalisation of GISc and it was meant to provide a framework of curriculum and standardisation (du Plessis & Van Niekerk, 2014: 2). “The GISc USBQ comprises four tiers called study areas, unit standards, outcomes, and assessment criteria. A total of 19 study areas and 128 unit standards, spanning the breadth of the GISc domain, were identified by the GISc Standards Generating Body (SGB) (du Plessis & Niekerk, 2014: 2).” Du Plessis and Van Niekerk (2014) conducted a qualitative study to solicit inputs from members of the GISc industry through a series of workshops and conferences. As supported by a combination of aspects from three models, a new framework was developed to help South African institutions of higher learning to devise a curriculum for teaching GISc.

Hodza, Schaab, Coetzee, van der Merwe and Vog (2015) conducted a comparative study of the proportional compositions of geo-spatial related technology at three global universities, namely; Karlsruhe University of Applied Sciences (HsKA, Germany), University of Pretoria (UP) in South Africa and University of Colorado Springs (UCCS, USA). The UP Geoinformatics curriculum was compared against the curricula in Europe and America. The proportional comparison of study programs shows complete differences and similarities that are not obvious when only comparing the content (Hodza et al., 2015: 248). *“The compositional differences naturally result in graduates with*

different knowledge and skills that are suitable for significantly different job opportunities and career paths" (Hodza et al., 2015: 248).

2.3.1. The challenges for teaching geographical information systems in South African universities

There are a number of concerns noted with regard to the introduction of GIS in South Africa universities, either as part of teaching in the discipline of geography or as a standalone field of study. Although outdated, the empirical studies conducted in South Africa so far proved that a lack of trained staff, limited cooperation among South African universities and shortage of funding (Hill & Nell, 1996: 150-154, SSAG, 2003: 106), ongoing expenses that include costs of keeping abreast with the rapidly changing software, as well as the cost of maintenance contracts with data vendors have been deemed to defeat the whole effort of using GIS for teaching and research (Hill & Nel, 1996: 150-154). Moreover, digital data was and still is, in part, hardly available and costly to obtain (Hill & Nel, 1996: 150), which impacts negatively on teaching and research at various universities. Even if some data is obtained, the issue of data quality is another challenge (Hill & Nel, 1996: 150). Although findings by Hill and Nell (1996) are now outdated, there is still a challenge of data quality even today. This is in part caused by paucity of metadata and lack of enforcement and compliance to the Spatial Data Infrastructure Act, 2003.

In 2003, the SSAG published a survey report that was broadly aimed at assessing the state of the geography discipline between 2001 and 2002 in South African university geography departments. In spite of an increased demand of trained GIS practitioners, the integration of GIS within geography curricula of universities was still requiring attention (SSAG, 2003). The assessment done by the SSAG showed little consideration of the value of GIS within the discipline of geography. The SSAG claims that GIS has nowadays become a component of the teaching with the field of 'GISc and Geomatics', and as a result, GIS is deeply rooted in the disciplines of mathematics and computer science, where advances in GIS technical applications are embedded. The claim made by the SSAG (2003: 106) that seeks to suggests that GIS is deeply rooted in mathematics and computer science can be challenged on a number of reasons, like the one below. The

kind of mathematics that is involved in GIS is the same mathematical literacy which every geographer would require for the measurement and mapping of the earth's surface. In essence, GIS makes use of a computer programme to provide accurate, fast measurement from maps and a tool that is able to carry a large number of disparate datasets (Goodchild, 2013).

Investing in the technically equipped laboratories involves a high cost. The substantial number of students to register for a practical course is inversely proportional to the cost factor (SSAG, 2003: 106). Training in GIS requires a qualified and competent instructor and competition of employment benefits in public and private sector make it difficult to attract such skills (SSAG, 2003: 106). Preparation of teaching materials has been noted as difficult in addition to the lack of innovation instructors. While it is acknowledged that students need intensive supervision in their training, there has been a challenge due to the lack of innovative instructors and difficulty in the preparation of teaching materials (SSAG, 2003: 106). A claim by SSAG (2003) is that training in GIS is time consuming and this has been noted, perhaps, as the most important implication in the inclusion of GIS in the geography curriculum at all levels. In conclusion, the SSAG (2003: 106) suggested the setting up of formal GISc courses rather than accommodating training in conventional practical classes. For this reason, GIS is perceived to be a challenge with respect to time allocation in undergraduate curricula. Arguments have been made that there should be an increase in the number of practical work assignments per week, to ensure that proper training is provided.

The SSAG's recommendation has a negative inclination on the future of geography. The reason being that there is a tendency to dissociate GIS as a main core engine within the geography domain. A continued advancement of technology requires geographers to take advantage of the GIS strength in order to remain relevant in the higher education spectrum. This goes back to the argument made by Sinton (2009), that geographers have a responsibility to capitalise on the power of GIS and this will likely make it easy to create openings to cultivate spatial perspective within diverse curricula, which is seen to have a profound significance of ensuring a wider return of geography in the higher education.

2.4. CONCLUSION

Although some may be outdated, the experiences learnt from the work done by Hill and Nel (1996), the SSAG's report on state of geography in South African universities (2003) and the framework developed by Du Plessis and Van Niekerk (2014) have really ushered an interesting background with regard to the status of GIS in South Africa as well as its role in geography. It is the intent of this study to investigate the extent to which GIS is being used for teaching and research among South African universities. A case study approach has been adopted for this study that requires a particular research design and methodology, to which the details will be provided in the next chapter.

CHAPTER THREE

METHODOLOGICAL APPROACH AND CASE STUDIES

3.1. INTRODUCTION

This chapter provides a methodological framework adopted for the purpose of this study research. The study follows a unique research methodology and research design in order to ensure that the objectives of the research are achieved with ease. Chapter three also provides a thematic description of each case study of the three universities under study. The knowledge of the study areas is drawn from the work of Visser et al. (2006) in which lecturers from various Universities in South Africa provided an account of the history and development of geography in South Africa.

3.2. BACKGROUND ACCOUNT OF THE STUDY AREAS (CASE STUDIES)

This section provides a brief overview on the origin and growth of geography as a discipline in three selected South African universities under study. The rationale behind choosing Wits University, UL and NWU was based on a number of considerations. Firstly, this study took into consideration the diversity of most South African universities, and in so doing, it is necessary to strike a balance between universities that were historically classified as white universities (e.g. Wits University and NWU [formerly Potchefstroom University]) and those previously classified as black universities (in this case, represented by UL). The teaching of geography, attraction of competent lecturers and availability of resources (e.g. software and high processing computers, fieldwork data capturing tools, etc.) to teach geography modules, in particular GIS, was not evenly distributed across the board in South African universities.

At Wits University two GIS introductory modules are offered as part of an undergraduate geography curriculum. At NWU there is only one GIS introductory module offered within an undergraduate degree programme. It is only at UL where more than three GIS modules are taught at an elementary and advanced level. This is because UL offers a four year

undergraduate degree. Thus, the advanced GIS course is taught at fourth year level of study.

3.2.1. University of the Witwatersrand

Wits University is geographically located in the City of Johannesburg in Gauteng Province of South Africa with the location defined using coordinates 26.1917° S, 28.0328° E. In Johannesburg, geography teaching was introduced in 1917 in the faculty of Arts under the leadership of a 29 year old Scottish lecturer, James Hutcheon (Visser et al., 2016: 71). In the same year, Hutcheon launched the South African Geographical Society. The establishment of the Geography department took place in 1922 after which the department was moved to the faculty of Science around 1923 (Murray, 1982), where the initial focus was on landscape geographies (Visser et al., 2016: 72). Regional study was introduced around 1960s, followed by teaching of quantitative methods using statistics around 1970s (Visser et al., 2016: 72). Although the geography department was historically focused on Physical geography (i.e. geomorphology, and climatology), it became evident around 1980s that Human Geography was matching Physical Geography in terms of volume, quality, pace and diversity.

In the 1990s and mostly post-apartheid era, Wits University Geography Department faced major changes in line with its transformative agenda. Introduction of a coursework Master's programme aimed at teaching even those students coming from historical underprivileged background, "working out how to curve out a research identity of both geographer and social scientist contributing to South Africa's post-apartheid development challenges", were among other transformation issues to deal with (Visser et al., 2016: 81). Although the Geography department had almost spent its entire lifespan in the faculty of science, it was only around 2000s that the decision was taken to merge geography with other disciplines in order to form a new school called School of Geography, Archeology and Environmental Studies (GAES). The recent appointment of GISc lecturers at Wits University is seen to have bolstered the capacity of teaching and researching using GIS and Remote Sensing within the Wits Geography department (Visser et al., 2016: 84).

3.2.2. University of North-West

After the amalgamation of universities that took place post-1994 democratic dispensation in South Africa, Potchefstroom University (PU) had merged with the NWU (formerly known as the Bophuthatswana University), and they are now both referred to as the NWU. This study, however, focuses on the Geography department that is located in Potchefstroom campus. The geographical location of the NWU is thus defined using coordinates 26.6905° S, 27.0932° E. Sandham and van Brakel in a book published by Visser et al., (2016) provide insights on the history and background of geography teaching at the NWU.

The history of geography at NWU (the then Potchefstroom University) could be divided into three phases (Visser et al., 2016: 95). The first phase comprises a period between 1934 and 1971, which involves the establishment of the Geography department as well as the offering of the degree programme. The second phase would involve the period between 1970 and1988 when the university started to offer diploma programmes at Potchefstroom campus and the introduction of full time and after hour's programmes at Vaal Triangle satellite campus. It is reported that during the second phase, the then PU mainly accepted white students and classes were taught only in Afrikaans (Visser et al., 2016: 95). The third phase started from 1998 to date, which involves a merger that took place in 2004 between PU and NWU, the Mafikeng campus. It was during the third phase where PU had experienced post-apartheid reconfiguration which resulted in having students from other races being accepted at the University and consequently having English accepted as media of learning (Visser et al., 2016: 95). The most important structural changes that took place in phase three, as alluded to by Sandham and Brakel in Visser et al., (2016: 95), were that the University moved from being a Christian based educational institution to adopting a school system, where the geography department became part and parcel of the School of Environmental Science and Development around 2000. Furthermore, the Geography Department also formed part of the School of Geo- and Spatial Sciences (SGSS) in 2012.

According to North-West University website, the SGSS *"has a vision to provide relevant value-driven training and research of international standard, focused on proven expertise*

within the environmental sciences and development (http://natural-sciences.nwu.ac.za/geo-spatial-sciences/about-us).” Geology, Geography and Environmental Management, Urban and Regional Planning consist as part of the structure of the SGSS; and they are said to offer “a unique suite of disciplines in order to provide comprehensive multidisciplinary training and research that equip students in becoming well-rounded environmental scientists” *(http://natural-sciences.nwu.ac.za/geo-spatial-sciences/about-us)*. Geography at NWU has been offered as catalyst to many disciplines, hence the GIS training. The shift to focus on GIS training took place around the late 1990’s due to a rise in the demand from Environmental Management and GIS sectors because employers required graduates with geography (Visser et al., 2016: 104).

3.2.3. University of Limpopo

The UL, formerly known as the University of the North (UNIN), which is located at Makweng, an estimated 35 kilometres east of Polokwane, Limpopo Province, which is in the northern hemisphere of South Africa. The coordinate location of the UL, Turfloop campus is defined as 23.8865° S, 29.7379° by E. Tait, Donaldson, Hattingh and Ramudzuli in a book published by Visser et al., (2016). It provides an historical account on the establishment of the UL during the apartheid era of separate development and segregation. The authors state that UL was formed on 1 August 1959 falling under the trusteeship of the University of South Africa (UNISA) and gained independence a decade later through the so called University of the North Act, 1969 (Act No. 47 of 1969).

The UL was mainly meant to cater for the black population (Visser et al., 2006: 256). In the late 1990s Hannes Botha was appointed by the Geography Department to establish GIS and Remote Sensing laboratories at the UL, but it was reported that he later moved to VISTA University after which he migrated (Visser et al., 2016: 268). The authors report that the teaching of GIS at the UL is currently offered as a service module in the programmes of Agricultural Economics, Soil Science and Community Water and Sanitation; and it is reported that the Geography Department also offers GIS workshops for postgraduate students (Visser et al., 2016: 268).

3.3. RESEARCH DESIGN AND METHODOLOGY

This study is a non-experimental research. According to Andy Tolmie, Daniel Muijs and Erica McAteer (2011), non-experimental research *"generally attempts to provide descriptions of real-world phenomena which are as far as possible complete, accurate, and ecologically valid (i.e., true to the context they are intended to describe)."* Non-experimental research collects data on a range of variables and this is done in the field rather than relying on the laboratory environment, where risks of artificial contexts that may produce unrepresentative results do exist (Tolmie et al., 2011: 33). Non-experimental research makes use of survey or observational methods to collect data, because they are less likely to influence or distort the nature of the data collected (Tolmie et al., 2011: 33). The correlation design is therefore employed for the purpose of this research. Tolmie et al., (2011:33) state that correlation designs refer to "*studies that collect information on a number of variables at the same time (e.g., via a survey), with the objective of describing the pattern of responses, and relationships between theses variables."*

Brynard, Hanekom and Brynard (2014:31) state that research methodology can best be described as the strategy of the research. According to Webb and Auriacombe (2006:591), the important part of a research design is to define the methods and techniques that are appropriate for the realisation of the research goals. It is therefore important to choose a particular method as well as the techniques to be used for data collection. Two different methodological approaches, quantitative and qualitative were followed. Webb and Auriacombe (2006:591) further state that the difference between quantitative and qualitative research is that the first one is predominately concerned with finding explanations, whereas the latter focuses on the in-depth description of a phenomenon.

The quantitative approach refers to analytical research with the purpose to arrive at a universal conclusion (Mouton 1983:128 as cited in Brynard & Hanekom 2006). The advantages of conducting a quantitative study is that it is associated with the use of methods adopted from the natural sciences that seek to provide generalisation, reliability and objectivity of the findings (Webb & Auriacombe 2006:592). "Quantitative techniques are concerned with how research participants are selected randomly from the study

population in an unbiased manner, the standardised questionnaire or intervention they receive and the statistical methods used to test predetermined hypotheses regarding the relationships between the specified independent and dependent variables (Webb & Auriacombe 2006:592).” In order to execute the quantitative study, methods such as experiments and surveys are required to describe and explain phenomena, wherein observation, preliminary investigations, quantitative analysis and questionnaires are used as applicable techniques. However, Webb and Auriacombe (2006:592) argue that quantitative study has a weakness of “decontextualizing human behaviour in a manner that removes the event from its real world setting, as well as not considering the effects of variables, which were not included in the model”.

In contrast, qualitative methodology deals with research that produces descriptive data. The descriptive data generally include the participant’s own written or spoken words relating to their own experience or perception (Brynard & Hanekom 2006:37). When dealing with qualitative methodology, the main point of departure is to understand the phenomenon, rather than explaining it (De Vos et al., 2002:79 as cited in Brynard & Hanekom 2006). “Case studies, in depth interviewing of key informants, participant observation, questionnaires and reading of personal documents are used as possible methods” (Brynard & Hanekom 2006:37). Brynard and Hanekom (2006:37) argue that qualitative research intends to discover unintentional findings with the possibility to alter research plans in order to respond to such incidental discoveries. As highlighted above, the advantage of the qualitative method is that it generates rich information and provides a context for understanding the behaviour of a phenomenon. The disadvantage of using the qualitative method, however, is that the data collection process and analysis thereof may require more labour and time (Webb & Auriacombe 2006:592).

Nonetheless, it is important to decide on a type of methodology to be adopted in line with answering the problem at hand. Therefore, the following subsection will detail the approach used for this study. This study makes use of both the qualitative and quantitative approach because they complement each other.

3.3.1. Instruments/ techniques for data collection

This is an empirical study that involves the use of a multi-institutional case study. Use of data from more than one institution has benefits which supersede the pitfalls of relying on data collected from one institution (Şeremet & Chalkely, 2015; Yin, 2009). The research will use both primary and secondary data. The principal research tool to be used in this study is a standardised questionnaire designed to collect information from final year GIS students (see Annexure A: standardised student questionnaire). The standardised interview questions were also circulated to GIS lecturers in order to solicit their perspectives (see Annexure B: Lecturer's interview questions).

The students' questionnaire comprises of open-ended and closed-ended questions that require both quantitative and qualitative data analysis. Responses gathered from closed-ended questions are analysed in two different ways; the use of basic statistical analysis and advanced statistical analysis. Firstly, the basic statistical analysis approach focuses on the use of simple percentage graphs based on the rating scale on the questionnaires. Secondly, the use of non-parametric test (i.e. Mann-Whitney U Test) to test the significance of the results with 95% confidence interval. The justification into the use of Mann-Whitney U Test is that it is appropriate when analysing data that require ranking of responses such as Likert-scale data.

The qualitative analysis is employed for open-ended questions. The qualitative analytical approach also involved the use of a thematic technique built on content analysis (Gillham, 2000; Richards, 2009). Where possible, the response given by students are triangulated and tested against other available evidence. The course contents will be one of evidence to be used to validate the findings. Furthermore, interviews with lecturers will also help validate the findings from the students' questionnaire. Table 1 below provides a link between the aim and objectives of the study as well as the tools/ techniques required to achieve each objective.

Table 1: The link between the research aim, objectives and tools of analysis

Aim: This project investigates the GIS curriculum at three different South African university geography departments with the aim to examine the link between the academic discipline of geography and the professionalisation of GIS as a vocational training.	
Objectives	**Tools of analysis**
• Conceptualise GIS within the discipline of geography.	• Literature review
• Explore the similarities and difference of three different South African universities' geography curricula in teaching GIS and other geospatial technologies.	• Mann-Whitney U Test to get the mean scores of each university and the p-value. Again, use of secondary data which includes GIS module content and the comparison of what is covered on each university compared against the other university.
• Examine the strength and weakness of teaching GIS and other geospatial technologies within the three different South African universities' geography curricula.	• Qualitative data analysis using the responses from lecturers and students on open-ended questions as well as the analysis of secondary data.
• Explore the readiness of undergraduate geography students in performing GIS and other geospatial technological jobs available in the industry.	• Comparing the results obtained using both qualitative and quantitative data to compare against the needs of the industry

3.3.2. Population Sampling and distribution of questionnaire and interview

In general, it can be said that this research case study approach makes use of snowball sampling. Snowball sampling can be explained as a chain of referral sampling, a way of purposive sampling, where participants are selected based on identification and referral. At UL, a lecturer volunteered to distribute questionnaires - a class of 40 final year students studying towards a BSc Environmental and Resource Studies was convened to complete the questionnaire. All the questionnaires were submitted to the lecturer after completion. This approached proved to be useful since it yielded 100% response rate (40/40). At NWU, a lecturer indicated that the GIS module is only offered during the first semester of the third year of undergraduate study. Because students' questionnaires were administered during the second semester, a GIS lecturer at NWU volunteered to send an email to all final year students who were registered for a GIS module to collect questionnaires. Based on the information provided by the lecturer, there were 67 students registered for the GIS module at the final year level. Though it could not be established if

all students have collected the questionnaires, only 29 students returned the questionnaires.

At Wits University two GIS modules are offered as part of an undergraduate geography programme. One compulsory GIS module is offered at the second year level while the other is offered as an optional GIS module at the third year level. The GIS module in the second year teaches introduction to GIS, whereas the third year GIS module teaches an introduction to RS. Bearing in mind that this research focuses on final year GIS students, it was decided by the researcher and a supervisor that all students who have registered for the third year GIS module should be the main target population to constitute a sample. According to the information received from an undergraduate course coordinator, there were 57 students at the final year level of study, but only 11 of them have enrolled for a final or third year GIS module.

The GIS module at final year level of study at Wits University was offered as a block release during the first semester. The data collection took place during the second semester. As a result, a researcher relied on the assistance of lecturers who were teaching other geography modules during the fourth block to allow the researcher to go into their classes after the contact session to explain the informed consent as well as to distribute questionnaires. Students were requested to drop the completed questionnaire in the assignment box by a specified due date. A follow up was made with the lecturers to remind the students of the obligation to the written questionnaires. At least 18 students returned the completed questionnaires during the prescribed period. The benefit out of this exercise was that, out of the total of those 18 students, at least 9 of them were registered for GIS module at final year level of study. As a result, 9 out of 18 GIS final year students have returned the questionnaires.

Table 2 shows that there are 87 student participants, 40 students are from UL, 29 students from NWU and at least 18 students from Wits. Each University has at least one lecturer who participated. Percentage-wise, there is overall 46% of respondents from UL, 33% of respondents from NWU, while 21% of respondents are from Wits University.

Table 2: Percentage distribution of respondents

Universities	**Number of participants**		**Total number**	**Percentages**
	Students	Lecturers		
University of Limpopo	40	01	41	46%
North-West University	29	01	30	33%
Wits University	18	01	19	21%
Grand-total	**87**	**03**	**90**	**100%**

3.4. CONCLUSION

This chapter provided a methodological approach and research design appropriate for the attainment of the aims and objectives of this study. This chapter further provided a distinction between qualitative and quantitate research methods to highlight the advantages of using both methods when used together in the study. On the one hand, quantitative approach has to do with analytical research with the purpose to arrive at a universal statement. The advantages of conducting a quantitative study is that it is associated with the use of methods adopted from the natural sciences that seek to provide generalisation, reliability and objectivity of the findings.

On the other hand, qualitative methodology deals with research that produces descriptive data. The descriptive data generally include the participant's own written or spoken words relating to their own experience or perception. When dealing with qualitative methodology, the main point of departure is to understand the phenomenon, rather than explaining it. Due to the nature of questions which this research seeks to answer, both research method approaches are applied. Likert scale data collected using questionnaires completed by students will be analysed using quantitative analysis, whereas open-ended questions will be analysed qualitatively together with the use of answers received from lecturers as well as the secondary data (course outlines). The next chapter will present the results of the study

CHAPTER FOUR

INTERPRETING THE RESULTS OF THE DATA ANALYSIS: SIMPLE PERCENTAGE DISTRIBUTION

4.1. INTRODUCTION

Chapter three provided valuable insights into the research design and methodological approach appropriate for the purpose of this study. Chapter four is therefore mainly focusing on interpreting the results of the data analysis. Due to the nature of the data gathered for the purpose of this research, the analysis are subdivided in two fold; simple percentage distribution using graphs and use of Mann-Whitney U-Test. This chapter therefore focuses on data analysis and presentation using simple percentage. Chapter five will present analysis of data using Mann-Whitney U Test.

4.2. SIMPLE PERCENTAGE DISTRIBUTION

Figure 2: Gender distribution of respondents per university

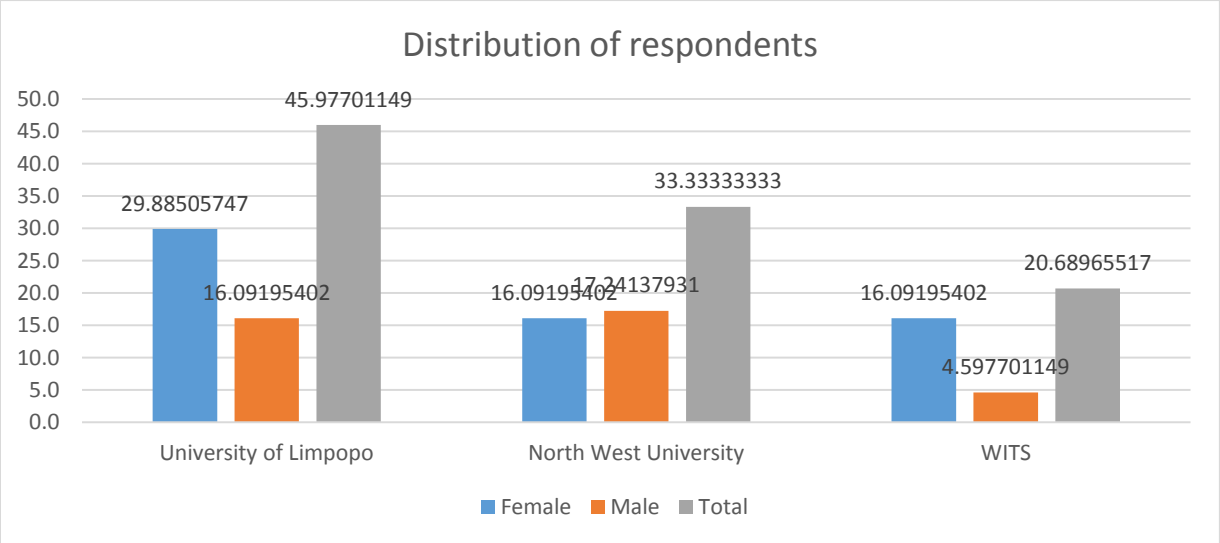


Figure 2 above shows the distribution of respondents according to their gender. From the overall total of 46% in UL, 29% of those students are Female and 16.1% are Male counterparts. NWU has a total number of 33.3% of respondents, where 16.1% are

Female and 17.2% are Male counterparts. Wits University has a total number of 20.7% of which 16.1% are Female and 4.6% are Male counterparts.

a) General questions (Open-ended questions)

There were few open-ended questions that were asked in the questionnaire.

i. Motive/Reasons for studying towards a Geography degree

Question 1 of the student questionnaire asked students to provide the motive/reasons behind studying towards a Geography degree. There were a number of responses provided by students from different universities and this study will try to summarise and categorize the responses in percentages. See table below:

Table 3: Percentage distribution of respondents on a desire to study geography degree

Categories of responses	**Response per percentages**
I like geography or I chose geography because I have love for the environment and natural resources. Geography teaches about both natural and human environment and how they interact with one other.	85.%
I chose geography because of job prospects	3.5%
I took geography as a second choice, my desired degree was full / I was only qualifying for a geography degree.	2.3%
I loved geography from high school, therefore I decided to register for it.	5.8%
I chose geography because I like farming.	2.3%
I took geography module for my degree credit.	1.2%
Total	100%

Based on table 3, 85% of students chose geography on the basis of their love for both the natural and human environment. At least 3.5% specified that they chose geography due to career prospects.

ii. Motive/Reasons for studying GIS in Geography

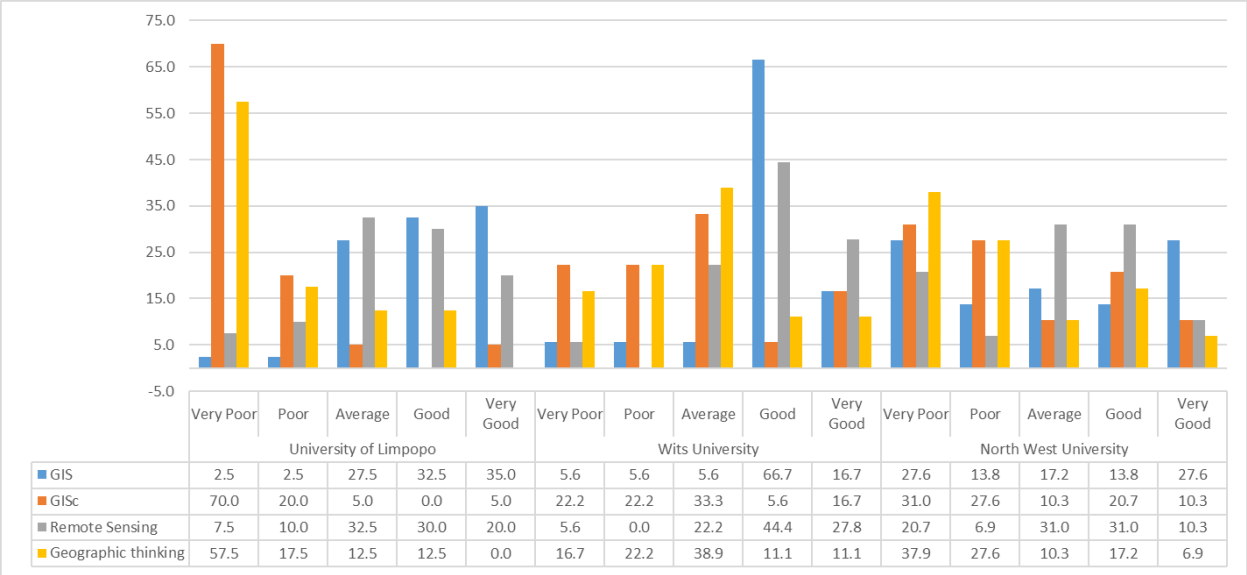
With regard to question 2, students were asked if the choice of GIS was compulsory or if it was an elective module, as well as to give reasons for choosing it. All students from UL and NWU indicated that it was compulsory to do GIS modules. At Wits University, GIS

was a compulsory subject for geography students during the second year of study, but the GIS module (Remote sensing part) offered at third year level was taken as a choice.

iii. Defining concepts

Question 3 of the questionnaire required students to define four concepts which were marked and ranked into a score of five. Figure 3 below shows the percentage distribution of responses on all four geographic concepts.

Figure 3: Knowledge of GIS, GISc, Remote Sensing and Geographical thinking in percentages



	University of Limpopo					Wits University					North West University				
	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good
GIS	2.5	2.5	27.5	32.5	35.0	5.6	5.6	5.6	66.7	16.7	27.6	13.8	17.2	13.8	27.6
GISc	70.0	20.0	5.0	0.0	5.0	22.2	22.2	33.3	5.6	16.7	31.0	27.6	10.3	20.7	10.3
Remote Sensing	7.5	10.0	32.5	30.0	20.0	5.6	0.0	22.2	44.4	27.8	20.7	6.9	31.0	31.0	10.3
Geographic thinking	57.5	17.5	12.5	12.5	0.0	16.7	22.2	38.9	11.1	11.1	37.9	27.6	10.3	17.2	6.9

According to the results presented in figure 3, at least 2,5% of students from UL portrayed a very poor knowledge of the GIS concept. Again, 27, 5% of students from UL showed an average knowledge of GIS concept. Overall, 67.5% performed above average, with 32.5% of respondents who attained good results and 35% of respondents proved to have a very good knowledge of the GIS concept. Wits University students' performance as far as GIS concept is as follows: 5.6% of respondents have very poor knowledge, 5.6% respondents showed poor knowledge, 5.6% of respondents showed an average knowledge, 66.7% showed good GIS knowledge, and 16.7% of respondents showed very good knowledge. At NWU, 27.6% of students have shown a very poor knowledge of GIS concept, 13.8% of students showed a poor understanding, 17.2% of students showed an

average knowledge, 13.8% of students showed a good knowledge of GIS, and lastly 27.6% showed a very good knowledge in understanding the GIS concept.

With regard to the concept of GISc, at least 70% of UL students have shown a very poor understanding, 20% of UL students have poor knowledge, 5% of UL students have average knowledge, and at least 5% of the UL students have shown a very good knowledge of the understanding of the GISc concept. At Wits University, 22.2% of students showed a very poor knowledge of GISc concept, 22.2% of students showed a poor understanding of the GISc concept, 33.3% of students showed an average knowledge of the GISc concept, 5.6% showed a good understanding of the GISc concept, and 16.7% of students showed a very good understanding of the GISc concept. In the case of NWU, 31% of students showed a very poor knowledge of the GISc concept, 27.6% of students showed a poor understanding of the GISc concept, 10.3% of students showed an average knowledge of the GISc concept, 20.7% of students showed a good understanding of the GISc concept, and 10.3% of students showed a very good knowledge of the GIS concept.

With regard to the concept of Remote Sensing (RS), at least 7.5% of UL students have shown a very poor understanding, 10% of UL students have poor knowledge, 32.5% of UL students have average knowledge, 30% of UL students have shown a good knowledge, and 20% of UL students have showed a very good knowledge of RS concept. At Wits University, 5.6% of students showed a very poor knowledge of RS concept, 22.2% of students showed an average knowledge of RS concept, 44.4% of students showed a good understanding of RS concept, and 27.8% of students showed a very good understanding of RS concept. In a case of NWU, 20.7% of students showed a very poor knowledge of RS concept, 6.9% showed to have a poor understanding of RS concept, 31% of students showed an average knowledge of RS concept, 31% of students showed a good understanding of RS concept, and 10.3% of students shown a very good knowledge of RS concept.

With regard to the concept of geographic thinking, at least 57.5% of UL students have shown a very poor understanding, 17.5% of UL students have poor knowledge, 12.5% of UL students have average knowledge, 12.5% of UL students have shown good

knowledge, and 0% of UL students have shown to have a very good knowledge of the geographical thinking concept. At Wits University, 16.7% of students showed a very poor knowledge of the geographical thinking concept, 22.2% of students showed a poor knowledge of the geographical thinking concept, 38.9% of students showed an average understanding of the geographical thinking concept, 11.1% of students showed a good understanding of the geographical thinking concept, and 11.1% of students showed a very good understanding of the geographical thinking concept. In the case of NWU, 37.9% of students showed a very poor knowledge of the geographical thinking concept, 27.6% showed a poor understanding of the geographical thinking concept, 10.3% of students showed an average knowledge of the geographical thinking concept, 17.2% of students showed a good understanding of the geographical thinking concept, and 6.9% of students showed a very good knowledge of the geographical thinking concept.

iv. List of GIS modules and related practical taken by students

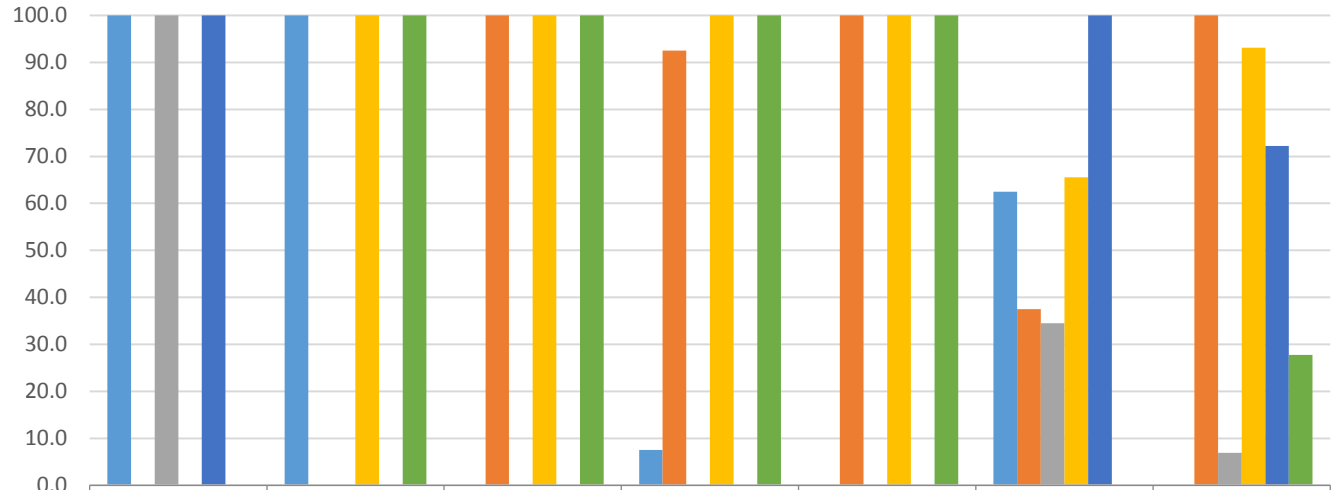
Question 4 of the questionnaire solicited answers with regard to GIS modules that students have registered for including the maximum number of practical hours for each module, if any. Students from Wits University indicated two modules at maximum (GIS module offered at second year level which had 3 hours practical per week; and also a Remote Sensing module offered at third year level which also had 3 hours practical per week). NWU students have indicated that they only did the GIS module on third year level which had a maximum of 3 hours per week. UL students have many modules compared to their counterparts from other universities. UL students showed that they have registered for the cartographic studies module at the first year level of study with practical of 1 hour per week; while second year, third year and fourth year levels of study have had a module each with a maximum of 4 hours practical. All the modules at UL were compulsory.

v. List of GIS software used during the study

Figure 4 shows the results from question 5 of the students' questionnaire. The question required students to indicate the kind of software they were exposed to during the term of their studies. It was established that all universities make use of ESRI software for

training. There is 100% response rate in each university where students indicate that they were exposed to the ESRI GIS software package. All UL students showed that they have been introduced to Quantum GIS, which is an online software package. No students from all three universities were introduced to Post GIS which is a free/online software package. 7.5% of students from UL showed that they have been introduced to GRASS, which is a free/online software package while 92.5% indicated that they have never been introduced to GRASS software. Approximately 62.5% of UL students indicate that they have been introduced to Google Earth software, while 37.5% showed that they have never used Google Earth Software. All Students from Wits University indicated to have been introduced to Google Earth software. There was 34.5% of NWU students who indicated that they have been introduced to Google Earth while 65.5% showed that they have never been introduced to Google Earth software. There was 6.9% of students from NWU who indicated that they have been exposed to other software while 93.1% of students indicated that they have never been exposed to other software packages. There was 72.2% of Wits University students who showed that they have been exposed to other software packages while 27.8% of students indicated otherwise.

Figure 4: Percentage of students using GIS software for training or practical work



	ESRI	Quantum GIS	Post GIS	GRASS	R Studio	Google Earth	Other
University of Limpopo Yes	100	100	0	7.5	0	62.5	0
University of Limpopo No	0	0	100	92.5	100	37.5	100
North West Univesity Yes	100	0	0	0	0	34.48275862	6.896551724
North West Univesity No	0	100	100	100	100	65.51724138	93.10344828
Wits University Yes	100	0	0	0	0	100	72.22222222
Wits University No	0	100	100	100	100	0	27.77777778

b) Technical knowledge and skills

This section presents results in a percentage graph derived from the analysis of the Likert scale data.

i. Office digitisation

Figure 5 presents response results in a form of percentages where students rated their skill in different GIS aspects. With regard to office digitisation, 42.5% of UL students rated themselves to have an average skill, 37.5% of UL Students have indicated to be good and only 12.5% of UL students rated themselves to have a very good skill. At least 44.4% of Wits University students have indicated to have gained an average skill in office digitisation, 27.8% of Wits University students have shown to have gained good skill in office digitisation and only 22.5% of Wits University students that have shown to have gained a very good skill in office digitisation. In NWU, 13.8% of students have an average skill in office digitisation, 41.4% of students are good while 34.5% students are very good in office digitisation.

ii. Fieldwork data collection

With regard to fieldwork data collection, 32.5% of UL students rated themselves to have an average skill, 25% of UL Students have indicated to be good, and only 22.5% of UL students rated themselves to have a very good skill. At least 50% of Wits University students have indicated to have gained an average skill in fieldwork data collection, 27.8% of Wits University students have shown to have gained a good skill in fieldwork data collection, and only 16.7% of Wits University students have shown to have gained a very good skill in fieldwork data collection. In NWU, 27.6% of students have an average skill in fieldwork data collection, 37.9% of students are good while 24.1% students are very good in fieldwork data collection.

iii. Map projection and data transformation

With regard to map projection and data transformation, 40% of UL students rated themselves to have an average skill, 32.5% of UL students have indicated to be good, and only 20% of UL students rated themselves to have a very good skill. At least 50% of Wits students have indicated to have gained an average skill in map projection and data transformation, 27.8% of Wits University students have shown to have gained a good skill in map projection and data transformation and only 16.7% of Wits University students have shown to have gained a very good skill in map projection and data transformation. In NWU, 13.8% of students have an average skill in map projection and data transformation, 41.4% of students are good while 44.8% students are very good in map projection and data transformation.

iv. Interpretation of a topographic map

Regarding an interpretation of a topographic map, 10% of UL students rated themselves to have an average skill, 37.5% of UL Students have indicated to be good, and only 47.5% of UL students rated themselves to have a very good skill. At least 16.7% of Wits University students have indicated to have gained an average skill in the interpretation of a topographic map, 50% of Wits students have shown to have gained a good skill in the interpretation of a topographic map, and only 27.8% of Wits students have shown to have gained a very good skill in the interpretation of a topographic map. In NWU, 13.8% of students have an average skill in the interpretation of a topographic map, 31% of students are good while 55.2% students are very good in the interpretation of a topographic map.

v. Making a topographic map

With respect to making a topographic map, 22.5% of UL students rated themselves to have an average skill, 35% of UL Students have indicated to be good and only 32.5% of UL students rated themselves to have a very good skill. At least 38.9% of Wits University students have indicated to have gained an average skill in making a topographic map, 38.9% of Wits University students have shown to have gained a good skill in making a topographic map, and only 16, 7% of Wits University students that have shown to have

gained a very good skill in making a topographic map. In NWU, 13.8% of students have an average skill in making a topographic map, 27.6% of students are good while 55.2% students are very good in making a topographic map.

vi. Modifying a topographic map in a digital format

With respect to modifying a topographic map in a digital format, 12.5% of UL students rated themselves to have a very poor skill, 17.5% of UL students rated themselves to have a poor skill, 30% of UL students have rated themselves to have an average skill, 30% of UL Students have indicated to be good and only 10% of UL students rated themselves to have a very good skill. At least 33.3% of Wits University students have indicated to have a poor skill in modifying a topographic map in a digital format, 44.4% of Wits University students have gained an average skill in modifying a topographic map in a digital format, 16.7% of Wits University students have shown to have gained a good skill in modifying a topographic map in a digital format, and only 5.6% of Wits University students have shown to have gained a very good skill in modifying a topographic map in a digital format. In NWU, 17.2% of students have an average skill in modifying a topographic map in a digital format, 41.4% of students are good while 37.9% students are very good in modifying a topographic map in a digital format.

vii. Making a professional thematic map

With respect to making a professional thematic map, 5% of UL students rated themselves to have a very poor skill, 10% of UL students rated themselves to have a poor skill, 37.5% of UL students have rated themselves to have an average skill, 27% of UL Students have indicated to be good, and only 20% of UL students rated themselves to have a very good skill. At least 22.2% of Wits University students have indicated to have a poor skill in making a professional thematic map, while 44.4% of Wits University students have gained an average skill in making a professional thematic map, 16.7% of Wits students have shown to have gained good skill in making a professional thematic map, and only 16.7% of Wits University students have shown to have gained a very good skill in making a professional thematic map. In NWU, 20.7% of students have an average skill in making

a professional thematic map, 37.9% of students are good while 41.4% students are very good in making a professional thematic map.

viii. Gathering data required to produce a thematic map

With regard to gathering data required to produce a thematic map, 2.5% of UL students rated themselves to have a very poor skill, 7.5% of UL students rated themselves to have a poor skill, 42.5% of UL students have rated themselves to have an average skill, 37.5% of UL Students have indicated to be good, and only 10% of UL students rated themselves to have a very good skill. At least 55.6% of Wits University students have gained an average skill in gathering data required to produce a thematic map, 27.8% of Wits University students have shown to have gained a good skill in gathering data required to produce a thematic map, and only 16.7% of Wits students have shown to have gained a very good skill in gathering data required to produce a thematic map. In NWU, 34.5% of students have an average skill in gathering data required to produce a thematic map, 31% of students are good while 34.5% students are very good in gathering data required to produce a thematic map.

ix. Creation and publishing of maps on internet

With respect to the creation and publishing of maps on internet, 12.5% of UL students rated themselves to have a very poor skill, 17.5% of UL students rated themselves to have a poor skill, 30% of UL students have rated themselves to have an average skill, 17.5% of UL Students have indicated to be good, and only 22.5% of UL students rated themselves to have a very good skill. At least 22.2 % of Wits University students have indicated to have a very poor skill in the creation and publishing of maps on internet, 27.8% of Wits University students have indicated to have a poor skill in the creation and publishing of maps on internet, 33.3% of Wits University students have gained an average skill in the creation and publishing of maps on internet, 16.7% of Wits University students have shown to have gained good skill in the creation and publishing of maps on internet, and only 0% of Wits University students have shown to have gained a very good skill in the creation and publishing of maps on internet. In NWU, 3.4% of students have rated

themselves to have a very poor skill in creating and publishing of maps on internet, 27.6% of students have an average skill in the creation and publishing of maps on internet, 24.1% of students are good while 44.8% students are very good in the creation and publishing of maps on internet.

x. Processing basic statistical geographic data

Regarding the processing of basic statistical geographic data, 20% of UL students rated themselves to have poor skill, 32.5% of UL students have rated themselves to have an average skill, 40% of UL Students have indicated to be good, and only 7.5% of UL students rated themselves to have a very good skill. At least 5.6 % of Wits University students have indicated to have a very poor skill in the processing of basic statistical geographic data, 27.8% of Wits University students have indicated to have a poor skill in the processing of basic statistical geographic data, 38.9% of Wits University students have gained an average skill in the processing of basic statistical geographic data, 16.7% of Wits University students have shown to have gained good skill in the creation and publishing of maps on internet, and only 11.1% of Wits University students have shown to have gained a very good skill in the creation and publishing of maps on internet. In NWU, 3.4% of students have rated themselves to have a very poor skill in creating and publishing of maps on internet, 3.4% of students have a poor skill, 13.8% of students average skill in the creation and publishing of maps on internet, 44.8% of students are good while 34.5% of students are very good in the creation and publishing of maps on internet.

xi. Using GIS tools

Regarding the use of GIS tools (e.g. database creation, scanning, creation of shapefile, projections and manipulation), 2.5% of UL students rated themselves to have a very poor skill, 7.5% of UL students have a poor skill, 37.5% of UL students have rated themselves to have an average skill, 37.5% of UL Students have indicated to be good, and only 15% of UL students rated themselves to have a very good skill. At least 0% of Wits University students have indicated to have both a very poor and poor skill in using GIS tools, 33.3%

of Wits University students have gained an average skill in using GIS tools, 38.9% of Wits University students have shown to have gained a good skill in using GIS tools and only 27.8% of Wits University students have shown to have gained a very good skill in the use of GIS tools. In NWU, 3.4% of students have rated themselves to have a very poor skill in the use of GIS tools, 10.3% of students have an average skill in the use of GIS tools, 31% of students are good while 55.2% of students are very good in the use of GIS tools.

xii. The ability to use geoprocessing tools

Regarding the ability to use geoprocessing tools (e.g. buffer, clip etc.), 5% of UL students rated themselves to have a poor skill, 7.5% of UL students have rated themselves to have an average skill, 32.5% of UL Students have indicated to be good, and only 55% of UL students rated themselves to have a very good skill. At least 11.1% of Wits University students have indicated to have poor skill in using geoprocessing tools, 33.3% of Wits University students have gained an average skill in using geoprocessing tools, 44.4% of Wits University students have shown to have gained a good skill in using geoprocessing tools, and only 11.1% of Wits University students have shown to have gained a very good skill in the use of geoprocessing tools. In NWU, 0% of students have rated themselves to have both a very poor and poor skill in the use of geoprocessing tools, 6.9% of students have an average skill in the use of geoprocessing tools, 34.5% of students are good while 58.6% of students are very good in the use of geoprocessing tools.

xiii. The ability to perform spatial analysis

With respect to the ability to perform spatial analysis (e.g. create slope, viewshed, contours, etc.), 10% of UL students rated themselves to have a very poor skill, 17.5% of UL students have rated themselves to have a poor skill, 32.5% of UL students have indicated to have an average skill, 35% of UL students rated themselves to have a good skill and only 5% of UL students have indicated to have a very good skill. At least 22.2% of Wits University students have indicated to have poor skill in spatial analysis, 33.3% of Wits University students have gained an average skill in spatial analysis, 27% of Wits University students have shown to have gained a good skill in spatial analysis, and only

16.7% of Wits students have shown to have gained a very good skill in spatial analysis. In NWU, 0% of students have rated themselves to have both a very poor and poor skill in spatial analysis, 13.8% of students have an average skill in the use of spatial analysis, 24.1% of students are good while 62.1% of students are very good in spatial analysis.

xiv. Creation and querying of spatial databases

With respect to the ability to create and query geodatabases, 2.5% of UL students rated themselves to have a very poor skill, 10% of UL students have rated themselves to have a poor skill, 25% of UL students have indicated to have an average skill, 35% of UL students rated themselves to have a good skill and only 27.5% of UL students have indicated to have a very good skill. At least 5.6% of Wits University students have indicated to have very poor skill in creating and querying geodatabases, 16.7% of Wits University students have a poor skill in creating and querying geodatabases, 61.1% of Wits University students have gained an average skill in creating and querying geodatabases, 16.7% of Wits University students have shown to have gained good skill in creating and querying geodatabases, and only 0% of Wits University students that have showed to have gained a very good skill in creating and querying geodatabases. In NWU, 3.4% of students have rated themselves to have a poor skill in creating and querying geodatabases, 20.7% of students have an average skill in creating and querying geodatabases, 27.6% of students are good and 48.3% of students are very good in creating and querying geodatabases.

xv. Managing and manipulating digital geographical data for a project use

With regard to the ability to manage and manipulate digital geographic data for a project use, 0% of UL students rated themselves to have a very poor skill, 12.5% of UL students have rated themselves to have a poor skill, 17.5% of UL students have indicated to have an average skill, 50% of UL students rated themselves to have a good skill and only 20% of UL students have indicated to have a very good skill. At least 0% of Wits students have indicated to have very poor skill in the ability to manage and manipulate digital geographic data for a project use, 16.7% of Wits University students have a poor skill in in the ability

to manage and manipulate digital geographic data for a project use, 27.8% of Wits University students have gained an average skill in in the ability to manage and manipulate digital geographic data for a project use, 50% of Wits University students have shown to have gained good skill in in the ability to manage and manipulate digital geographic data for a project use, and only 5.6% of Wits University students have shown to have gained a very good skill in the ability to manage and manipulate digital geographic data for a project use. In NWU, 3.4% of students have rated themselves to have a poor skill in the ability to manage and manipulate digital geographic data for a project use, 17.2% of students have an average skill in the ability to manage and manipulate digital geographic data for a project use, 31% of students are good and 48.3% of students are very good in the ability to manage and manipulate digital geographic data for a project use.

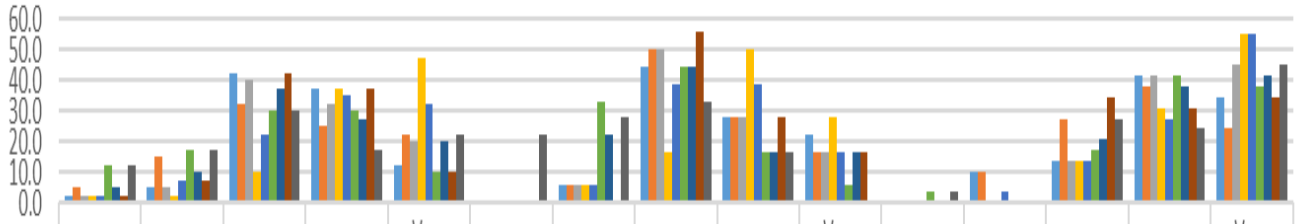
xvi. Ability to use free/open GIS software

With regard to the ability to use open license GIS software packages, 12.5% of UL students have rated themselves to have a poor skill, 17.5% of UL students have indicated to have an average skill, 45% of UL students rated themselves to have a good skill and only 25% of UL students have indicated to have a very good skill. At least 5.6% of Wits University students have indicated to have very poor skill in the ability to use open license GIS software packages, 5.6% of Wits University students have a poor skill in the ability to use open license GIS software packages, 61.1% of Wits University students have gained an average skill in the ability use open license GIS software packages, 22.2% of Wits University students have shown to have gained good skill in the ability to use open license GIS software packages, and only 5.6% of Wits University students that have shown to have gained a very good skill in the ability to use open license GIS software packages. In NWU, 17.2% of students have rated themselves to have a very poor skill in in the ability to use open license GIS software packages, 3.4% of students have rated themselves to have poor skill in the ability to use open GIS software packages, 20.7% of students have an average skill in the ability to use open license GIS software packages, 41.4% of students are good and 17.2% of students are very good in the ability to use open license GIS software packages.

xvii. Ability to identify the difference between open and commercial GIS software

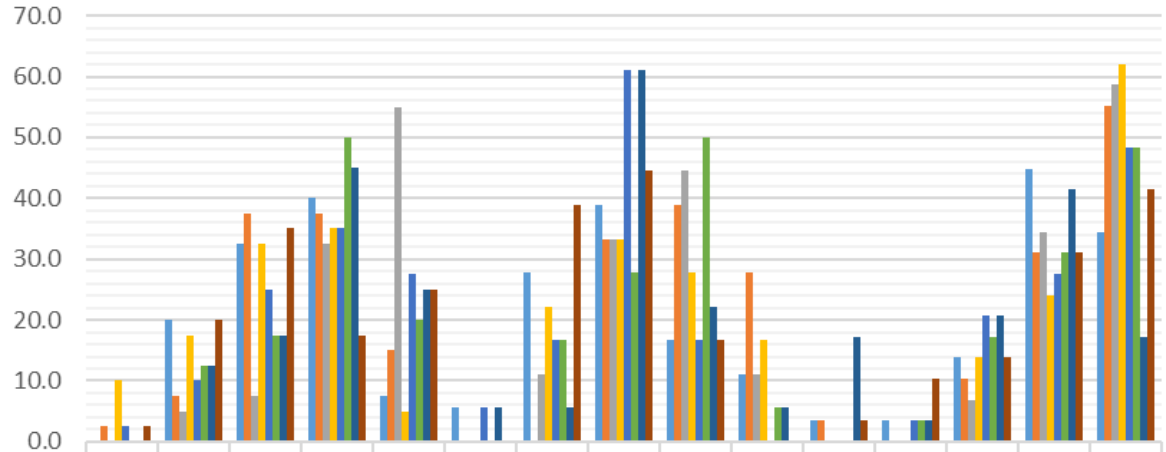
With regard to the ability to identify the difference between commercial and open GIS software, 2.5% of UL students have rated themselves to have a very poor skill, 20% of UL students rated themselves to have a poor skill, 35% of UL students have indicated to have an average skill, 17.5% of UL students rated themselves to have a good skill and only 25% of UL students have indicated to have a very good skill. At least 38.9% of Wits University students have indicated to have poor skill in the ability to identify the difference between commercial and open GIS software, 44.4% of Wits University students have gained an average skill in the ability use open license GIS software packages, 16.7% of Wits University students have shown to have gained good skill in the ability to identify the difference between commercial and open GIS software, and only 0% of Wits University students have shown to have gained a very good skill in the ability to identify the difference between commercial and open GIS software. In NWU, 3.4% of students have rated themselves to have a very poor skill in the ability to identify the difference between commercial and open GIS software, 10.3% of students have rated themselves to have a poor skill in the ability to identify the difference between commercial and open GIS software, 13.8% of students have an average skill in the ability to identify the difference between commercial and open GIS software, 31% of students are good and 41.4% of students are very good in the ability to identify the difference between commercial and open GIS software.

Figure 5: Percentage distribution of respondents' knowledge and skills on certain GIS technical aspects



	University of Limpopo					Wits University					North West University				
	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good
Office digitasation	2.5	5.0	42.5	37.5	12.5	0.0	5.6	44.4	27.8	22.2	0.0	10.3	13.8	41.4	34.5
Fieldwork data collection	5.0	15.0	32.5	25.0	22.5	0.0	5.6	50.0	27.8	16.7	0.0	10.3	27.6	37.9	24.1
Map projection and data transformation	2.5	5.0	40.0	32.5	20.0	0.0	5.6	50.0	27.8	16.7	0.0	0.0	13.8	41.4	44.8
Intepretation of topographic map	2.5	2.5	10.0	37.5	47.5	0.0	5.6	16.7	50.0	27.8	0.0	0.0	13.8	31.0	55.2
Making a topographic map	2.5	7.5	22.5	35.0	32.5	0.0	5.6	38.9	38.9	16.7	0.0	3.4	13.8	27.6	55.2
Modifying a topographic map in digital format	12.5	17.5	30.0	30.0	10.0	0.0	33.3	44.4	16.7	5.6	3.4	0.0	17.2	41.4	37.9
Making a professional thematic map	5.0	10.0	37.5	27.5	20.0	0.0	22.2	44.4	16.7	16.7	0.0	0.0	20.7	37.9	41.4
Gathering data required to produce thematic map	2.5	7.5	42.5	37.5	10.0	0.0	0.0	55.6	27.8	16.7	0.0	0.0	34.5	31.0	34.5
Creation and publishing maps on internet	12.5	17.5	30.0	17.5	22.5	22.2	27.8	33.3	16.7	0.0	3.4	0.0	27.6	24.1	44.8

Figure 5: Percentage distribution of respondents' knowledge and skills on certain GIS technical aspects (Continued)



	University of Limpopo					Wits University					North West University				
	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good
Processing basic statistical data	0.0	20.0	32.5	40.0	7.5	5.6	27.8	38.9	16.7	11.1	3.4	3.4	13.8	44.8	34.5
Using GIS tools	2.5	7.5	37.5	37.5	15.0	0.0	0.0	33.3	38.9	27.8	3.4	0.0	10.3	31.0	55.2
Geoprocessing tools	0.0	5.0	7.5	32.5	55.0	0.0	11.1	33.3	44.4	11.1	0.0	0.0	6.9	34.5	58.6
Geographic analysis	10.0	17.5	32.5	35.0	5.0	0.0	22.2	33.3	27.8	16.7	0.0	0.0	13.8	24.1	62.1
Creation and Querying spatial databases	2.5	10.0	25.0	35.0	27.5	5.6	16.7	61.1	16.7	0.0	0.0	3.4	20.7	27.6	48.3
Managing and manipulating data for project use	0.0	12.5	17.5	50.0	20.0	0.0	16.7	27.8	50.0	5.6	0.0	3.4	17.2	31.0	48.3
Ability to free/use Open GIS	0.0	12.5	17.5	45.0	25.0	5.6	5.6	61.1	22.2	5.6	17.2	3.4	20.7	41.4	17.2
Difference in Open and commercial GIS	2.5	20.0	35.0	17.5	25.0	0.0	38.9	44.4	16.7	0.0	3.4	10.3	13.8	31.0	41.4

xviii. Understanding of Spatial Data Infrastructure Act, 2004

Figure 6 presents the results. With respect to the understanding of Spatial Data Infrastructure (SDI) Act, 27.5% of UL students have rated themselves to have a very poor knowledge, 30% of UL students rated themselves to have a poor knowledge, 20% of UL students have indicated to have an average knowledge, 20% of UL students rated themselves to have a good knowledge and only 2.5% of UL students have indicated to have a very good knowledge. At least 55.6% of Wits University students have indicated to have a very poor knowledge of the SDI Act, 22.2% of Wits University students have a poor knowledge of the SDI Act, 22.2% of Wits University students have an average knowledge of SDI Act, and 0% of Wits University students have shown to have good and very good knowledge of the SDI Act. In NWU, 10.3% of students have rated themselves to have a very poor knowledge of the SDI Act, 13.8% of students have rated themselves to have a poor knowledge of the SDI Act, 34.5% of students have an average knowledge of the SDI Act, 24.1% of students are good and 17.2% of students have a very good knowledge of the SDI Act.

xix. Knowledge of South African Constitution, 1996

Figure 6 presents the results. With respect to the understanding of The South African Constitution, 10% of UL students have rated themselves to have a very poor knowledge, 12.5% of UL students rated themselves to have poor knowledge, 15% of UL students have indicated to have an average knowledge, 25% of UL students rated themselves to have good knowledge and only 37.5% of UL students have indicated to have very good knowledge of SA Constitution. At least 55.6% of Wits University students have indicated to have a very poor knowledge of SA Constitution, 22.2% of Wits University students have indicated a poor knowledge of SA Constitution, 22.2% of Wits University students have an average knowledge of SA Constitution and 0% of Wits University students have shown to have good and very good knowledge of SA Constitution. In NWU, 10.3% of students have rated themselves to have a very poor knowledge of SA Constitution, 27.6% of students have rated themselves to have a poor knowledge of SA Constitution, 24.1% of

students have an average knowledge of SA Constitution, 34.5% of students are good and 3.4% of students have a very good knowledge of SA Constitution.

xx. Knowledge of South African Geomatics Act

Figure 6 presents the results. Regarding the understanding of South African Geomatics Act, 45% of UL students have rated themselves to have a very poor knowledge, 25% of UL students rated themselves to have a poor knowledge while 17.5% of UL students have indicated to have an average knowledge, 12.5% of UL students rated themselves to have a good knowledge and 0% of UL students have indicated to have a very good knowledge of SA Geomatics Act. At least 77.8% of Wits University students have indicated to have a very poor knowledge of SA Geomatics Act, 22.2% of Wits University students have a poor knowledge of SA Geomatics Act, 0% of Wits University students have an average, good and very good knowledge of SA Geomatics Act. In NWU, 10.3% of students have rated themselves to have a very poor knowledge of SA Geomatics Act, 34.5% of students have rated themselves to have a poor knowledge of SA Geomatics Act, 34.5% of students have an average knowledge of SA Geomatics Act, 20.7% of students are good and 0% of students have a very good knowledge of SA Geomatics Act.

xxi. Knowledge of South African Geographical Names Act

Figure 6 presents the results. Regarding the understanding of South African Geographical Names Act, 37.5% of UL students have rated themselves to have a very poor knowledge, 25% of UL students rated themselves to have be poor, 10% of UL students have indicated to have an average knowledge, 22.5% of UL students rated themselves to have a good knowledge and only 5% of UL students have indicated to have a very good knowledge of SA Geographical Names Act. At least 77.8% of Wits University students have indicated to have a very poor knowledge of SA Geographical Names Act, 16.7% of Wits University students have a poor knowledge of SA Geographical Names Act, 5.6% of Wits University students have an average knowledge of SA Geographical Names Act and 0% of Wits University students have showed to have good and very good knowledge of SA Geographical Names Act. In NWU, 10.3% of students have rated themselves to have a

very poor knowledge of SA Geographical Names Act, 37.9% of students have rated themselves to have a poor knowledge of SA Geographical Names Act, 31% of students have an average knowledge of SA Geographical Names Act, 20.7% of students are good and 0% of students have a very good knowledge of SA Geographical Names Act.

xxii. Knowledge of Spatial Planning and Land Use Management Act

Figure 6 presents the results. With respect to the understanding of Spatial Planning and Land Use Management (SPLUMA), 20% of UL students have rated themselves to have a very poor knowledge, 22.5% of UL students rated themselves to have a poor knowledge, 30% of UL students have indicated to have an average knowledge, 20% of UL students rated themselves to have a good knowledge and only 7.5% of UL students have indicated to have a very good knowledge of SPLUMA. At least 77.8% of Wits University students have indicated to have a very poor knowledge of SPLUMA, 16.7% of Wits University students have a poor knowledge of SPLUMA, 5.6% of Wits University students have an average knowledge of SPLUMA and 0% of Wits University students have showed to have good and very good knowledge of SPLUMA. In NWU, 10.3% of students have rated themselves to have a very poor knowledge of SPLUMA, 44.8% of students have rated themselves to have a poor knowledge of SPLUMA, 20.7% of students have an average knowledge of SPLUMA, 24.1% of students are good and 0% of students have a very good knowledge of SPLUMA.

xxiii. Knowledge of Land Survey Act

Figure 6 presents the results. With respect to the understanding of the Land Survey Act, 35% of UL students have rated themselves to have a very poor knowledge, 32.5% of UL students rated themselves to have poor the knowledge, 20% of UL students indicated to have an average knowledge, 12.5% of UL students rated themselves to have a good knowledge and 0% of UL students indicated to have a very good knowledge of the Land Survey Act. At least 72.2% of Wits University students have indicated to have a very poor knowledge of the Land Survey Act, and 27.8% of Wits University students have a poor knowledge of the Land Survey Act. In NWU, 10.3% of students have rated themselves to

have a poor knowledge of the Land Survey Act, 44.8% of students have an average knowledge of the Land Survey Act, 24.1% of students are good and 20.7% of students have a very good knowledge of the Land Survey Act.

xxiv. Knowledge of the Copyright Act

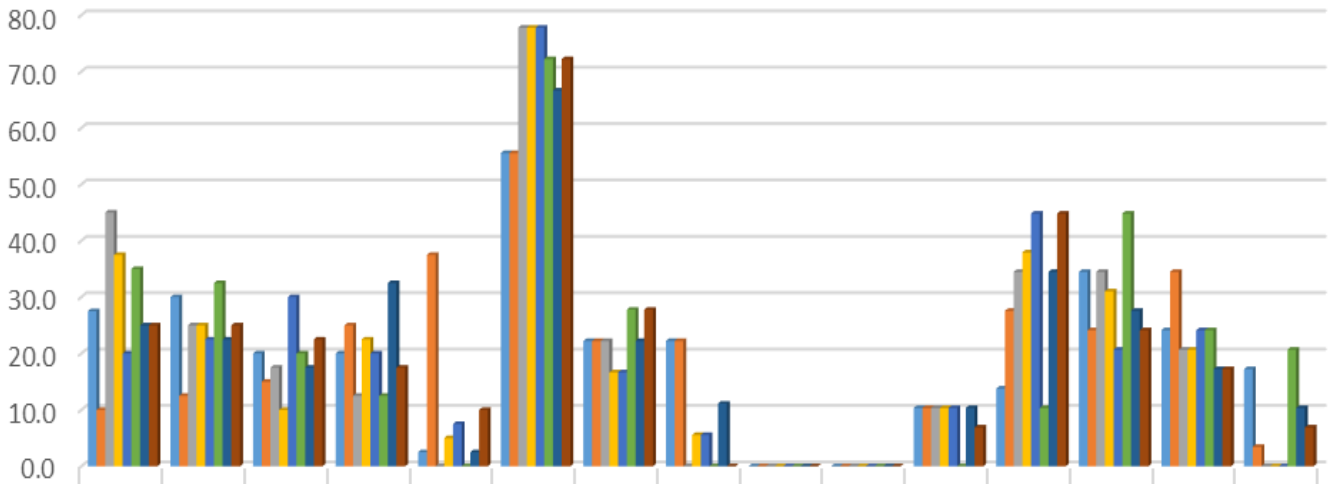
Figure 6 presents the results. With respect to the understanding of the Copyright Act, 25% of UL students rated themselves to have a very poor knowledge, 22.5% of UL students rated themselves to have poor, knowledge, 17.5% of UL students indicated to have an average knowledge, 32.5% of UL students rated themselves to have a good knowledge and only 2.5% of UL students indicated to have a very good knowledge of the Copyright Act. At least 66.7% of Wits University students indicated to have a very poor knowledge of the Copyright Act, 22.2% of Wits University students have a poor knowledge of the Copyright Act, 11.1% of Wits University students have an average knowledge of the Copyright Act and only 0% of Wits University students showed a good and very good knowledge of the Copyright Act. In NWU, 10.3% of students rated themselves to have a very poor knowledge of the Copyright Act, 34.5% of students rated themselves to have a poor knowledge of the Copyright Act, 27.6% of students have an average knowledge of the Copyright Act, 17.2% of students are good and 10.3% of students have a very good knowledge of the Copyright Act.

xxv. Knowledge of Promotion of Access to the Information Act

Figure 6 presents the results. With respect to the understanding of Promotion of Access to the Information Act (PAIA), 25% of UL students rated themselves to have a very poor knowledge, 25% of UL students rated themselves to have be poor, 22.5% of UL students indicated to have an average knowledge, 17.5% of UL students rated themselves to have a good knowledge and only 10% of UL students have indicated to have a very good knowledge of PAIA. At least 72.2% of Wits University students indicated to have a very poor knowledge of PAIA, 27.8% of Wits University students have a poor knowledge of PAIA. In NWU, 6.9% of students have rated themselves to have a very poor knowledge of PAIA, 44.8% of students have rated themselves to have a poor knowledge of PAIA,

24.1% of students an average knowledge of PAIA, 17.2% of students are good and 6.9% of students have a very good knowledge of PAIA.

Figure 6: Percentage distribution of respondents' knowledge of legislation governing GIS and use of spatial information



	University of Limpopo					Wits University					North West University				
	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good	Very Poor	Poor	Average	Good	Very Good
SDI Act	27.5	30.0	20.0	20.0	2.5	55.6	22.2	22.2	0.0	0.0	10.3	13.8	34.5	24.1	17.2
SA constitution	10.0	12.5	15.0	25.0	37.5	55.6	22.2	22.2	0.0	0.0	10.3	27.6	24.1	34.5	3.4
SA Geomatics Act	45.0	25.0	17.5	12.5	0.0	77.8	22.2	0.0	0.0	0.0	10.3	34.5	34.5	20.7	0.0
SA Geographical Names Act	37.5	25.0	10.0	22.5	5.0	77.8	16.7	5.6	0.0	0.0	10.3	37.9	31.0	20.7	0.0
SPLUMA	20.0	22.5	30.0	20.0	7.5	77.8	16.7	5.6	0.0	0.0	10.3	44.8	20.7	24.1	0.0
Land Survey Act	35.0	32.5	20.0	12.5	0.0	72.2	27.8	0.0	0.0	0.0	0.0	10.3	44.8	24.1	20.7
Copyright Act	25.0	22.5	17.5	32.5	2.5	66.7	22.2	11.1	0.0	0.0	10.3	34.5	27.6	17.2	10.3
PAIA	25.0	25.0	22.5	17.5	10.0	72.2	27.8	0.0	0.0	0.0	6.9	44.8	24.1	17.2	6.9

xxvi. Application of GIS in other geography module

Figure 7 shows results from closed-ended questions (yes/no) within which students were required to answer if they have an opportunity to use GIS and other geospatial software such as Remote Sensing to do practical work using examples from other geographical modules, such as climatology, population and geography, etc. In this regard, students indicated if they have done any practical work using GIS or other geospatial technology to map and analysed some geographical aspects highlighted in the questionnaire. The study reveals that 72% students from UL have indicated that they have used GIS and other related geospatial technology software in climatology (i.e. weather forecast, climate change analysis, etc.), and 27.5% of UL students indicated that they have never used GIS in climatology or meteorological analysis. At least 88.9% of Wits University students indicated that they have applied GIS in climatology while 11.1% stated that they have never used GIS in climatology. At least 93.1% of students from NWU have indicated that they have used GIS in climatology while 6.9% indicated that they have never used GIS in studying climatology.

With regard to the use of GIS in population and demography, 67.5% of UL students indicated that they have used GIS and 32.5% indicated that they have never used GIS in a population study. At least 94.4% of Wits University students showed that they have used GIS in studying population and demography while 5.6% showed that they have never used GIS for such studies. At least 89.7% of NWU students showed that they have used GIS in population and demography while 10.3% indicated that they have never used GIS for studying population and demography.

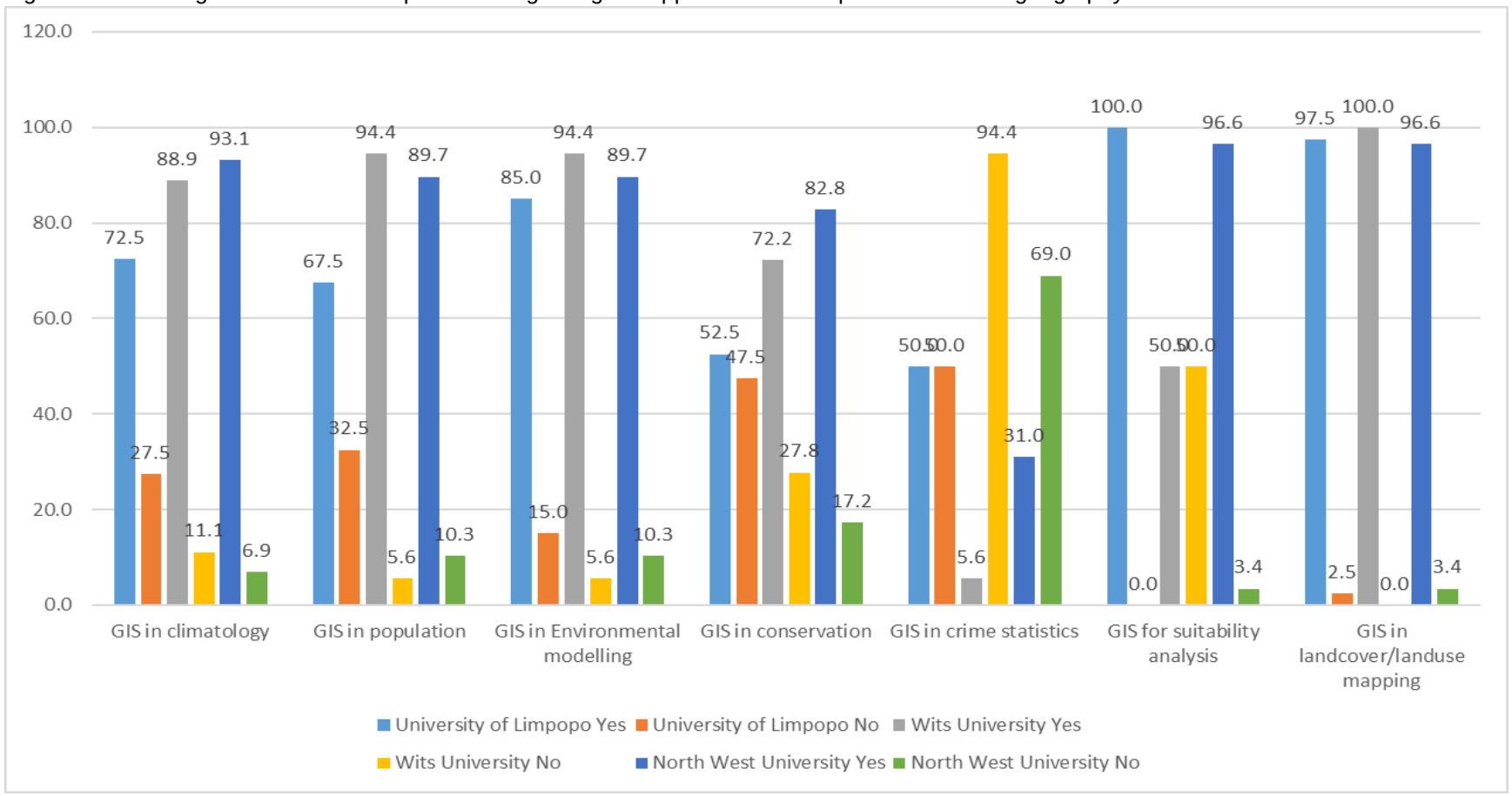
With respect to the use of GIS in Environmental modelling, the study revealed that 85% of students from UL have indicated that they were exposed to the use of GIS on environmental modelling while 15% indicated that they have never used GIS for such purpose. 94.4% students from Wits University indicated that they have used GIS in performing environmental modelling while 5.6% of students showed that they have never used GIS for studying environmental modelling. At least 89.7% of students from NWU

indicated that they were exposed to the use of GIS in environmental modelling while 10.3% showed that they have never used GIS for environmental modelling exercises.

At least 52.5% of students from UL indicated that they have been exposed in the use of GIS in conservation management while 47.5% of students showed that they have never been exposed to the use of GIS in biogeography (conservation and preservation of natural resources). At least 72.2% of Wits University students have indicated that they have used GIS for biogeography practical while 27.8% stated otherwise. 82.8% of NWU students indicated that they have used GIS in studying biogeography while 17.2% stated otherwise. Regarding to the use of GIS in crime statistics, 50% of UL students have indicated they were exposed while 50% stated otherwise. At Wits University, at least 5.6% indicated that they were exposed to practical work that deals with crime statistics while 94.4% stated otherwise. 31% of NWU students indicated that they were exposed to GIS practical work in crime statistics while 69% indicated otherwise.

As far as the use of GIS for suitability analysis is concerned, 100% UL students indicated that they have been exposed to such practical work. At least 50% of Wits University students indicated that they had an exposure to doing practical work on suitability analysis while other 50% of students indicated the opposite. At least 96.4% of NWU students indicated that they had a practical exposure in using GIS for suitability analysis while 3.4% indicated otherwise. At least 97.5% of UL students indicated that they have had an exposure in the use of GIS for Landover/land use mapping while 2.5% indicated otherwise. At least 100% of Wits University students indicated to have been exposed to doing practical work towards studying Landover/land use mapping. At least 96.6% of NWU students have indicated that they have been exposed to Landover/land use mapping practical work while 3.4% indicated differently.

Figure 7: Percentage distribution of respondents regarding the application of GIS practical in other geography modules



xxvii. Future prospects in GIS

Figure 8 provides results from a list of questions to which students were required to indicate their interest in taking on GIS work and the prospect of registering for a GIS postgraduate degree in future. With regard to the prospect of registering with the South African Geomatics Council (SAGC), 12.5% of UL students indicated that they were not interested, 15% of UL students indicated that they are slightly interested, 20% of UL students were not sure, 27.5% of UL students were interested, and 25% of UL students indicated that they were very interested. At least 11.1% of Wits University students indicated that they were not interested, 11.1% of Wits University students were slightly interested, 33.3% of Wits University students were not sure, 11.1% of Wits University students were interested, and 33.3% were very interested. At least 20.7% of NWU students were not interested, 3.4% of NWU students were slightly interested, 20.7% of NWU students were undecided, 27.6% of NWU students were interested, and 27.6 of NWU students were very interested.

With respect to the prospect of registering for a postgraduate degree in GIS or geography using GIS, 25% of UL students indicated that they were not interested, 15% of UL students indicated that they were slightly interested, 20% of UL students were not sure, 22.5% of UL students were interested, and 17.5% of UL students indicated that they were very interested. At least 5.6% of Wits University students indicated that they were not interested, 27.8% of Wits University students were slightly interested, 16.7% of Wits University students were not sure, 33.3% of Wits University students were interested, and 16.7% were very interested. At least 24.1% of NWU students were not interested, 6.9% of NWU students were slightly interested, 6.9% of NWU students were not sure/were undecided, 44.8% of NWU students were interested, and 17.2 of NWU students were very interested.

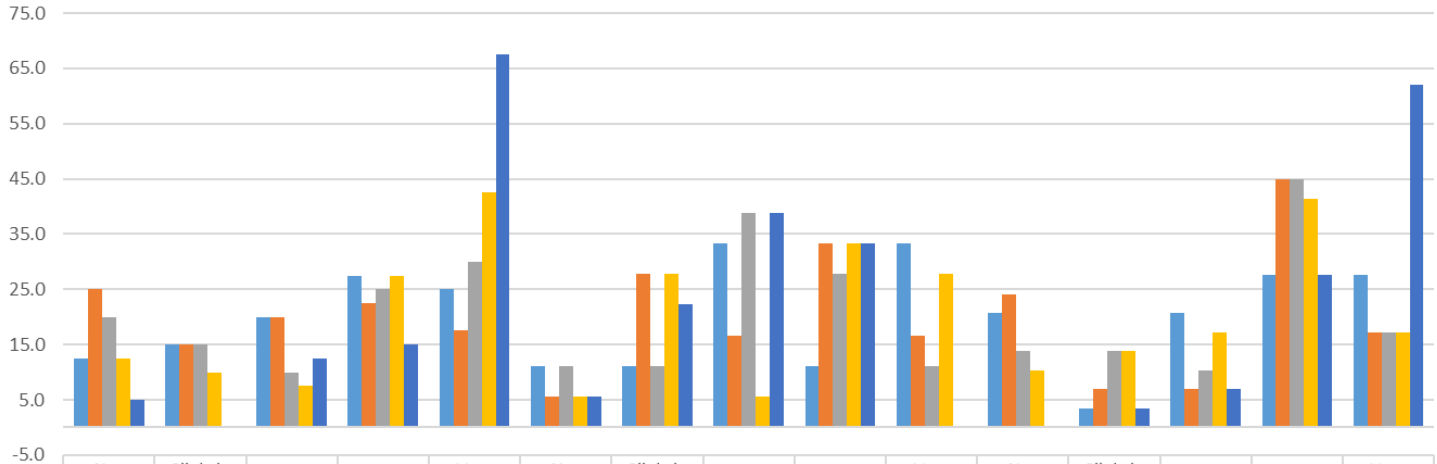
With regard to a perceived capacity to use GIS on self-employed basis (company), 20% of UL students indicated that they were not interested, 15% of UL students indicated that they were slightly interested, 10% of UL students were not sure, 25% of UL students were interested, and 30% of UL students indicated that they were very interested. At least

11.1% of Wits University students indicated that they were not interested, 11.1% of Wits University students were slightly interested, 38.9% of Wits University students were not sure, 27.8% of Wits University students were interested, and 11.1% were very interested. At least 13.8% of NWU students were not interested, 13.8% of NWU students were slightly interested, 10.3% of NWU students were not sure/ were undecided, 44.8% of NWU students were interested, and 17.2 of NWU students were very interested.

With respect to a desire to work in a GIS company, 12.5% of UL students indicated that they were not interested, 10% of UL students indicated that they were slightly interested, 7.5% of UL students were not sure, 27.5% of UL students were interested, and 42.5% of UL students indicated that they are very interested. At least 5.6% of Wits University students indicated that they were not interested, 27.8% of Wits University students were slightly interested, 5.6% of Wits University students were not sure, 33.3% of Wits University students were interested, and 27.8% were very interested. At least 10.3% of NWU students were not interested, 13.8% of NWU students were slightly interested, 17.2% of NWU students were not sure/were undecided, 41.4% of NWU students were interested, and 17.2 of NWU students were very interested.

The last question required students to indicate if they find the teaching of GIS within the geography curriculum to be useful. At least 5% of UL students strongly disagreed, 12.5% of UL students were neutral, 15% of UL students slightly agreed, and 67.5% of UL students strongly agreed to the question. Furthermore, at least 5.6% of Wits University students strongly disagreed, 22.2% of Wits University students slightly disagreed, 38.9% of Wits University students were neutral, 33.3% of Wits University students slightly agreed, and 0% of Wits University students strongly agreed to the question. At least 0% of NWU students chose to strongly disagree, 3.4% of NWU students slightly disagreed, 6.9% of Wits University students were neutral, 27.6% of NWU students slightly agreed, and 62.1% of NWU students strongly agreed to the question.

Figure 8: Percentage distribution of respondents regarding the future prospect in GIS



	University of Limpopo					Wits University						North West University			
	Not Interested	Slightly Interested	Not Sure	Interested	Very Interested	Not Interested	Slightly Interested	Not Sure	Interested	Very Interested	Not Interested	Slightly Interested	Not Sure	Interested	Very Interested
Register with SAGC	12.5	15.0	20.0	27.5	25.0	11.1	11.1	33.3	11.1	33.3	20.7	3.4	20.7	27.6	27.6
Register for Postgraduate in GIS	25.0	15.0	20.0	22.5	17.5	5.6	27.8	16.7	33.3	16.7	24.1	6.9	6.9	44.8	17.2
Use of GIS in a company	20.0	15.0	10.0	25.0	30.0	11.1	11.1	38.9	27.8	11.1	13.8	13.8	10.3	44.8	17.2
Desire to work in GIS	12.5	10.0	7.5	27.5	42.5	5.6	27.8	5.6	33.3	27.8	10.3	13.8	17.2	41.4	17.2
Usefulness of GIS in geography	5.0	0.0	12.5	15.0	67.5	5.6	22.2	38.9	33.3	0.0	0.0	3.4	6.9	27.6	62.1

xxviii. Strength and weakness of teaching GIS within geography degree

UL students have highlighted strengths that cover the ability to collect, analyse, manage and map geographical reference data. The majority of students indicated that GIS and remote sensing practical work helped them to understand how environmental problems could be solved with ease. One student even stated that *"I have had to apply GIS in many fields which I didn't think were possible, things that would take long to complete were actually done in a shorter period using GIS."*

Another UL student mentioned strength by stating that *"It covered a lot of data processing phenomenon and now I am able to digitise, buffer, and analyse all sorts of spatial analysis on any level of data provided, it can be interpolation and other techniques."*

With regard to weakness of teaching GIS within geography degrees, UL students highlighted a number of challenges, namely; computers were slow in processing data, there were only a few computer laboratories, making it difficult to have enough time to do practical work, lack of fieldwork, poor facilitation or lack of assistance from lecturers during practical work, there is more theory but with less practical work mostly when it comes to Remote Sensing and GIS, practical work was seen to take much time from students while they have other modules to attend to.

Wits University students have highlighted that given access to apply GIS and teraset to solve environmental problems was one of the strengths of the study. One student had the following to say: *"The courses and practical did not require any prior knowledge and they were pitched at a very accessible level for those with less computer, scientific and statistical data knowledge. I was able to achieve the highest marks in the class for both modules, but I do not feel competent in applying my skills."* Another student was quoted stating the following strength: *"being exposed to software such as ArcGIS and teraset which you wouldn't use in other modules."*

With respect to the weakness, Wits University students mentioned numerous challenges also, which included old computers that keep crashing, lack of assistance from instructors during practical classes, as well as little time allocated to do practical sessions. One student had the following points to make: *"At Wits, GAES offers 2 blocks (1 in 2nd year,*

and 1 in 3rd year) in GIS and RS. These courses are very basic introduction modules. Comparing this to other universities who do entire degrees in GIS, Wits does not sufficiently prepare us for a future in the profession. Practicals are also interrupted by the old computers crashing."

NWU students have provided numerous strengths in studying GIS within the geography degree, which include the ability to use GIS to solve environmental problems and help to develop problem solving and analytical skills. One student had the following points to make: "The lecturer is very good and knows all about GIS, they know how to channel students to the right resources to understand concepts related to GIS." With regard to weaknesses, NWU has mentioned that not all computers were installed with GIS software, not enough time is spent on practical sessions which led to insufficient training, and there was no field trip for practical experience.

4.3. CONCLUSION

From the basic statistical data analysis approach applied in this chapter, the results show that as far as the understanding of GIS concept is concerned, Wits and UL students are good compared to NWU students. The cumulative percentage of average, good and very good understanding shows that 89% of Wits University students and 89% of UL students understand the GIS concept while 68% of NWU students do so. UL students performed bad on GISc concept compared to other universities with only 10% of students that understand the GISc concept. Wits Students are far better in understanding GISc concept with 55.6% cumulative results. 41.3% of NWU students understand GIS concept. Although Wits University students are slightly higher than 50%, which makes the students to be much better prepared than other universities, it is clear that universities are not preparing students well enough to comprehend the GISc concept and its implication in GIS and geography as a field of study.

As far as the RS concept is concerned, it is clear that students from all universities have been trained well. UL students have a cumulative result of 82.5%, Wits University students have a cumulative results of 94.4% which proves them to be more prepared than other universities, and NWU students have a cumulative result of 72.3%. The challenge

however, is on the understanding of the geographical thinking concept. UL students and NWU students are just below 50% of cumulative results and Wits is just slightly above 50% proving Wits University students to be more prepared than other universities.

There is little exposure of students on different kinds to open license GIS software. UL introduces students to Quantum GIS though, but Wits University and NWU does not give students chance to use open license GIS software at an undergraduate level. This makes it difficult for students to differentiate between the advantages and disadvantages of this software, thereby limiting their skills in using GIS software for different kinds of analysis.

All universities have prepared their students enough to do fieldwork data collection with UL having cumulative results of 80%, Wits University has 94.4% cumulative results and NWU has 89.7% cumulative results. Students are prepared well for office digitisation with a slight difference on cumulative results, where UL has 82.5%, Wits University has 94.4% and NWU has 89.7%. Students in all universities show to be well prepared for map production aspects, but there is poor training on the creation and publishing of maps on internet for Wits students. NWU is preparing students to deal with processing basic statistical data much better than the other two universities. NWU has 93.1% cumulative results (average, good and very good ratings), followed by UL with 50% and Wits University has 65.7%. Students from all universities are well prepared in using GIS tools and geoprocessing tools, although NWU is much higher than others percentage wise. Wits University students have a cumulative result of 67.8% on geographical analysis, UL has 72.5% on geographical analysis while NWU students showed to have 100% well prepared on geographical analysis. Students from all universities are prepared well for geodatabases, although NWU students have rated themselves to be much higher than others on cumulative results. All universities are not preparing students on legislations that govern the use of spatial information in South Africa.

CHAPTER FIVE

INTERPRETING THE RESULTS OF THE DATA ANALYSIS: MANN-WHITNEY U TEST APPROACH

5.1. INTRODUCTION

Chapter four interpreted results of data analysis using a simple percentage graph to show the distribution of responses. Chapter five however is geared towards the interpretation of the findings of data analysis derived using the Mann-Whitney U Test. The Mann-Whitney U Test results use a two sided p-value. This kind of analysis focuses on the sum of means. The analysis of means helps to establish the similarity and differences on the understanding of different technical aspects of GIS by students in different universities when compared to one another. The p-value offers the measure of significance on the results.

5.2. MANN-WHITNEY U TEST APPROACH

In this section, a hypothesis test is performed to understand if there is any similarity or difference in the knowledge and skills which students have acquired in all three different universities' programmes. Further, the analysis will also involve the presentation of results in a form of percentages in order to understand the distribution of responses across the board. Different questions were asked, ranging from open-ended to closed-ended questions. The majority of questions sought to solicit information from different aspects of GIS knowledge areas, notable geographic concepts; data collection; map production; data processing, manipulation and reproductive procedures; geographic analysis operations; geographic databases; use of GIS software; GIS and society; application of GIS in different geographical modules and future prospects in GIS related work and research.

From a student questionnaire, section B consists of open-ended questions - concepts which students were expected to define. The answers given to the concepts were marked with a score of 1 (very poor), 2 (poor), 3 (average, 4 (good) and 5 (very good). The scores were then analysed using the Mann Whitney U Test. Table 9 provides results of Likert Scale data analysed using the Mann Whitney U Test (Wilcoxon Rank Sum Test). In order

to interpret the results of table 4, the following non-parametric test research hypothesis is considered:

H_0: The two populations are equal versus

H_1: The two populations are not equal.

The significance level for the data testing is kept at 0.05%, which is alternatively referred to as 95% significance level.

a) Geographic concepts

As explained above, the students' questionnaire had open-ended questions that were marked and ranked into a maximum score of 5. The ranking results were analysed using the Mann-Whitney U Test (Wilcoxon Rank Sum Test). The next subsection provides a presentation and an analysis of the results (see table 13).

i. Understanding of GIS concept

The comparison between UL versus NWU shows a p-value of 0.0163 which is less than 0.05% significance level. Therefore, the null hypothesis in this case is rejected in favour of the alternative hypotheses. It can be concluded that there is no sufficient information to conclude that the understanding of the GIS concept between students at UL and NWU is the same. According to the mean scores, UL students have a much higher understanding of the GIS concept compared to their counterparts at NWU. This is because UL students have a mean score of 39.8 which is higher than the 28.4 mean score for NWU students.

Furthermore, the comparison of NWU versus Wits University students shows that there is no significant difference in both universities in terms of the understanding of the GIS concept since the P-value is 0.1122. As a result, we fail to reject the null hypothesis. Data from UL students versus Wits University students proved that the null hypothesis cannot be rejected (p-value 0.7636). As a result, it can be concluded that there is sufficient information to prove that students at Wits University and UL have equal understanding of

the GIS concept. Even the mean scores for UL (29.9) and Wits (28.5) are relatively the same.

ii. Understanding of GISc concept

With regard to UL versus NWU, the p-value is at 0.0005 which is far less than the 0.05% significant level. As a result, it can be concluded that there is insufficient information to conclude that the GISc concept is understood equally in both universities. The data results show that NWU students have a much better understanding of GISc concept than those that are studying at UL. The mean scores for NWU is 43.9 while UL has 28.6. However, when comparing NWU versus Wits University, the mean scores are not significantly different from each other (NWU has 25.4 and Wits University has 23.1) with a p-value of 0.5682 which is far higher than 0.05% significance level. As a result, it can be concluded that there is sufficient information to prove that the students at Wits University and NWU have equal understanding of the GISc concept.

Moreover, Wits University students have a score of 40.7 versus UL students with a score of 24.5. The scores are significantly different and this is supported by a p-value of 0.0001 which is far less than 0.05% significance level. As a result, the null hypothesis is rejected in favor of an alternative hypothesis. This means that there is insufficient information to conclude that students at Wits University have an equal understanding of the GISc concept compared to those at UL. Wits University students have a much better understanding compared to UL students when it comes to the concept of GISc.

iii. Understanding of Remote Sensing concept

In a comparison between UL and NWU, the null hypothesis cannot be rejected since the p-value is 0.2238 which is far higher than the 0.05% significance level. As a result, it can be concluded that there is sufficient information to conclude that the knowledge of students at NWU versus those at UL is equal when coming to the understanding of the remote sensing concept. Again, the comparison of Wits University versus NWU shows that a null hypothesis is rejected because the p-value is at 0.0214 which is lower than 0.05% significance level. As a result, it can be concluded that the understanding of the

remote sensing concept by students at both universities is dissimilar/not equal. Wits University students have a better understanding compared to those at NWU. The comparison of Wits University versus UL shows that students from both universities have an equal understanding of the remote sensing concept since the p-value is 0.1506 which is much higher than 0.05% significance level. Although the mean score for Wits University is 34.1 versus 27.4 of NWU, statistically there is no significant difference in both populations.

iv. Understanding of geographic thinking Concept

In comparison of UL and NWU, the null hypothesis cannot be rejected since the p-value is 0.1073 which is higher than 0.05% significance level. As a result, it can be concluded that there is sufficient information to conclude that the knowledge of students at NWU versus those at UL is equal when coming to the understanding of the geographic thinking concept. When comparing Wits University and NWU, the null hypothesis cannot be rejected because the p-value is at 0.1514 which is higher than 0.05% significance level. As a result, it can be concluded that there is sufficient information to prove that Wits University and NWU students have an equal understanding of the geographic thinking concept. The comparison of Wits versus UL shows that the p-value is 0.0034 which is less than 0.05% significance level. As a result, it can be concluded that there is insufficient information to conclude that the understanding of the geographic thinking concept is equal in both universities. Wits University students have a much higher understanding of the geographic concepts compared to their counterparts at UL.

b) Data collection

The following subsection presents and analyses statistical results as far as data collection skills are concerned.

v. Office digitization

With regard to UL versus NWU, the p-value is at 0.0234 which is far less than the 0.05% significant level. As a result, it can be concluded that there is insufficient information to

conclude that students from both universities have acquired equal skills on office digitisation. The data results show that NWU students have gained a more advanced skill level on office digitisation compared to UL students. The mean scores for NWU is 41.1 while UL has 30.6. However, when comparing NWU to Wits University, the p-value of 0.1958 is higher than 0.05% significance level. As a result, it can be concluded that there is sufficient information to prove that the students at Wits University and NWU have acquired equal skill levels in office digitisation.

When comparing Wits University and UL students, the p-value is 0.7165 which is significantly higher than 0.05% significance level. As a result, the null hypothesis cannot be rejected in this case. There is sufficient information to conclude that students in both universities have gained equal skill as far as office digitisation is concerned.

vi. Fieldwork data collection

UL versus NWU, the p-value is 0.2865 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal skill levels on fieldwork data collection. Wits University versus NWU, the p-value is 0.4053 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at Wits University and NWU have gained equal skill levels on fieldwork data collection. UL versus Wits University, the p-value is 0.8309 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill levels on fieldwork data collection.

vii. Map projection and data transformation

UL versus NWU, the p-value is 0.0024 which is significantly lower than the 0.05% significance level. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels on map projection and data transformation. Wits University versus NWU, the p-value is

0.0037 which is significantly lower than 0.05% significance level. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill levels on map projection and data transformation. When comparing UL versus Wits University, the p-value is 0.6937 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill levels on map projection and data transformation.

c) Map production

The following subsection presents and analyses statistical results as far as map production skills is concerned.

viii. Interpretation of topographic map

UL versus NWU, the p-value is 0.5563 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal skill on interpretation of a topographic map. Wits University versus NWU, the p-value is 0.0793 which is higher than 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at Wits University and NWU have gained equal skill levels on the interpretation of a topographic map. When comparing UL versus Wits University, the p-value is 0.2008 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill levels on the interpretation of a topographic map.

ix. Making a topographic map

UL versus NWU, the p-value is 0.0492 which is slightly lower than 0.05% significance level. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels on making a topographic map. Wits University versus NWU, the p-value is 0.0082 which is significantly

lower than 0.05% significance level. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill on making a topographic map. UL versus Wits University, the p-value is 0.3248 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill levels on making a topographic map.

x. Modifying a topographic map in digital format

UL versus NWU, the p-value is 0.0002 which is significantly lower than 0.05% significance level. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels on modifying a topographic map in digital format. Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05% significance level. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill levels on modifying a topographic map in digital format. UL versus Wits University, the p-value is 0.5271 which is significantly higher than the 0.05% significance level. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill levels on modifying a topographic map in digital format.

xi. Making a professional thematic map

UL versus NWU, the p-value is 0.004 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels in making a professional thematic map. Students from NWU have rated themselves to be good in making a professional thematic map compared to those from UL. Wits University versus NWU, the p-value is 0.0018 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill levels in making a professional thematic map. Students from NWU have rated themselves to be good in making a professional thematic map compared to those from

Wits University. UL versus Wits University, the p-value is 0.4021 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill in making a professional thematic map.

xii. Gathering data required to produce a thematic map

UL versus NWU, the p-value is 0.0188 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels in gathering data required to produce a thematic map. Students from NWU have rated themselves to be good in gathering data required to produce a thematic map compared to those from UL. Wits University versus NWU, the p-value is 0.1381 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at Wits University and NWU have gained equal skill levels in gathering data required to produce a thematic map. UL versus Wits University, the p-value is 0.7041 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and Wits University have gained equal skill levels in gathering data required to produce a thematic map.

xiii. Creation and publishing maps on internet

UL versus NWU, the p-value is 0.0052 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels in creation and publishing maps on internet. Students from NWU have rated themselves to be good in creation and publishing maps on internet compared to those from UL. Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill in creation and publishing maps on internet. Students from NWU have rated themselves to be good in creation and publishing maps on internet compared to those from Wits University. UL versus Wits University, the p-value is 0.0438 which is

significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and Wits University have gained equal skill levels in creation and publishing maps on internet. Students from UL have rated themselves to be good in creation and publishing maps on internet compared to those from Wits University.

d) Data processing, manipulation and reproductive procedures

The following subsection presents and analyses statistical results as far as data processing, manipulation and reproductive procedures skills are concerned.

xiv. Processing basic statistical geographic data

UL versus NWU, the p-value is 0.0015 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill in processing basic statistical geographic data. Students from NWU have rated themselves to be good in processing basic statistical geographic data compared to those from UL. Wits versus NWU, the p-value is 0.0012 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill levels in processing basic statistical geographic data. Students from NWU have rated themselves to be good in processing basic statistical geographic data compared to those from Wits University. UL versus Wits University, the p-value is 0.1978 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students from UL and Wits University have gained equal skill levels in processing basic statistical geographic data.

xv. Using GIS tools

UL versus NWU, the p-value is 0.0002 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill in using GIS tools (e.g. database creation, scanning, creation of shapefiles, projections, and manipulation). Students from NWU

have rated themselves to be good in using GIS tools compared to those from UL. Wits University versus NWU, the p-value is 0.0521 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at Wits University and NWU have gained equal skill in using GIS tools. UL versus Wits University, the p-value is 0.1678 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students from UL and Wits University have gained equal skill levels in using GIS tools.

xvi. The ability to use GIS geoprocessing tools

UL versus NWU, the p-value is 0.6253 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal skill levels in the ability to use GIS geoprocessing tools (e.g. buffer, clip, etc.). Wits University versus NWU, the p-value is 0.0002 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from Wits University and NWU have gained equal skill levels in the ability to use GIS geoprocessing tools. Students from NWU have rated themselves to be good in the ability to use GIS geoprocessing tools compared to those from Wits University. UL versus Wits University, the p-value is 0.0006 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits have gained equal skill levels in the ability to use GIS geoprocessing tools. Students from UL have rated themselves to be good in the ability to use GIS geoprocessing tools compared to those from Wits University.

e) Geographic analysis operations

The following subsection presents and analyses statistical results as far as geographic analysis operations are concerned.

xvii. The ability to perform spatial analysis

UL versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels in the ability to perform spatial analysis (e.g. create slope, viewshed, contours, etc.). Students from NWU have rated themselves to be good in the ability to perform spatial analysis compared to those from UL. Wits University versus NWU, the p-value is 0.0003 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill levels in the ability to perform spatial analysis. Students from NWU have rated themselves to be good in the ability to perform spatial analysis compared to those from Wits University. UL versus Wits University, the p-value is 0.4138 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students from UL and Wits University have gained equal skill levels in the ability to perform spatial analysis

f) Geographic databases

The following subsection presents and analyses statistical results as far as geographic databases (geodatabases) operations are concerned.

xviii. Creation and querying spatial databases

UL versus NWU, the p-value is 0.0707 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal skill in the ability to create and query spatial databases. Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from Wits University and NWU have gained equal skill in the ability to create and query spatial databases. Students from NWU have rated themselves to be good in the ability to create and query spatial databases compared to those from Wits University. UL versus Wits, the p-value is 0.0017 which is significantly lower than 0.05%.

Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal skill levels in the ability to create and query spatial databases. Students from UL have rated themselves to be well skilled in the ability to create and query spatial databases compared to those from Wits University.

xix. Managing and manipulating data for project use

UL versus NWU, the p-value is 0.0298 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill levels in the ability to manage and manipulate data for project use. Students from NWU have rated themselves to be good in the ability to manage and manipulate data for project use. Wits University versus NWU, the p-value is 0.0036 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill levels in the ability to manage and manipulate data for project use. Students from NWU have rated themselves to be good in the ability to manage and manipulate data for project use compared to those from Wits University. Comparing UL versus Wits University, the p-value is 0.1736 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students from UL and Wits University have gained equal skill levels in the ability to manage and manipulate data for project use.

g) Use of GIS software

The following subsection presents and analyses statistical results as far as the use of GIS software is concerned.

xx. Ability to use free/open GIS software for education and research

UL versus NWU, the p-value is 0.2029 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal skill levels in the ability to use free/open GIS

software for training and research. Wits University versus NWU, the p-value is 0.2132 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at Wits University and NWU have gained equal skill in the ability to use free/open GIS software for training and research. UL versus Wits University, the p-value is 0.0017 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal skill levels in the ability to use free/open GIS software for training and research. Students from UL have rated themselves to be good in the ability to use free/open GIS software for training and research compared to those from Wits University.

xxi. Ability to identify the difference in the use of open and commercial GIS software

When comparing UL versus NWU, the p-value is 0.0466, which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal skill in the ability to identify the difference in the use of open and commercial GIS software packages. Students from NWU have rated themselves to be good in the ability to identify the difference in the use of open and commercial GIS software packages. When comparing Wits University versus NWU, the p-value is 0.0003 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal skill in the ability to identify the difference in the use of open and commercial GIS software packages. Students from NWU have rated themselves to be good in the ability to identify the difference in the use of open and commercial GIS software packages compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.0395 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal skill in the ability to identify the difference in the use of open and commercial GIS software packages. Students from UL have rated themselves to be good in the ability to identify the difference

in the use of open and commercial GIS software packages compared to those from Wits University.

h) GIS and society

The following subsection presents and analyses statistical results as far as the use of GIS and society (GIS in organisations) is concerned.

xxii. Knowledge of Spatial Data Infrastructure Act

Comparing UL versus NWU, the p-value is 0.0064 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the Spatial Data Infrastructure Act (SDI Act). Students from NWU have rated themselves to be good in the ability to understand the SDI Act compared to their counterparts at UL. Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis.

There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of the SDI Act. Students from NWU have rated themselves to be good in the ability to understand the SDI Act compared to those from Wits University. UL versus Wits University, the p-value is 0.0235 which is significantly lower than 0.05%. Therefore, we fail to reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of the SDI Act. Students from UL have rated themselves to be good in the ability to understand the SDI Act compared to those from Wits University.

xxiii. Knowledge of South African Constitution

When comparing UL versus NWU, the p-value is 0.0128 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the South African Constitution. Students from UL students have rated

themselves to be good in the ability to understand the South African Constitution compared to their counterparts at NWU. When comparing Wits University versus NWU, the p-value is 0.0002 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of the South African Constitution. Students from NWU have rated themselves to be good in the ability to understand the South African Constitution compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of the South African Constitution. Students from UL have rated themselves to be good in the ability to understand the South African Constitution compared to those from Wits University.

xxiv. Knowledge of South African Geomatics Act

When comparing UL versus NWU, the p-value is 0.0058 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the South African Geomatics Act. Students from NWU have rated themselves to be good in the ability to understand the South African Geomatics Act compared to their counterparts at UL. When comparing Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of the South African Geomatics Act. Students from NWU have rated themselves to be good in the ability to understand the South African Geomatics Act compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.008 which is significantly lower than 0.05%. Therefore, we fail to reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of South African Geomatics Act. Students from UL have

rated themselves to be good in the ability to understand the South African Geomatics Act compared to those from Wits University.

xxv. Knowledge of South African Geographical Names Act

When comparing UL versus NWU, the p-value is 0.1867 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the South African Geographic Names Act. When comparing Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of the South African Geographical Names Act. Students from NWU have rated themselves to be good in the ability to understand the South African Geographical Names Act compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.002 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of the South African Geographical Names Act. Students from UL have rated themselves to be good in the ability to understand the South African Geographical Names Act compared to those from Wits University.

xxvi. Knowledge of Spatial Planning and Land Use Management Act

When comparing UL versus NWU, the p-value is 0.6519 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the Spatial Planning and Land Use Management Act (SPLUMA). Comparing Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of SPLUMA. Students from NWU have rated themselves to be good in the

ability to understand SPLUMA compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of SPLUMA. Students from UL have rated themselves to be good in the ability to understand SPLUMA compared to those from Wits University.

xxvii. Knowledge of Land Survey Act

When comparing UL versus NWU, the p-value is 0.0577 which is nearly significant because it is slightly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of Land Survey Act. Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of the Land Survey Act. Students from NWU have rated themselves to be good in the ability to understand the Land Survey Act compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.0023 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of the Land Survey Act. Students from UL have rated themselves to be good in the ability to understand the Land Survey Act compared to those from Wits University.

xxviii. Knowledge of Copyright Act

When comparing UL versus NWU, the p-value is 0.6164 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the Copyright Act. In the comparison of Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University

and NWU have gained equal knowledge in the understanding of the Land Survey Act. Students from NWU have rated themselves to be good in the ability to understand the Copyright Act compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.0004 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of the Land Survey Act. Students from UL have rated themselves to be good in the ability to understand the Land Survey Act compared to those from Wits University.

xxix. Knowledge of Promotion of Access to Information Act

Comparing UL versus NWU, the p-value is 0.6673 which is significantly higher than 0.05%. Therefore, we fail to reject the null hypothesis. There is sufficient information to conclude that students at UL and NWU have gained equal knowledge in the understanding of the Promotion of Access to Information Act (PAIA). In a comparison of Wits University versus NWU, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students at Wits University and NWU have gained equal knowledge in the understanding of PAIA. Students from NWU have rated themselves to be good in the ability to understand PAIA compared to those from Wits University. When comparing UL versus Wits University, the p-value is 0.0001 which is significantly lower than 0.05%. Therefore, we reject the null hypothesis. There is insufficient information to conclude that students from UL and Wits University have gained equal knowledge in the understanding of PAIA. Students from UL have rated themselves to be good in the ability to understand PAIA compared to those from Wits University.

Table 4: Statistical results from student questionnaire using Mann-Whitney U Test (Wilcoxon Rank Sum Test)

knowledge and skills	Mann Whitney U Test (Wilcoxon Rank Sum Test)								
	UL vs NWU			NWU vs WITS			UL vs WITS		
	Students in University of Limpopo	Students in North West University	p-value (two-sided)	Students in Wits University	Students in North West University	p-value (two-sided)	Students in University of Limpopo	Students in Wits University	p-value (two-sided)
	Mean Scores								
GIS	39.8	28.4	0.0163	27.9	21.6	0.1122	29.9	28.5	0.7636
GISc	28.6	43.9	0.0005	25.4	23.1	0.5682	24.5	40.7	0.0001
Remote Sensing	37.4	31.6	0.2238	29.6	20.5	0.0214	27.4	34.1	0.1506
Geographic thinking	31.9	39.3	0.1073	27.6	21.8	0.1514	25.4	38.6	0.0034
Office digitisation	30.6	41.1	0.0234	20.8	26.0	0.1958	29.0	30.7	0.7165
Fieldwork data collection	32.9	37.9	0.2865	21.9	25.3	0.4053	29.2	30.2	0.8309
Map projection and data transformation	29.1	43.2	0.0024	17.0	28.3	0.0037	30.1	28.2	0.6937
Interpretation of topographic map	33.9	36.6	0.5563	19.9	26.5	0.0793	31.3	25.5	0.2008
Making a topographic map	31.2	40.3	0.0492	17.7	27.9	0.0082	30.9	26.3	0.3248
Modifying a topographic map in digital format	27.7	45.0	0.0002	14.7	29.8	0.0001	30.4	27.4	0.5271
Making a professional thematic map	29.4	42.7	0.004	16.6	28.6	0.0018	30.7	26.8	0.4021
Gathering data required to produce thematic map	30.5	41.3	0.0188	20.3	26.3	0.1381	29.0	30.7	0.7041
Creation and publishing maps on internet	29.5	42.6	0.0052	13.6	30.4	0.0001	32.4	23.0	0.0438
Processing basic statistical data	28.9	43.4	0.0015	16.3	28.8	0.0012	31.4	25.4	0.1978
Using GIS tools	27.9	44.8	0.0002	19.5	26.8	0.0521	27.5	33.9	0.1678

Geoprocessing tools	34.1	36.2	0.6253	15.2	29.4	0.0002	34.2	19.1	0.0006
Geographic analysis	24.8	49.1	0.0001	15.6	29.2	0.0003	28.3	32.1	0.4138
Creation and Querying spatial databases	31.5	39.9	0.0707	13.9	30.3	0.0001	33.9	19.8	0.0017
Managing and manipulating data for project use	30.8	40.8	0.0298	17.0	28.3	0.0036	31.4	25.3	0.1736
Ability to free/use Open GIS	37.5	31.6	0.2029	20.9	25.9	0.2132	33.1	21.4	0.0107
Difference in Open and commercial GIS	31.1	40.4	0.0466	15.2	29.4	0.0003	32.4	23.0	0.0395
SDI Act	29.6	42.5	0.0064	14.1	30.1	0.0001	32.7	22.3	0.0235
SA constitution	40.1	27.9	0.0128	15.1	29.5	0.0002	36.2	14.7	0.0001
SA Geomatics Act	29.6	42.5	0.0058	12.4	31.2	0.0001	33.1	21.6	0.008
SA Geographical Names Act	32.3	38.7	0.1867	13.1	30.8	0.0001	33.7	20.2	0.002
SPLUMA	35.9	33.7	0.6519	13.3	30.6	0.0001	35.6	16.0	0.0001
Land Survey Act	31.3	40.2	0.0577	13.2	30.7	0.0001	33.7	20.3	0.0023
Copyright Act	34.0	36.4	0.6164	14.2	30.1	0.0001	34.4	18.6	0.0004
PAIA	34.1	36.2	0.6673	12.6	31.1	0.0001	35.0	17.3	0.0001
Register with SAGC	34.8	35.3	0.9148	24.1	23.9	0.97	29.3	30.1	0.8704
Register for Postgraduate in GIS	33.2	37.6	0.3607	23.8	24.1	0.9493	28.2	32.3	0.4048
Use of GIS in a company	35.1	34.9	0.9706	21.9	25.3	0.4012	30.4	27.6	0.5503
Desire to work in GIS	38.1	30.7	0.1205	24.9	23.5	0.7404	30.7	26.8	0.3924
Usefulness of GIS in geography	35.3	34.6	0.8614	19.4	26.9	0.0478	32.3	23.3	0.0397

Significant results are shown using red cloured p-values, nearly significant results are shown with light gold colour. Dark grey colour represents high mean scores.

5.3. GIS STAFF RESPONSES TO AN INTERVIEW QUESTIONS

In every university under study, one lecturer participated in this study. All lecturers who participated were responsible for the teaching of GIS in an undergraduate geography curriculum.

5.3.1 The rationale in teaching GIS within an undergraduate geography curriculum

Question one of the interview focused on establishing the rationale behind the teaching of GIS within the undergraduate geography curriculum. Generally, almost all three lecturers, when completing interview questions, indicated that they are teaching GIS as a tool to solve spatial problems. For instance, below are the direct answers from each respondent.

NWU lecturer states: *"We teach GIS as a tool that is applied by Geographers, Zoologists, and Ecologists etc. We equip students to use the tool to solve spatial-temporal problems."*

Wits University lecturer states: *"The module's rationale is to provide students with a background in the history of mapping and an introduction to the principles of GIS, focusing mainly on teaching students how to make maps with GIS."*

UL lecturer states*: "GIS is a tool that cuts across all disciplines and it's very essential in the geography discipline."*

5.3.2 Number of GIS modules at undergraduate level

It was established that NWU only teaches one compulsory GIS module at the third year/final year level of undergraduate study (Module Code: GGFS 312). This module is offered as an introductory course. Wits University offers two GIS modules at an undergraduate level - GEOG 2013 (Methods, models and GIS) offered at second year level of study, and GEOG 3017 (Advanced GIS) offered at third year/final year level of study. The advanced GIS module offered at Wits University focuses on the introduction to the remote sensing course. In contrary to the above, UL offers four GIS modules at undergraduate level.

5.3.3 Introductory and advanced GIS teaching at an undergraduate study

The third question sought to establish if the training of an undergraduate geography curriculum focuses on both introductory and advanced teaching of GIS. Responses that were received showed that GIS is taught as introductory modules at Wits University and NWU, with the exclusion of UL where the lecturer has indicated that their curriculum also focuses on the advanced GIS training within an undergraduate level.

Wits lecturer states:

"GIS at Wits is purely introductory and is only taught within a block module (7 weeks)."

NWU lecturer responded as follows:

"No. Advanced GIS applications are taught at the honours level. Only one GIS module in the third year. Auxiliary skills such as map work, aerial photo interpretation, 'spatial thinking' etc. are covered as practical in first and second year."

5.3.4 Resources in terms of capacity and capability to teach GIS

The interview questions also sought to establish the capacity and capability of each university in teaching GIS modules. The results from the interview showed that at least two lecturers are available to teach GIS modules (one in Archeology and the other in Geography). Furthermore, NWU also has two lecturers to teach GIS, while the UL only has three lecturers in the department. The study results furthermore established that GIS is taught as a compulsory module at all universities. NWU generally has 140 Geography students at third year level in the GGFS 312 module, 20 Honours students of which around 15 are in the Advanced GIS modules. At Wits University, GEOG2013 is a compulsory course and generally enrolls 90 students, whereas GEOG3017 has an average of 50 students and it is an elective module at third year level. In Limpopo, GIS is taught as a compulsory module and has roughly 70 students enrolled.

GGFS 312 offers 40 contact hours and 42 practical sessions at NWU. At Wits University, at least 35 contact hours excluding practical are dedicated for both GEO 2013, and GEO 3017, and there are three practical sessions for each module per week. UL has not

provided information about the contact hours for the two GIS modules that were provided. However, all the GIS modules provided by the lecturers have 4 practical sessions per week. It was established that all universities have a GIS laboratory with software. UL has indicated that the university has a site license with SOO, whereas NWU has indicated that the university has a site license with ESRI and individual students' licenses are available. At Wits University, undergraduate students are exposed to ArcGIS and Teraset licenses. All universities have their own individual challenges as far as teaching GIS at an undergraduate geography level is concerned. A UL lecturer had highlighted that the lack of financial support to take students to the field is a huge problem. A NWU lecturer, on the other hand, indicated that the low level of computer literacy amongst a large number of students remains a big challenge in the teaching of GIS at undergraduate level.

A Wits University lecturer had indicated that challenges *"have been the lack of a dedicated lab at undergraduate level, the limited time dedicated to the teaching of the subject (one block module in GIS and one in RS of only 7 weeks each). This does not allow the development of the subject into analytical aspects of GIS and the module remains pretty much a stand-alone subject that the students appreciate only if they continue at Honours level where they can take the advanced module of GIS."*

5.3.5 GIS for vocational training

One of the questions posed to lecturers was to understand if the teaching of GIS in various universities' undergraduate curricula is meant for preparing students to take up active GIS jobs in the industry. Almost all universities under study do not prepare students to take full responsibility of GIS careers after completing an undergraduate qualification. However, only UL indicated that they prepare students to work in the GIS industry.

A NWU lecturer categorically states that they *"do not train students for the GIS industry* specifically (Geoinformatics), we train them to solve spatial-temporal problems in a scientific way, and GIS (in the same way as statistics) is a tool that we equip them with."

At Wits University, the lecturer states that *"there is no specific GIS curriculum that prepares students for the GIS industry. The Geography curriculum is not accredited with SAGS. The students that want to pursue a career in GIS generally continue at Honours*

and Master level where they can receive specialised knowledge. The challenge is the lack of a dedicated curriculum that will be introduced in 2019 with a third major in Geospatial Sciences at second year level (to be taken in conjunction with Geography and another subject of choice) and can be carried over at third year level."

5.3.6 Linking examples from the knowledge learnt from other geography modules during GIS practical

It was established that all universities are unable to always link the knowledge gained from other Geography modules during GIS practical exercises. There are a number of reasons linked to this failure and the following are answers provided by lecturers from each university with the exception of UL where a lecturer opted not to answer the question.

At Wits University, the lecturer indicates that: *"GEOG2013 is directly linked to GEOG2010 (Thinking geographically). GEOG2010 covers geographical concepts and GEOG2013 teaches ways of putting them into practice through practical work. The students make both a topographic and a thematic map of an area visited during GEOG2010 where they reflect on various aspects of geography in an area of Johannesburg (I include the practical instructions for the map work). Some mapping concepts are then used in GEOG3017 but this course is mainly RS. Other undergraduate courses at second and third year level do not really connect with knowledge acquired during the GIS course."*

The lecturer from NWU has provided the following response:

"Yes in some cases but not always. Practical will often be linked to current events in the media etc. that have a spatial context."

5.3.7 The recommendation regarding teaching of GIS and teaching about GIS at undergraduate geography curricula

All the lecturers who participated in the study have provided different answers to the question which sought to find out the recommendations in improving the teaching of GIS as well as teaching about GIS within an undergraduate geography curriculum. Below are answers provided by each lecturer from participating universities.

Wits University lecturer has provided the following recommendation: *"Different approaches must be chosen to distinguish the teaching of GIS as a tool for geographical research and GIS as a professional discipline. A higher vertical alignment and more time is needed for the students to fully grasp the subject. This is a consideration that students have made several times in students' feedback questionnaires through the years."*

NWU lecturer has provided the following recommendation: *"Having GIS as a separate module is not always ideal. It might be better to teach GIS as part of the practical components of other undergraduate modules such as Climatology, Economic Geography etc. In this way GIS can be used to help teach geography. However, the large number of students in the first and second year (290 and 180 respectively) makes it difficult to do this due to challenges with facilities."*

UL lecturer has recommended the following: *"Exposure of students to various software."*

5.4. CONCLUSION

Chapter five presented results from both the student's questionnaire and lecturer's interviews from all participating universities. The quantitative analysis focuses on comparing one university compared to another on different GIS aspects. The analysis used the p-value to show if there was any difference in the results. The significance level is 0.5% which is used to test any difference in the results of two populations under study. The results showed that when comparing UL and NWU, there is a difference in the understanding of the GIS concept with UL students seeming to be more prepared compared to NWU students. NWU students are better prepared to understand the GISc concept compared to UL students. Wits University students are also well prepared to understand the GISc concept compared to UL students. Wits University students are better prepared than NWU in the understanding of the RS concept. Wits University students are better prepared than UL students on the geographical thinking concept. NWU students are better prepared than UL students on office digitisation. NWU students are better prepared than UL and Wits University students on map projection and data transformation. In making a topographic map, NWU students are better prepared than UL and Wits University students. NWU students also seem to be better prepared in modifying

a topographic map than Wits and UL students. NWU students are better prepared in creating and publishing maps on internet compared to Wits University and UL students. However, UL students are better prepared in creating and publishing maps on internet compared to Wits University students.

NWU are better prepared in processing basic geostatistical data compared to UL and Wits University. NWU are better prepared in using GIS tools compared to UL students. NWU students are also better prepared in geographical analysis compared to Wits and UL students. In creating and querying of spatial databases, NWU are better prepared compared to Wits University students, and UL students are better prepared compared to Wits University students. NWU students are also better prepared in managing and manipulating data for project use compared to UL and Wits University students. UL students are better prepared in using open/free GIS compared to Wits University students. Students from all universities have the same interest in registering for GIS postgraduate degree, registering with SAGC, and working for a GIS company. However, Wits University students believe that GIS is useful in geography in contrast to NWU students. UL students on the other hand believe that GIS is more useful in geography whereas Wits students do not agree.

CHAPTER SIX

DISCUSSION, RECOMMENDATIONS AND CONCLUSION

6.1. INTRODUCTION

Chapter four and chapter five provided invaluable information from the data analysis using both basic statistics and advanced statistics, respectively. Based on the data analysis results, this chapter is therefore geared towards a discussion of the findings as well as the implications of the study results. The aim of this study is to investigate the GIS curriculum at three different South African university geography departments with the aim to examine the link between the academic discipline of geography and the professionalisation of GIS as a vocational training. The objectives of the study are to conceptualise GIS within the discipline of geography, explore the similarities and differences of three different South African universities' geography curricula in teaching GIS and other geospatial technologies; examine the strength and weakness of teaching GIS and other geospatial technologies within the three different South African universities' geography curricula; and lastly, to explore the readiness of undergraduate geography students in performing GIS and other geospatial technological jobs available in the industry. The following sections will therefore discuss the results and make recommendations and conclusions in line with the findings of the study.

6.2. DISCUSSION ON THE RESEARCH FINDINGS

The research findings provide invaluable information as far as the use of GIS within the geography discipline is concerned. This research project managed to achieve its objectives by providing clarity with regard to the difference between GIS and GISc and how the two are conceptualised within the discipline of geography. These research findings emphasised the role of GIS in spatial thinking as alluded to by Bednarz (2009). Lack of resources to teach GIS, the shortage of GIS lecturers, the inability of universities to structure GIS teaching within a geography curriculum to afford students the vocational skill and professionalism that they require, continue to undermine the positioning of GIS and the benefits it provides, as top priority in the study of geography . This research also confirms the findings of the academic work done by Kemp et al. (1992), Nellis (1994); Hill

and Nell (1996) as well as Zietsman (2002). The inability of the undergraduate geography curriculum in South Africa to equip students with sufficient knowledge and skills creates a heavy burden on the labour market because employers are expected to retrain graduates when they commence their formal employment. If graduates are not well prepared, it makes it difficult for them to find employment. As a result, if students continue to find it hard to secure geography related jobs that require knowledge of GIS, the university undergraduate degrees will become obsolete and all interest will be lost.

SSAG (2003) notes many challenges of teaching GIS in South African geography curricula, which include the lack of qualified instructors, lack of budget to keep abreast with technological advancement such as procurement of high processing computers and software. This study also discovered that indeed the investment on technology such as high processing computers to meet the demand of students is still an issue, even to date. Students still complain of low processing computers and lack of assistance from GIS instructors. The majority of GIS lecturers do not have a pure GIS qualification, but they only use GIS in their research. This becomes a challenge for ensuring effective teaching of GIS within the geography discipline.

Again, limited time frame allocated for GIS and RS practical in all universities as well as poor facilities (i.e. not enough computers to accommodate students, slow processing of machines, etc.) have proven to be a major drawback in producing well prepared GIS graduates. UL seems to have more modules in GIS, but the quality of the training does not seem to be good enough. To demonstrate the findings, chapter five provided evidence that students at UL were rating themselves not to be good on some aspects of GIS while those who only did GIS at final year in NWU were rating themselves much better. The training of GIS at Wits Universities and NWU is also not good enough, because students are hardly prepared to master all GIS aspects within the short space of time allocated for the GIS module.

The findings of this study also proved that indeed students have shown great interest in using GIS to solve environmental problems. The GISc demand of knowledge and skills survey (2016) shows that data collection is one of the most needed skills in the industry. These research findings show that all universities do prepare students, although there is

an outcry about the lack of enough time to do practical work using GIS software as well as lack of fieldwork data collection. This research study further revealed an inconsistence in the teaching of GIS within undergraduate geography curricula which makes it difficult for students to acquire similar knowledge and skills. Some universities offer only one module whereas another offers more than three modules in GIS at an undergraduate geography curricula. This disjuncture causes students to have variable knowledge and skills. In all three universities, it was established that students never had an opportunity to do fieldwork using GIS. This can be linked to a lack of time and budget. A UL Lecturer also attested to a lack of funding to do GIS practical work. This challenge undermines the whole purpose of teaching students about GIS and teaching them with GIS. GIS is better understood if all aspects are covered.

6.3. RECOMMENDATIONS

Based on the outcomes of the study research, it is recommended that:

- Universities should revise their undergraduate geography programmes to ensure that GIS is taught as a tool as well as to prepare students for vocational work. However, in South Africa, GIS degrees are now being introduced but at too few universities. Should universities want their geography curricula to remain relevant and more marketable in a modern technological era, aspects of GIS and Remote Sensing are to be considered and taught thoroughly. This will enable students to be fully prepared to solve environmental problems using GIS as well as for the students to take advantage of GIS Analyst jobs, etc. The GIS teaching at undergraduate degree level, should include basic and advanced teaching with an increased amount of time for practical work. If universities are to teach GIS within the geography degree as a tool, it is advisable that such training should be embedded in other modules. For example, when a lecturer is teaching climatology, GIS should be used as a tool to solve climatological problems. This can be challenging if lecturers are not trained in GIS, but can prove to be beneficial. Again, if GIS is to be taught for vocational purposes within undergraduate geography degrees, it is advisable that a comprehensive course content be designed and be used across the board by universities. This approach could help to make

geography degrees still relevant. There is no sense in teaching students geography degrees, while after graduation they would struggle to find jobs in climatology, geomorphology, biogeography and population geography. For geography to remain relevant and a subject of choice at institutions of higher learning, the integration of GIS for teaching and research needs some reconsideration.

- GIS is currently taught as a tool in South African Universities but with little time and resources allocated to it. As a result, students are not fully prepared to use GIS after completing the programme. This was also acknowledged by lecturers that are teaching students GIS is a spatial analysis tool, but does not prepare students to perform GIS industry related jobs. It should be acknowledged, however, that most GIS professionals, technologists and technicians in South Africa come from a background of geography/ environmental sciences degree qualifications. As a result, universities should take advantage of market needs, because it will be useless to teach students geography degrees while they cannot be fully equipped to perform such duties.

- Furthermore, there should be a consistency and alignment of GIS curricula at universities that offer undergraduate geography qualifications. This should help to ensure that students who have geography degrees from different universities have acquired similar knowledge and be ready to use such GIS skill in the market. The majority of students, including those who studied at UL where there are a number of GIS modules, specified that they do not feel competent enough to use GIS skills in the workplace. It was established that universities teach GIS modules differently, and they also specified that they are using GIS as a tool. Even if GIS is being trained as a tool, it is not giving students enough exposure on the theory and practical application thereof. As a result, a holistic review is needed to ensure that universities take advantage of GIS for vocational training as well. In the South African labour market, many people who are working in GIS industries have a background of geography degrees. Records to attest this are available from SAGC.

6.4. CONCLUSION

The study has revealed many similarities and differences on the teaching of GIS within undergraduate geography curricula of three South African Universities. Because the universities that participated in the study are all representing a historical disadvantaged (formerly known as black universities) and previously privileged universities (formerly known as white universities), the results therefore gives a clear picture on the widespread use of GIS for teaching and research in South African universities. It is clear that universities are not preparing undergraduate students well enough to take advantage of GIS jobs. The statistical analysis showed some significant results and insignificant results when comparing the outcomes of the students' rating of different GIS aspects. The responses from lecturers also stated some challenges experienced in teaching a GIS module in undergraduate geography. For this reason, the South African undergraduate geography degree curricula need revision in order to help students to be ready to take GIS jobs after completion. It will be unfair to allow students to study a postgraduate GIS degree in order to get jobs, due to the failure of having had better training during their undergraduate degree studies. As previously mentioned, in South Africa, a job entry requirement is NQF 7, which is an undergraduate degree. It is therefore important that universities take cognisance and advantage of GIS market needs in order to train students appropriately. Funding is another challenge that needs to be addressed by universities to ensure that geography degrees take advantage of GIS in order to continue attracting more students as well as to remain a subject of choice to many.

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Annexure A: Students' Questionnaire

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Faculty of Science

School of Geography, Archaeology & Environmental Studies

Master of Sciences (MSc) in GIS and Remote Sensing (Research report)

Students' Questionnaire

Section A: Demographic information of Student

Gender	Male		University (Tick appropriate box)				NWU		Name of Degree:		
							WITS				
	Female						UL				
Population group	African		Indian		Coloured		White		Not Specified		
Age group	18-20 years		21-23 years		24-26 years		27 years and above				

Section B: General Questions

1. What is your motive/ reasons for studying towards geography degree?

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   ……
   ……
   ……
   ……
   ……

2. What is your motive/ reasons for studying GIS in Geography curriculum? Was it compulsory or was your choice? Please elaborate

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   ……
   ……
   ……
   ……
   ……

3. Briefly explain your understanding of the following concepts?

3.1. Geographic Information Systems (GIS)

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3.2. Geographic Information Science (GIScience or GISc)

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……
……

3.3. Remote Sensing (Earth Observation)

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3.4. Geographic thinking

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……

4. Provide name (s) of GIS and other geospatial technology related modules taken in the degree. Please, indicate if a module was taken as a compulsory or elective.

Module Name/Code	Level of study (e.g. 1st, 2nd, or 3rd Year)	Compulsory	Elective	Maximum practical hours (Per week or per course)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				

5. Tick any GIS software used by the University for training/practical Work.

ESRI GIS		(ArcView)
ESRI GIS		(ArcEditor)
ESRI GIS		(ArcInfo)
Quantum GIS		
PostGIS		
GRASS		
R Studio		
Google Earth		
Other (specify):		……

Section C: Technical knowledge and skills

Please, circle the answers that best represent your knowledge and skills from below:

Note the following explanations before choosing your appropriate answers:

- ***Score of 1 (very poor)*** - means that a student has never been introduced to the concepts and practical training
- ***Score of 2 (Poor)*** - means that a student has been introduced to concepts and training (if any), but the knowledge and skills was not enough. Therefore, there is a need for more training on the subject matter.
- ***Score of 3 (Average)*** **-** means that a student has been introduced to the concepts and practical training, but still the knowledge and skills is not fully understood/ or taught properly. As a result, a student may struggle to use knowledge and skills at workplace.
- ***Score of 4 (Good)*** **-** means a student has fully been exposed to the concepts and practical training (if any), and is competent enough to use gained knowledge and skills in the work place, but with little help.
- ***Score of 5 (Very good)*** **-** means that a student has fully been exposed to both training and practical (if any) in the subject matter) and can fully and effectively use such skills in the workplace without a need for assistance.

Data Capturing/ Data Collection

1.	Ability to capture spatial data (e.g. office digitisation)	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
2.	Fieldwork data collection (e.g. using Global Positioning Systems, Spectrometer in Remote Sensing, etc)	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
3.	Ability to define projection and data transformation	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

Map production

4.	Interpretation of topographic map	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
5.	Making a topographic map	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
6.	Modifying a topographic map in digital format	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
1.	Making a professional thematic map	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
7.	Gathering data required to produce thematic map	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)
8.	Ability to create maps and publish them on internet	1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

Data processing, manipulation and Reproductive procedures

9. Processing basic statistical geographic data 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

10. Using GIS tools (e.g. database creation, scanning creation of shapefiles, projections, and manipulation) 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

11. The ability to use GIS geoprocessing tools (e.g. Buffer, Clip, etc.) 1 (Very Poor) 2 (Poor) 3 (Average) 4 (Good) 5. (Very Good)

Geographical Analysis operations

12. The ability to perform spatial analysis (e.g. create slope, Viewshed, contours, etc.) 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

Geographic databases (Geodatabases)

13. Creation & querying of spatial database (geodatabase) 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

14. Managing and manipulating digital geographical data (Both vector and raster) for project use 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

Use of GIS Software

15. Using of free/ open GIS software for Education and research (e.g. Quantum GIS, GRASS, etc.) 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

16. Ability to identify the difference in the use of free/open GIS versus commercial software's (e.g. ESRI GIS, QGIS) 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

GIS and Society (GIS in Organisation)

17. Understanding of the Spatial Data Infrastructure Act (SDI) and its role in geo-spatial information management. 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

18. Knowledge of SA Constitution 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

19. Knowledge of South African Geomatics Act, 2013 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

20. Knowledge of SA Geographical Names Act 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

21. Knowledge of Spatial Planning and Land Use Management Act 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

22. Knowledge of Land survey Act No. 8 of 1997 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good

23. Knowledge of Copyright Act 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

24. Knowledge of Promotion of Access to information Act 1. (Very Poor) 2. (Poor) 3. (Average) 4. (Good) 5. (Very Good)

Application of GIS and GI related technology in other geography modules

You are required to answer yes or no for the next questions (from 25 to 31)

25. I have used GIS practical sessions to perform analysis on data relating to climate (Weather forecast, climate change, etc.) (YES/ NO)
26. I have used GIS practical sessions to perform analysis on human population (e.g. migration patterns, population density) (YES/ NO)
27. I have used GIS practical sessions for environmental modelling (e.g. pollution analysis, mapping fire & flood hazards, etc.) (YES/ NO)
28. I have used GIS practical sessions for biogeography (e.g. conservation and preservations of natural resources) (YES/ NO)
29. I have used GIS practical sessions to analyse and map crime statistics (YES/ NO)
30. I have used GIS practical sessions to perform suitability analysis (e.g. landfill site selection, a place to build school, etc.) (YES/ NO)
31. I have used GIS practical session to perform land cover/land use changes or classification (YES/NO)

Future prospects in GIS related work and research

32.	Do you wish to register with South African Geomatics Council (Council responsible to administer GISc profession)	1. (Not interested) 2. (Slightly interested) 3. (Not sure) 4. (Interested) 5. (Very interested)
33.	Perceived capacity for registering postgraduate degree in GIS or in Geography using GIS as research tool	1. (Not interested) 2. (Slightly interested) 3. (Not sure) 4. (Interested) 5. (Very interested)
34.	Perceived capacity for using GIS on self-employed basis	1. (Not interested) 2. (Slightly interested) 3. (Not sure) 4. (Interested) 5. (Very interested)
35.	Desire to work in a company that specialises in GIS analysis	1. (Not interested) 2. (Slightly interested) 3. (Not sure) 4. (Interested) 5. (Very interested)
36.	Do you find GIS teaching in geography curricula useful?	1. (Strongly disagree) 2. (Slightly disagree) 3. (Neutral) 4. (Slightly agree) 5. (Strongly agree)

37. According to your own learning experience, what do you think was the strong and weak points in studying GIS modules within your university degree (Geography)? List them below

Strength (Opportunities/benefits)

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Weakness (Challenges)

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38. List the GIS and RS practical work which you have done during your studies?
(Example: 1. Land cover classification using ARCGIS 10.4 or ENVI software)

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Annexure B: Lecturers' Interview questions

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Faculty of Science

School of Geography, Archaeology & Environmental Studies

Master of Sciences (MSc) in GIS and Remote Sensing (Research report)

GIS Staff/Lecturer Interview questions

Section A: Demographic information of Staff

Gender	Male		University (Tick appropriate box)				NWU		Name of GISc module(s) responsible for at an undergraduate level:		
							WITS				
	Female						UL				
Population group	African		Indian		Coloured		White		Not Specified		
Highest degree and discipline of the degree											
Professional experience (Tick appropriate box)	0-5 years			5- 10 years		10 -15 years		15 years and more			

Section B: Interview questions on the teaching of GIS and other geospatial technologies in a geography degree

1. What do you consider to be the rationale behind the teaching of GIS within your undergraduate geography degree?

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   ……

2. Mention GIS and related module (s) that are taught at undergraduate curricula?

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   ……

3. Does your undergraduate geography degree teach GIS at introductory and an advanced level? Please elaborate the structure of your GIS teaching in your geography curriculum.
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……
……
……

4. Resources (Capability and Capacity of GIS teaching and research)

    a. How many lecturers are available for teaching GIS in your department?
    ……

    b. Specify the number of average GIS students' enrolment within (both lower and upper level of) geography degree?

    ……
    ……

    c. How many contact hours are dedicated for GIS module (s)? (Include hours for practical work, if any)

Module Name/Code	Level of study (e.g. 1st, 2nd, or 3rd Year)	Compulsory	Elective	Contact hours per semester/year	Maximum practical hours (Per week or per course)
1.					
2.					
3.					
4.					
5.					

    d. Does the University have enough resources (e.g. hardware - computers, plotters, GPS, etc. and software) to teach GIS? Give details about the type of hardware and software in use (This can include hardware specifications, number of computers against number of registered students for a module)

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e. List the challenges that are faced by your department in teaching GIS within geography curriculum?

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5. In your University- do you teach GIS within your undergraduate geography degree in order to prepare students for vocational training (to be trained in line with demands of GIS industry)? If not- What seems to be a challenge?

……
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…….

6. Do you use examples (complements your GIS practical) with the knowledge taught from other geography modules during GIS practical? For example- application of GIS in geomorphology, Climatology, human geography application? Give examples of practical work if any? This can include a practical handout given to students during a course of study.

7. What would be your recommendations towards improving the teaching of GIS and teaching about GIS in geography undergraduate geography discipline?

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The End.

Annexure C: Approval letter from Wits University

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

OFFICE OF THE DEPUTY REGISTRAR

02 August 2018

Mr M.O. Maswanganye
Student Number 360661

TO WHOM IT MAY CONCERN

"Assessing the depth of Geographical Information Systems for teaching and research within the undergraduate Geography curricula of the three South African universities"

This letter serves to confirm that the above project has received permission to be conducted on University premises, and/or involving staff and/or students of the University as research participants. In undertaking this research, you agree to abide by all University regulations for conducting research on campus and to respect participants' rights to withdraw from participation at any time.

If you are conducting research on certain student cohorts, year groups, courses or with academic staff within specific Schools and within the teaching term, permission must be sought from Heads of School or individual academics.

Ethical clearance has been obtained (protocol number **GAES 5-2018-0012**).

Nicoleen Potgieter
UNIVERSITY DEPUTY REGISTRAR

Approval letter from Limpopo University

University of Limpopo
Department of Geography & Environmental Studies
Private Bag X1106, Sovenga, 0727, South Africa
Tel: (015) 268 2330, Fax (015) 268 2323/2892, Email : Marubini.ramudzuli@ul.ac.za

TO: **MASWANGANYE MO (360661)**

WITS MSc GIS and RS STUDENT

DATE: **26 JULY, 2018**

SUBJECT: APPROVAL TO CONDUCT AN ACADEMIC RESEARCH IN THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL STUDIES, UNIVERSITY OF LIMPOPO BY MASWANGANYE MO (360661)

Your letter dated the 5th of July, 2018 bears reference.

The Department of Geography and Environmental Studies together with the directorate of The School of Agricultural and Environmental Sciences scrutinized your request to conduct research: **Assessing the depth of Geographical Information Systems for teaching and research within the undergraduate Geography curricula of three South African universities** among our students.

Kindly be informed that your request has been considered, and permission to conduct the research has been granted.

You are advised to check with the departmental administration with regard to the necessary arrangements for the activity.

Sincerely

DR M R Ramudzuli
Head of Department Geography & Environmental Studies
School of Agricultural and Environmental Sciences

Finding solutions for Africa

Annexure E: Approval letter from North-West University

North-West University
School of Geo and Spatial Sciences
Potchefstroom
Private Bag X6001, Potchefstroom, 2520, South Africa
Tel: (018) 299 1589, Email : Dirk.Cilliers@nwu.ac.za

ATTENTION : MASWANGANYE MO (360661)
WITS MSc GIS and RS STUDENT
DATE : 30 JULY, 2018

SUBJECT: APPROVAL FOR BY MR. MASWANGANYE MO (360661) TO CONDUCT ACADEMIC RESEARCH IN THE DEPARTMENT OF GEOGRAPHY AND ENVIRONMENTAL MANAGEMENT AT THE NWU

Your letter dated the 20th of July, 2018 refers.

The Department of Geography and Environmental Management considered your request to distribute questionnaires amongst third year Geography students at the NWU, Potchefstroom campus.

A decision has been taken to grant your request. You are advised to check with the departmental administration (or Dr. DP Cilliers) with regard to the necessary arrangements for the activity.

Sincerely,

Digitally signed by Dirk Cilliers
DN: cn=Dirk Cilliers, o, ou=Geography and Environmental Management, email=dirk.cilliers@nwu.ac.za, c=ZA
Date: 2018.07.31 15:56:18 +02'00'

Dr. DP (Dirk) Cilliers
Subject Group Chair
Geography and Environmental Management
Potchefstroom Campus