A FRAMEWORK FOR THE ADOPTION AND EFFECTIVE USE OF ICTs FOR VISUALLY IMPAIRED LEARNERS IN HIGHER EDUCATION

By

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DECLARATION OF INDEPENDENT WORK

I, SHEETHAL LIZ TOM, identity number and student number , do hereby declare that this research project submitted to the Central University of Technology, Free State for the Degree DOCTOR OF PHILOSOPHY IN INFORMATION TECHNOLOGY, is my own independent work. It complies with the Code of Academic Integrity, as well as other relevant policies, procedures, rules and regulations of the Central University of Technology, Free State; and has not been submitted before to any institution by myself of any other person in fulfilment (or partial fulfilment) of the requirements for the attainment of any qualification.

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SIGNATURE OF STUDENT **DATE**

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PUBLICATIONS

Tom, S., Mpekoa, N. and Swart, J. (2020). The role of ICTs in the provision of Engineering education to Visually Impaired Learners in South Africa, In *2020 Conference on Information Communications Technology and Society (ICTAS),* Durban,11-12 March 2020, pp.42-47. IEEE.ISBN 978-1-7281-3770-4.

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Tom, S., Mpekoa, N. and Swart, J. (2018). Factors that affect the provision of Visually Impaired Learners in Higher Education. *2018 Conference on Information Communications Technology and Society (ICTAS),* Durban, 8-9 March 2018, pp.1-5.IEEE.ISBN 978-1-5386-1000-8.

Other Research Outputs

Tom, S., Mpekoa, N. and Swart, J. (2017). A framework for the provision for visually impaired learners in Engineering education using ICTs in South Africa. *South African Institute of Computer Scientists and Information Technologists (SAICSIT 2017)*, ISBN: 978-1-4503-5250-5/17/09, Thaba'Nchu, 25 September 2017, pp. 385, Abstract.

ABSTRACT

Education is a vital asset that makes a valuable contribution in society. That is because it helps shape people into responsible citizens. Citizens who attain higher education play an important role in the economic stability and social prosperity of a nation. It is therefore imperative that all individuals in a country are assured of equal educational opportunities. The South African Constitution has embraced an inclusive education policy to ensure that no student is left behind in the education system. Inclusive education is an educational system that is designed in such a way that addresses the needs of all the students regardless of their disabilities. Special schools in South Africa cater for the educational needs of learners with disabilities. However, various researchers have observed that learners who are visually impaired are often excluded from participating in higher education institutions, especially in Engineering courses. Consequently, it is essential to identify the challenges that visually impaired learners in South Africa face when contemplating entry into higher education and more specifically, Engineering courses.

Unlike other courses such as Management and Education, Engineering courses are more practical-based. That is because Engineering courses are visual in nature, especially subjects such as Computer Science, IT and Electrical Engineering which might prove challenging to visually impaired learners. Therefore, such learners require the assistance of specialised Information and Communications Technology (ICT) tools and resources for studying Engineering courses. ICT has revolutionised the education sector by facilitating the teaching and learning process of visually impaired learners. This study aims to develop a framework for the provision of visually impaired learners in Engineering education in SA using ICTs. This study also examines the ICT tools that could be adopted to better facilitate the entry of visually impaired learners into Engineering courses.

A design science research paradigm is used in this study. The study started with an intensive literature review, followed by a case study which was divided into two parts: Part A and Part B. Part A of the case study was done at school level and utilised focus groups and questionnaires from educators at special schools. Part B of the case study was conducted at university level and utilised questionnaires to collect

data from disability units at universities; HODs and senior lecturers from Engineering faculties at universities. The data collected from all the data sources were triangulated to develop the proposed framework for the study.

The proposed framework for the provision of visually impaired learners in Engineering education in SA using ICTs comprised six components: government and management support; finance; infrastructure; mobility; teaching and learning; and student support services. The framework was evaluated by specific field experts so as to establish its validity and refine its suitability for higher education in SA. The proposed framework was refined based on the feedback from the experts. Experts consisted of a group of researchers who had done research in Engineering education, HODs of Engineering faculties, managers of disability centres and a visually impaired person working in an Engineering/IT field. Consequently, a modified framework is presented in this thesis.

The scientific contribution of this study is the provision of a framework that may be used to provide better access to Engineering courses for VILs in higher education in South Africa using ICT's. This research has identified six principal factors and twenty-one sub-factors that would assist the provision of VILs in Engineering education. Establishing such a framework could provide improved academic access for VILs in SA, thereby increasing their prospects of employment and empowerment. Accommodating VILs in the labour sector of SA will improve their quality of life, thereby contributing to the country's economic prosperity.

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ABBREVIATIONS

2D	2 Dimensional
3D	3-Dimensional
CCNA	Cisco Certified Network Associate
CPUT	Cape Peninsula University of Technology
CUT	Central University of Technology
DBE	Department of Basic Education
DHET	Department Higher Education and Training
DoH	Department of Health
DoE	Department of Education
DU	Disability Unit
EFLA	Evaluation Framework for Learning Analytics
E-learning	Electronic Learning
e-Tools	Electronic Tools
GUI	Graphical User Interface
HCI	Human Computer Interaction
HEDSA	Higher and Further Education Disability Services Association
HEIs	Higher Education Institutions
HOD	Head of Department
ICT	Information and Communications Technology
IDE	Integrated Development Environment
IT	Information Technology
JAWS	Job Access With Speech
MEC	Member of Executive Council
m-Tools	Mobile Tools
NMU	Nelson Mandela University
OCR	Optical Character Recognition
PGCE	Post Graduate Certificate of Education
pH	Power of Hydrogen
PWDs	People With Disabilities
SA	South Africa

STEM	Science, Technology, Engineering and Mathematics
TV	Television
UCT	University of Cape Town
UDL	Universal Design for Learning
UFS	University of Free State
UML	Unified Modelling Language
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNISA	University of South Africa
UWC	University of the Western Cape
VI	Visually Impaired
VILs	Visually Impaired Learners
WITS	University of the Witwatersrand
WSU	Walter Sisulu University
WYNN	What You Need Now

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Information and Communications Technology (ICT) has become an integral and important element of everyday life for many people. The importance of ICT has increased to the extent that ICT literacy is now a functional requirement for people's work, social, and personal lives. Most developed and developing countries have seen significant changes in all aspects of life (economics, education, communication, and travel) for the past few decades that can be traced to ICTs (Thioune and Robitaille, 2013). ICT can also enhance the quality of life for disabled people (World Summit on the Information Society, 2005). However, they are not utilised to the full potential for visually impaired people (Mølster and Nes, 2018).

Visual impairment is a disability that forms part of inclusive education that was introduced in South Africa (SA) to meet the educational needs of all learners regardless of their disabilities (Bui *et al.*, 2010). This approach aims at providing all students with high quality instruction and support that may help them to succeed in the core curriculum offered at an institution (Alquraini and Gut, 2012). A joint report by United Nations Educational, Scientific and Cultural Organization(UNESCO) Institute for Information Technologies in Education and the European Agency for Development in Special Needs Education (Donnelly and Watkins, 2011), states that ICT use for inclusion increases effective access and participation for all students. Educational research has provided strong evidence that ICT tools are both a medium and a powerful tool in supporting inclusive practice (Gould *et al.*, 2014). However, there is a general lack of statistics regarding the number of visually impaired people using ICT or to what extent they are using them. Strategies should exist to identify any gaps to ensure that visually impaired people enjoy the same benefits of using ICTs as abled people, which in turn may improve the quality of their life.

The legislation and policies in SA protect the rights of people with disabilities and promote their advancement (Republic of South Africa, 1998; Pieterse, 2000). But the reality is that people with special needs continue to be excluded from professional work (Ramutloa, 2010), ultimately leading to poverty. It is important to address this issue because the labour force that SA seeks for the 21st century can really only be fulfilled if people with disabilities are actively participating in the skilled labour sector (Carrim and Wangenge-Ouma, 2012). The labour sector in SA aims to create a force that is capable of handling the rapid changes in economy (Ramley, 2014).

Studies have indicated that higher education plays a very important role in promoting the participation of people with disabilities in the labour market (Kigotho, 2015). Higher education institutions in SA provide various courses that can assist visually impaired learners (VILs) to be accommodated in the labour sector of the country (Kirst and Stevens, 2015). For VILs, attaining knowledge by participating in these courses increases their prospects of employment and empowerment (Fuller, Bradley and Healey, 2004).

Knowledge is one of the most important aspects in the world and education is the process of imparting this knowledge to the people. According to Taylor, Sternberg, and Richards (2012), the cost of educating a student in SA is very high. When it comes to educating physically, mentally and visually challenged students, the situation gets more challenging. There are special schools to meet the special educational needs of these exceptional students in SA. Access to tertiary education is observed to be difficult for these students in SA, especially for those who are visual impaired. The term “visual impairment” refers to people having deficiencies ranging from partial sight to blindness. Although VILs are being enrolled in tertiary institutions, the institutions are not adequately equipped with the facilities to educate VILs, as these students require a great deal of additional support to complete their studies (Mushome and Monobe, 2013). The fact is that most universities in SA do not have the required resources for facilitating the entry of VILs into their programmes (Mutanga, 2017).

VILs face many challenges at university; like learning routes on campus, finding people in a crowd, recognizing people, finding information on notice-boards, etc. (Lourens and Swartz, 2016). While in class, VILs struggle to take down lecture notes and they may find it difficult to see and follow the PowerPoint slides (Jung and Zu Bexten, 2002). Reading printed notes given by the lecturer and finding books in the library can be time consuming for VILs (Bhardwaj, 2018). Diagrams, visual material and new vocabulary can be problematic unless a detailed explanation is given by the lecturer (Agesa, 2014). Recording classes can be useful to VILs, but the lecturer needs to be prepared to accept this request (Waterfield and West, 2008). The challenges are even worse for first-year VILs; this is due to the fact that they still have to find a way to adapt to the new environment and wider social activities of university life (Lourens and Swartz, 2016).

1.2 PROBLEM STATEMENT

Students with disabilities from disadvantaged backgrounds are often being excluded from higher education in SA (Department of Education, 2008). Despite having policies on inclusive education, inclusion in higher education in SA is not always open and accommodative to VILs (Carrim, 2002). While there are Disability Units (DUs) in many universities, the Fotim Report (2011) points out that these Units have minimal autonomy and direct communication with university management. The constraints faced by higher authorities reflect indirectly to academic staff leading to a lower level of participation and awareness regarding disability issues (Lyner-Cleophas *et al.*, 2014).

It was observed that there was a low number of VILs being enrolled in Engineering courses compared to other courses (Ohajunwa *et al.*, 2014). Mayat and Amosun (2011) in their study observed that students with disabilities are under-represented in Engineering courses due to the misapprehension among Engineering staff that students with disabilities could not fulfil all the criteria required to complete the Engineering programmes. Engineering courses are very technical and hands-on compared to other courses such as Management or Education. The technicality of these Engineering courses is what makes them very challenging and difficult for all stakeholders to teach and learn. Hence, ICT teaching tools used in Engineering courses may be different from ICT teaching tools used for other courses. Therefore, developing a framework for the adoption and effective use of ICTs for VILs in Engineering is warranted.

Institutions of higher learning in SA may have no effective framework to guide faculty members to care for VILs in their classes. Establishing such a framework relating to teaching Engineering courses to VILs in higher education using ICTs would prove to be a significant scientific contribution.

1.3 RESEARCH OBJECTIVES

Through numerous literature studies, the researcher understood that VILs are being marginalised from schools, higher education institutions and even in communities (Mayat and Amosun, 2011). Visual impairment and poverty share a strong relationship (Naidoo, 2007; Gilbert *et al.*, 2008; Ribadu and Mahmoud, 2010). It is difficult for VILs to secure a good job without a university degree. To address this issue it was important to investigate on the barriers that VILs had to face when contemplating entry into higher education institutions.

The main objective of this study was therefore to:

Develop a framework for the provision of VILs in Engineering education in SA using ICTs

This study aimed at identifying different challenges that affect the provision of VILs in Engineering education. Even though the framework is especially designed for Engineering education, it can be used as a general guideline for all tertiary academic courses.

To achieve the main objective mentioned above, the following five sub-objectives were accomplished (listed below with a brief methodology):

- ***Determine the degree to which Engineering faculties in SA are accommodating VILs.***

In order to achieve this sub-objective, the researcher performed a thorough literature review. The literature review is covered in Chapter 2. Studies have indicated that there is an under-representation of VILs in Engineering faculty (Mayat and Amosun, 2011). The data collected from the literature review assisted the researcher in formulating questions for the questionnaires and focus groups and to attain this objective. The data collected from questionnaires and focus groups are presented in Chapter 4 and 5 of this thesis. The outcome from this objective assisted the researcher in validating the need for developing a framework for VILs.

- ***Identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA.***

An intensive literature review was conducted by the researcher in which many challenges faced by VILs in higher education were identified. These challenges are presented in Chapter 2 of this thesis. The additional challenges which were not listed in other studies were identified from the data collected using questionnaires and by conducting focus group discussions at school and university level. Chapters 4 and 5 discuss the case studies conducted at school and university level. The outcome from this objective assisted the researcher in developing a framework for VILs.

- ***Examine the ICT tools that could be adopted to better facilitate the entry of VIL into Engineering courses.***

This objective is largely covered in Chapter 2, where an elaborate literature review on the various ICT tools that could be used for Engineering education are presented. The ICT tools form one of the components in the proposed framework.

- ***Incorporate many of these ICT tools into the framework to benefit VILs in Engineering education in SA.***

Chapter 6 of this thesis presents the framework for the provision of VILs in higher education, especially in Engineering courses. Each component in the framework is carefully explained and described in this chapter.

- ***Evaluate the framework with specific field experts so as to establish its validity and refine its suitability for higher education in SA.***

The framework evaluation is discussed in Chapter 6. Experts from the field of study were carefully chosen to evaluate the framework and to establish the validity of the framework. The experts consisted of researchers who have done research in Engineering education, heads of department (HOD)s of Engineering faculties, DU managers and visually impaired people working in the Engineering /IT field.

The subsequent section discusses the research questions.

1.4 RESEARCH QUESTIONS

About 80% of the students with disabilities in SA do not continue their studies after completing school (Merwe, 2017).The main challenge in SA is that the higher education institutions are not adequately equipped to educate VILs (Mutanga, 2017).This situation is worse in certain academic courses, such as Engineering (Mayat and Amosun, 2011). No research has been done so far to determine what could be the challenges that are specific to Engineering courses that result in the low intake of VILs. Some studies indicate that ICT tools assist VILs in their academic courses, thereby improving their performance (Eguavoen, 2016). It is therefore important to identify the appropriate tools and equipment (depending on the subject content and degree of disability) that would ensure the smooth teaching and learning process of VILs. This leads to the main research question:

What guidelines should exist in South African universities to facilitate the inclusion of VILs in Engineering using ICTs?

Five sub-questions exist as follows (listed below with appropriate discussions):

To what degree are the Engineering faculties in SA accommodating VILs?

Researchers like Mayat and Amosun (2011) have indicated in their study that there is marginalisation of students with disabilities in the Science and Engineering fields. This research question served the researcher in investigating the degree to which the Engineering faculties in SA are accommodating VILs. This question was determined with the help of a literature study. Further investigation regarding the accommodation of VILs in Engineering faculties was done using focus group discussions and questionnaires. The outcome of this investigation strengthened the necessity of formulating a conceptual framework for VILs in universities, especially Engineering courses.

The second research sub-question is discussed below:

What are the challenges that VILs in SA face while contemplating entry into Engineering courses?

Provision of access to higher education institutions is observed to be difficult for students with disabilities in SA, especially for VILs (Nkoane, 2006; Naidoo, 2010; Mutanga, 2017). This research question guided the researcher in understanding the challenges that VILs faced while considering entry in Engineering courses in SA. This question was determined with the help of a literature study. The challenges were further explored by means of focus groups and questionnaires. In order to develop a framework for the provision of VILs in Engineering, it was important to identify the challenges that they faced regarding their entry into Engineering courses.

The third research sub-question is discussed below:

What are the current ICT tools that could be effective for VILs in Engineering?

ICT is both a medium and a powerful tool in supporting inclusive education of VILs (Gould *et al.*, 2014). ICT tools or equipment used vary, depending on the nature of academic subject content and the degree of visual disability (partial blindness to total blindness) of the student (Hersh and Johnson, 2010). It was, therefore, important to identify the ICT tools that could be used by a VIL in Engineering courses to assist them in their courses. This question was determined purely with the help of literature study, and forming a component in the conceptual framework.

The fourth research sub-question is discussed below:

What guidelines should exist for the effective use of these ICT tools by VILs in Engineering?

Guidelines may serve as a checklist for institutions to resolve the identified challenges affecting the progress of the institutions (Ministry of Education, 2003). Such guidelines should exist for higher education institutions so that ICT tools can be effectively used in assisting VILs in their Engineering academic subjects. These set of prerequisites or guidelines formed the components of the conceptual framework. This question was determined with the help of a literature study. The factors or guidelines for the framework were further explored via focus group discussions and questionnaires. This question assisted the researcher in conceptualising the framework for the provision of VILs in Engineering courses at universities.

The fifth research sub-question is discussed below:

Why should this framework be evaluated by field experts?

To establish the validity of the framework, it should be evaluated by experts in the field of study (Cohen, Manion and Morrison, 2011). The experts consisted of researchers who have done research in Engineering education, HODs of Engineering faculties, DU managers and VI (visually impaired) people working in Engineering/IT field. This question was determined with the help of a literature study. A great many studies have indicated the importance of using the opinions of expertise on the research matter (Cuhls, 2005; Bogner, Littig and Menz, 2009). This question assisted the researcher to establish the reliability and validity of the conceptual framework for the provision of VILs in Engineering education. The subsequent section briefly discusses the research methodology and design used in this study.

1.5 RESEARCH METHODOLOGY AND DESIGN

1.5.1 Research Methodology

A research methodology is defined as a group of methods that complement one another and that have the ability to collect findings that will reflect the research question and serve the purpose of the researcher (Henning, Van Rensburg and Smit, 2004).It is important to choose the research approach that would be best for the study with regard to supporting the chosen research methodology.

A mixed method research design was selected for this study. In this approach, investigators collect and analyse both quantitative and qualitative data to provide the best understanding of a research problem (Bergman, 2008; Creswell and Poth, 2017). Both qualitative and quantitative methods have their limitations. Mixed methods research design will be able to neutralise or cancel the biases of both methods. Thus the concept of triangulating data sources, a means for seeking convergence across qualitative and quantitative methods (Jick, 1979) .

There are many designs of mixed methods research (Johnson, 2014). In this study, convergent parallel design was used. This approach collected and analysed two independent strands of quantitative and qualitative data at the same time, in a single phase. Both the methods were given equal priority and the data analysis was done independently. The results were mixed during the interpretation stage. Convergence, divergence, contradictions, or relationships of two sources of data were identified.

1.5.2 Data collection instruments

The effectiveness of a research design is determined by the research questions and objectives chosen for the study (Mackey and Gass, 2015), which have been given above. Obtaining answers to the research questions requires the use of data collection instruments or tools. The research tools used in this study were literature review, focus group discussions questionnaires and expert reviews.

The techniques implemented in this study were based on the research problem and are described in Figure 1.1. The figure gives an indication of the different phases of the study.

The study started with an intensive literature review. A literature review gives an overview of the existing methods and theories and hypotheses, what has been discussed, who the key authors are, and what techniques and methodologies are most appropriate and useful (Gardner, 2011). The literature review consisted of the challenges VILs face in SA, the current situation of VILs in South African universities, and the M-tools and E-tools that assist the VILs to learn. This research was based on a case study (Part A and Part B). All the special schools in the Free State Province (Bartimea School for the Blind and Deaf and Thiboloha School for the Blind and Deaf) were chosen for this study. Part A of the case study utilised focus groups for VILs and questionnaires from educators in special schools. The focus group assisted in gathering the perceptions of VILs about entry into higher education in SA.

Five focus groups with a maximum of 7 people participated in each group. The group was large enough to generate rich discussion, but not so large that some participants are left out. The participants for the focus groups were based on the availability of the participants with the permission of the participants. The discussion for each group was between 45 to 90 minutes long. A carefully predetermined set of questions was structured for the focus groups. Questionnaires provided to the special school educators were mixed questionnaires consisting of both closed and open questions. The data collected from the focus groups of VILs, and questionnaires from the educators of VILs assisted to determine the degree to which institutions of higher education in SA are accommodating VILs. Both qualitative (focus groups) and quantitative (questionnaires) data were collected. The data was analysed using a content analysis technique and statistical analysis.

The data gathered in Part A of the case study were used to prepare for Part B. Part B utilised questionnaires designed for the disability centres in universities and for HODs and senior lecturers from Engineering faculties. These questionnaires were distributed electronically through Google forms. The data was analysed using a content analysis technique and statistical analysis. The data collected from Part A and Part B assisted in identifying the challenges that VILs in SA faced when contemplating entry into higher education, and especially into Engineering.

The data collected from both phases of the case study were triangulated and a framework was developed which was assessed and evaluated by experts in the field. Compared to real environment evaluation of the framework, expert reviews were chosen based on the fact that the implementation of all the factors in the framework was not feasible for the study. Experts consisted of a group of researchers who had done research in Engineering education, HODs of Engineering faculties, managers of disability centres and a visually impaired person working in an Engineering/Information Technology (IT) field. Based on the reviews and feedback from the experts, the final framework was designed.

Figure 1.1 Research design

1.6 SIGNIFICANCE OF THE STUDY

Limited research has been done in the past around VILs in Engineering in SA. It is foreseen that this study will make a significant contribution to the provision of VILs in Engineering courses in South African universities. The scientific contribution of the study is to develop a framework for universities in SA to assist VILs in Engineering education.

The main aim was to develop a framework for the provision of VILs in Engineering education in SA using ICTs. It is important to know the perceptions of VILs towards provision of access to tertiary education as it is a crucial contribution in implementing inclusivity in the tertiary education system of SA (Mokiwa and Phasha, 2012). This study identified, analysed and suggested ways to address the challenges in the provision of VILs in Engineering; and it has also proposed a framework that could assist the universities in the provisioning of VILs in higher education. Even though the purpose of the framework was to assist VILs in entering Engineering courses, this framework can be used as a guideline for any faculty in higher education institutions.

The framework includes government and management requirements, infrastructural requirements, and requirements for effective teaching and learning which could assist VILs in attaining tertiary education.

1.7 LIMITATIONS OF THE STUDY

The main aim of the study was to develop a framework for the provision of VILs in Engineering education in SA. The case study at school level was limited to two special schools in the Free State Province. They are Bartimea School for the Blind and Deaf and Thiboloha School for the Blind and Deaf. This case study, which focused on the VILs and educators at these special schools, served as a sample of the special school education system within the South African context. The case study at university level was limited to collecting data from all the universities in SA, though some of the universities did not participate in the study. This case study, which focused on the DUs, HODs and senior lecturers from Engineering faculty in universities, served as a sample of the tertiary education system within the South African context. Of the institutions, 45% (9 out of 20 institutions) responded to the senior Engineering staff questionnaire and 25% of the institutions (5 out of 20 institutions) responded to the DU questionnaire.

Usability and usefulness of the tools that form part of the framework was not considered while developing the framework (for example, usability testing of the ICT tools that could be used in Engineering courses) due to the limited number of VILs studying Engineering. A similar study (PhD study) was done by Apulu(2012) in which he developed a framework for successful adoption of ICTs for SMEs, where no usability was involved. The scope of this study was to develop a framework for the provision of VILs in Engineering education in SA.

1.8 ETHICAL CONSIDERATIONS

Ethics are defined as behavioural norms and standards that distinguish between right and wrong. In this research, the researcher interacted with human participants and their rights were respected at all times. This meant that the decision to take part in the study remained the choice of the participants. Any participants in a research study should be assured that the information provided by them would be kept confidential and their identities or personal details would not be disclosed to others, except for research purposes (Bell, Bryman and Harley, 2018). Research participants were not subjected to harm in any way and communication with the participants were done with honesty and transparency. Ethical issues were considered throughout the entire research process and the final report of this study truly represented all of the data and relevant conditions. The researcher obtained ethical clearance from the Central University of Technology (CUT).

1.9 ORGANISATION OF THE THESIS

The thesis is structured into seven chapters. An overview of the chapters is outlined below:

Chapter 2: This chapter discusses the literature used in the study. This includes studies on different ICT tools that could be used to assist VILs in Engineering.

Chapter 3: This chapter discusses the research design and methodology used in this study. The research philosophy, approach and strategies are also discussed in this chapter.

Chapter 4: The chapter presents Part A of the case study that was done at school level. This case study involved collecting the views and perceptions of high school VILs and special school educators from all the special schools in Free State Province (Bartimea School for the Blind and Deaf and Thiboloha School for the Blind and Deaf) regarding the provision of access for VILs to Engineering education in SA. The findings from the literature, focus groups and questionnaires are presented in this chapter.

Chapter 5: This chapter presents Part B of the case study that was conducted at university level. This involved collecting the views and perceptions of DUs, HODs and senior lecturers of Engineering faculties at South African universities regarding the provision of VILs in Engineering education in SA. The findings from the literature and questionnaires are presented in this chapter.

Chapter 6: This chapter discusses the design, development and evaluation of the conceptual framework for VILs at universities. This framework was designed based on the information collected from Chapters 2, 4 and 5. The findings were analysed with the research questions and objectives that were formulated at the beginning of the study. The developed framework was evaluated by experts in the field of study. The experts consisted of researchers who have done research in Engineering education, HODs of Engineering faculties, DU managers and VI people working in Engineering/IT field. This chapter also discusses how the framework was refined and finalised based on the expert reviews.

Chapter 7: The study is concluded with this chapter. The research objectives, findings and recommendations are laid out together. Possible future work for this study is also presented.

1.10 SUMMARY

This chapter presents the main objective of this research: to develop a framework for the provision of VILs in Engineering education in SA. The research problem and research questions that guided the research are discussed in this chapter. Many higher education institutions in SA do not have an effective framework to assist Engineering faculties in accommodating VILs in their academic programmes. This motivated the researcher to develop such a framework for accommodating VILs in

Engineering using ICTs. An overview on the research methodology and design chosen for the study was also presented. This study utilised data from a case study which includes two parts. Part A relates to school level and Part B to university level. The research tools used for the study comprised a literature review, focus group discussions and questionnaires. The scope and significance of the study were also discussed along with ethical considerations. A brief overview of the thesis concluded the chapter.

Chapter 2 discusses in detail the literature review done for the study.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 1 presented a comprehensive overview of this study. The research problem, research aim, research questions and objectives were described in brief. The research process and methodology were also briefly discussed to show how the study is approached systematically in order to solve the research problem. The main aim of the study was to develop a framework for VILs in Engineering education in SA.

This chapter provides an overview of significant literature published on the research topic. Section 2.2 discusses the importance of ICT in education. A detailed literature review of ICT tools or assistive resources that could be used to assist VILs to study Engineering subjects is discussed in section 2.3. Section 2.4 presents a list of additional tools that could be used in assisting VILs in higher education. Section 2.5 discusses the current situation of VILs in SA, and the chapter summary is presented in section 2.6.

2.2 ICT IN EDUCATION

ICT plays a very important role in all aspects of life. Education is no exception. ICT is used in education as a means of supporting the process of learning, and contributes itself to more student-centred learning settings (Meyer and Gent, 2016). ICT offers teachers a multitude of options to deliver content to the students. It also provides them an opportunity to enhance the learning process of students (Sharma *et al.*, 2011). If ICT is used efficiently, it can engage all students regardless of their disabilities.

ICT plays a vital role in enhancing the education sector of developing countries by improving the ways of accessing and acquiring information (Tinio, 2002). Introducing ICT in education has helped to deliver quality instruction to students by allowing the teachers to experiment with a wide range of methodologies (Flecknoe, 2002). ICT has revolutionised the education sector by providing opportunities to people who are in distant places to participate in the learning process (Nleya, 2018). It has also paved the way towards adopting and practising various learning approaches and strategies (Mikre, 2011). ICT has enabled easy access to study materials through digital platforms (Hennessy *et al.*, 2010).This has allowed independent and constructivist learning for students, thereby increasing their participation and involvement in the learning process (Volman, 2005). Hence, ICT in education has assisted students to acquire the skills essential for the 21st century (Savvidis, 2019).

ICT is considered as a medium through which inclusive education can be exercised. Inclusive education can be defined as an educational model in which all students, regardless of any disabilities they may have, are provided with high quality instruction and support that may help them to succeed in the core curriculum offered in the institution (Bui *et al.*, 2010). VILs have the right to expect the same standard of education as other students. ICT-based tools can be used to assist VILs in their academic courses, thereby improving their academic performance (Arrigo, 2005).

Eguavoen (2016) conducted a study to examine the relationship of ICT and academic performance of students with visual impairment in special schools of the Lagos State of Nigeria. The objectives of the study were to identify ICT tools, and the level of ICT utilisation as well as their relationship to academic performance among students with visual impairments. A structured questionnaire was used to elicit information from VILs from two special schools located within the Lagos State. The results indicated that there was a significant relationship between ICT utilisation and academic performance of students with visual impairments.

Silman, Yaratan and Karanfiller (2017) did a study to examine the impact of ICT tools in the teaching and learning process of VILs in the Cyprus Turkish Blind Association. Semi-structured interviews were conducted with teachers, students and administrators of the Cyprus Turkish Blind Association to collect information regarding the benefits or issues they faced while using ICT tools in the teaching and learning of VILs. The findings indicated that ICT tools facilitated the teaching learning process of VILs and also enhanced the communication skills of VILs with people inside and outside the Association. The administrators also indicated that ICT tools helped them in the administrative process and kept them motivated to assist VILs.

The next section discusses ICT tools that could be used for VILs in Engineering courses.

2.3 ICT TOOLS FOR VILs IN ENGINEERING EDUCATION

Engineering is a field of study that involves the application of Science and Mathematics to innovate, design and maintain devices, systems or processes (Downey, 2009). It is a broad field of study with many branches, such as mechanical Engineering, electrical Engineering, civil Engineering, chemical Engineering, computer science, etc. The term “Engineering” is derived from the Latin meaning "cleverness" (Lee, Nielsen and Stephanopoulos, 2017) and is defined as follows by the International Engineering Alliance:

“*Engineering is an activity that is essential to meeting the needs of people, economic development and the provision of services to society. Engineering involves the purposeful application of mathematical and natural sciences and a body of Engineering knowledge, technology and techniques*.” – (Accord, 2013)

However, there is a general misconception that Engineering is difficult for VILs (The Conversation, 2014). Studies indicate that the number of VILs enrolling for Engineering courses are very few compared to other courses (Mayat and Amosun, 2011). According to the 2016 Higher Education Management Information System (HEMIS) database, just under 1% (7 525) of students enrolled in public higher education institutions have some form of disability, of which 51.1% were female while 48.8% were male students (Department of Higher Education and Training, 2018). Almost 50% of the students with disabilities had physical (1 887) and visual disabilities (1 764). However, VILs who have become successful in Engineering professions are the ones who had access to proper ICT tools or assistive resources for their academic courses (Ingber, 2005). Hence, this study seeks to investigate the different ICT tools that can be adopted to better facilitate the entry of VILs into

Engineering courses (sub-objective 3 from Chapter 1). Some ICT tools or assistive tools that could be used for VILs in Engineering courses are discussed below.

2.3.1 ICT TOOL 1: iNetSim

Computer networking enables communication between a set of computers that are physically distant (Balasubramaniam, 2015). The internet is a popular worldwide network that people use to access and share information (Forouzan, 2002). It is important for the students to understand how computers communicate as this is a powerful tool for information exchange. Therefore, Engineering branches such as mechatronics, electrical Engineering, computer science, information technology, etc. have included **Network Engineering** in their curriculum. Cisco systems offer certification programmes called Cisco Certified Network Associate (CCNA) for Network Engineering courses where the students are taught about interconnecting devices and troubleshooting networks. CCNA courses train students in network fundamentals, switching and routing technologies and infrastructure security and management.

However, VILs struggle to learn these courses as the software used in them are not accessible as the courses use small images of network topology. The learning materials utilised by these networking courses previously had a great deal of visual content and images. The common screen readers (JAWS) used by VILs do not work with the Flash application, Packet Tracer, which is used to display information in these courses. JAWS (Job Access With Speech) is an assistive tool which is a screen reader program that assists VILs to access content on a screen through a text-to-speech output or a Braille display. The Curtin University in Perth, Western Australia decided in 2004 to take an initiative to assist VILs in learning these courses (Murray and Armstrong, 2005).

Hope *et al*. (2006) introduced a network simulator called iNetSim, to assist VILs in (CCNA) laboratory sessions. The programming platform for iNetSim is Mac OS X Tiger. The screen reader, VoiceOver, was included along with the release of the execution platform of iNetSim (Apple Computer Inc., 2005). The network topology elements could be accessed and read via VoiceOver keys. Commands for setting device configuration, routing protocols, etc., could be run on the command line interface. iNetSim utilised routing tables to manage the simulation of the tasks efficiently. The user interface is depicted in Figure 2.1 below.

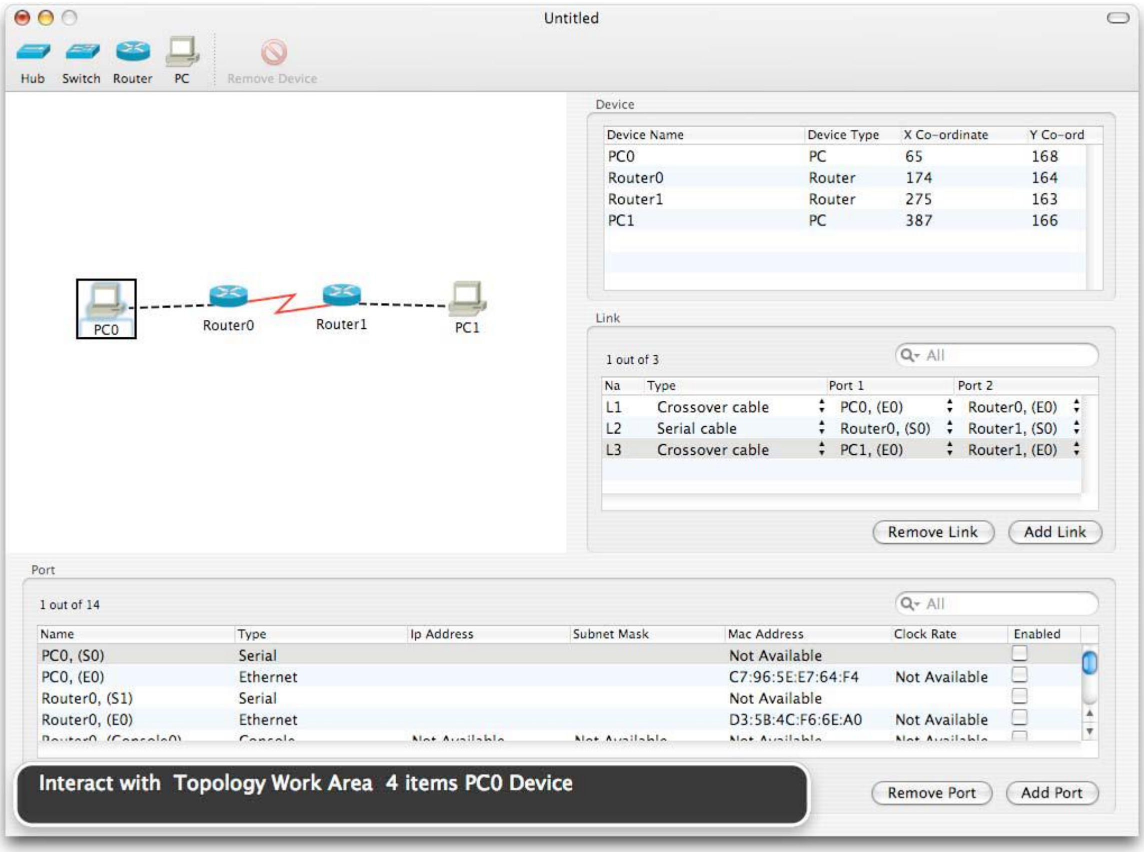


Figure 2.1 iNetSim User interface (Hope *et al.*, 2006)

The text indicated in the window in Figure 2.1 shows the information read by VoiceOver. VoiceOver captures information about the devices, links and ports. The user has the capability of adding and removing links and ports.

This tool was evaluated with help of a VIL who participated in a beta test of iNetSim. One of the participants indicated that he was satisfied with the easiness of using iNetSim in spite of being ignorant about the networking modules. The authors further reported that this tool was also evaluated by more VILs and also by using various accessibility tools. The results indicated that this tool was easy to use and accessible to VILs. The authors claimed that this tool was extensible and capable of eliminating the compatibility issues of the screen reader software with the support of a good graphical user interface. The evaluation of the tool with participants as VILs gave the authors a clear insight into the issues faced by VILs.

2.3.2 ICT TOOL 2: PRISCA

Software Engineering is the field of Engineering that involves designing and building of computer programs (Offutt, 2013). It can be challenging for the software developers to build an application without proper planning of the design of the system. Most of the gadgets and devices being used in our day-to-day lives are programmed. Therefore, Engineering courses like IT and computer science has incorportaed sofware Engineering in their curriculum. Unified Modelling Language (UML) is a modelling language used by software engineers to envision and document the outputs of a software system as a set of diagrams. The UML plays an important role in a software development process.

While many graphical models are principal elements of software design processes, the massive use of visual content as descriptions has made it challenging for VILs to use these models. This modelling approach uses visual diagrams and graphical notations to represent the design of software projects. Converting the 2- dimensional (2D) UML diagrams to 3-dimensional (3D) haptic diagrams might prove useful for VILs as they can touch and feel the diagrams.

Doherty and Cheng (2015) introduced PRISCA, a project to assist VILs in **Software Engineering,**. with the motive of making the modelling platforms accessible to VILs. In using PRISCA, a 3D printer format and 3D Braille format is generated by translating the UML output and textual annotations with the help of 3D-rendering libraries. 3D printing has proved to be an effective method of representing visual content to VILs (Jafri and Ali, 2015). OpenSCAD was used in PRISCA to generate 3D model programs from 2D UML notations (Kintel, 2015). The rich graphics library of OpenSCAD can be used on multiple platforms. 3D representations were generated using a MakerBot Replicator 2 3D printer. This printer is considered to be the most popular among students as it is affordable for them. The authors claim that the speciality of the project is its simplicity in that it generates only the surface geometry of any 3D element and does not require support for colour or texture. The steps involved in the PRISCA project are depicted in Figure 2.2 below.

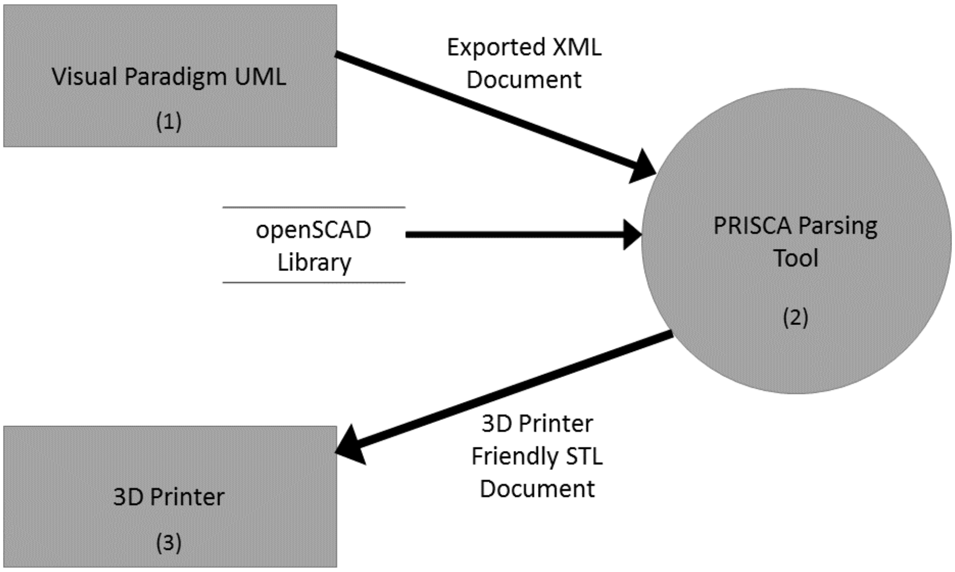


Figure 2.2 PRISCA project tool chain (Doherty and Cheng, 2015)

This project was evaluated by VILs who were doing courses involving industrial association. Based on their feedback, the limitations of this project were identified as follows:

- All textual annotations could not be converted to Braille as the size of the text in Braille was too large compared to the 3D print area.
- Further investigations of the other technologies are required in order to effectively represent all textual annotations for VILs.
- It is difficult to position connector endpoints and to scale diagrams efficiently with PRISCA.
- The graphics library used by PRISCA is not capable to capture all the necessary details.

PRISCA was a project designed with the motive of assisting VI software developers to collaborate with sighted developers using 3D software models. PRISCA offered a number of benefits

- It enables collaboration of sighted developers with visually impaired developers
- Creation of automatic 3D haptic diagrams
- PRISCA is extensible
- It facilitates reusability of diagrams.

The authors reported that PRISCA assisted VILs in better understanding of software modelling beyond what might have been gained from audio documents. The authors claimed that they would work closely with VILs in future to address all the issues mentioned by the participants.

2.3.3 ICT TOOL 3: AudioMath

Modern life urges all individuals to have good mathematical knowledge. Mathematics knowledge not only contributes to the technical skills of the individual but also shapes individuals to become moral and successful human beings (Hodaňová and Nocar, 2016). Learning Mathematics is essential for students at all levels. Most of the Engineering courses devote a good deal of time to studying Mathematics (Harris *et al.*, 2015).Mathematics is ,therefore, considered as one of the prerequisite subjects for students who are planning to enrol in Engineering courses (Kent and Noss, 2003). A study done at the Vaal University of Technology in South Africa revealed that a substantial percentage of the examination papers in all levels of an Electronics module involved the objective Application (from Bloom's Taxonomy), where students were required to complete many mathematical calculations (Swart, 2009). Many fields of Engineering require a firm Mathematical foundation for the design and evaluation of systems, but learning Mathematics might be challenging for VILs because geometry, trigonometry, calculus, etc., involve complex calculations.

Sánchez and Flores (2005) designed a virtual environment to assist VILs in learning **Mathematics** in Santiago (Chile). The authors introduced a virtual environment called AudioMath which used audio and short-term memory to teach Mathematics to VILs. AudioMath has e component-specific content, random card generator, computer model, projection and interface. Specific content is used to generate grids with pair of tokens. Random card generator allows the user to set the level of complexity. Computer model stores the system variables such as number of correct token pairs, time, user name, etc. The projection acts according to the user's preference. It implements the changes to the input signal such as converting it to audio signals. Interface is the interaction between input and output devices. The interfaces are presented in Figure 2.3 below. This tool was developed using Macromedia Director 8.5. The external joystick control Xtra RavJoystick required a rich library of routines.

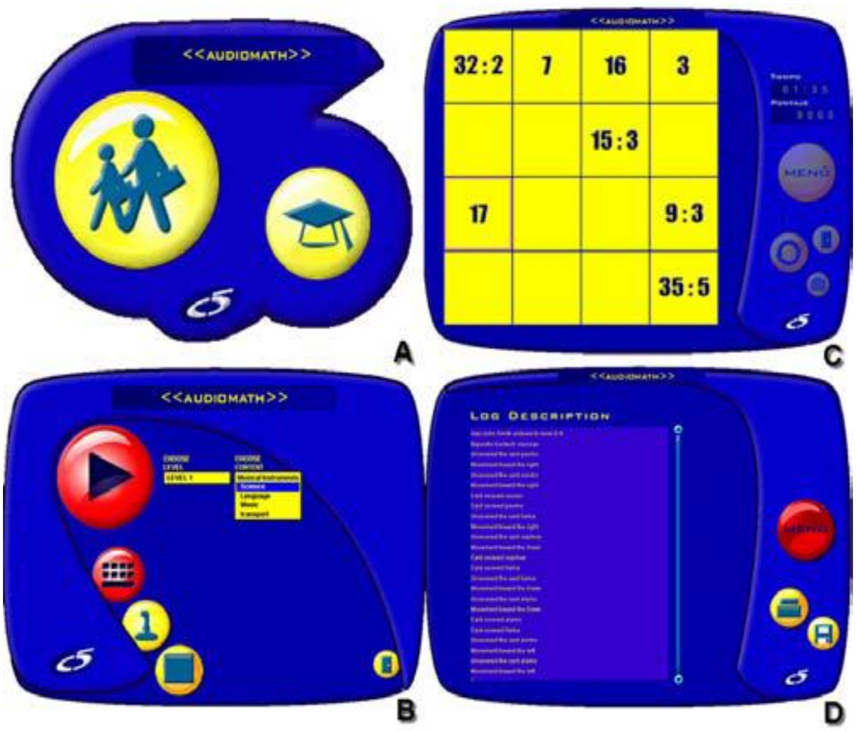


Figure 2.3 AudioMath interfaces (Sánchez and Flores, 2004)

Only audio-based interfaces are used for VILs in this tool. “A” in Figure 2.3 above depicts the screen where the mode can be chosen: facilitator or student. The level of complexity and the input buttons can be selected from screen “B”. “C” indicates options such as the position of the card grid, restart, register, etc. “D” indicates a log register that displays the user's actions performed.

The tool was assessed by VILs in a special school in Santiago (Sánchez and Flores, 2005). The VILs who participated in evaluating the tool were tested for both audio memory and mathematics knowledge. The results indicated that Mathematics learning in VILs can be improved with AudioMath, and that the memory of VILs was also enhanced with the help of this tool. Based on these results, the authors therefore claimed that AudioMath is a powerful tool for assisting VILs in learning Mathematics.

2.3.4 ICT TOOL 4: i-Math

As discussed in the previous section, Mathematics is the underpinning for Engineering courses and contributes to the development of science and technology (Chambers, 2008; Kusmaryono, 2014). The mathematical notations and visual representations like charts and graphs might prove challenging for VILs. There are many mathematical resources available for the students, both in printed and digital formats, to enhance their ability in solving mathematical problems (Sánchez and Flores, 2005). VILs access these resources using various methods such as using audio books, assigning a human reader, etc. Finding a trained human reader for VILs was not always practical and could also be expensive. Even though Braille is considered to be the most convenient tool for VILs, converting maths documents to Braille is difficult, costly and complicated (Moço and Archambault, 2004). The rendered audio generated by the audio tools is very long, making it difficult for VILs to understand the mathematical expressions (Soiffer, 2005). Furthermore, certain languages, such as the Thai language, are tonal languages requiring different tones to be used to assist VILs in understanding the meaning of the mathematical expressions. Keeping these factors in mind, Wongkia, Naruedomkul and Cercone (2012) decided to develop an automatic maths expression reading system, called i-Math, to assist VILs in Thailand to learn **mathematics**.

i-Math uses a screen reader to generate voice output on a computer. It is capable of reading maths materials aloud. Using i-Math features, students can read and practise maths problems conveniently and teachers can set assignments for the students in audio format. This tool was evaluated by 78 visually impaired students and six teachers in Thailand schools (Wongkia, Naruedomkul and Cercone, 2012). The results indicated that this tool was very useful for VILs as it assisted them to study independently, accessing the audio maths materials whenever they needed to. The limitation of this tool was that the speech output was in the Thai language. Some of the other popular maths-assistive tools are MathPlayer and Math Genie.

2.3.5 ICT TOOL 5: Learning Java

Programming is the process of developing innovative solutions for problems. It is considered a branch of Applied Mathematics (Amiri, 2011).It also assists in the development of problem solving and analytical skills. Engineering is the branch of study where students are taught how to deal with and solve problems related to the real world (Sharp, 1991; Shaw, 2001). Students use numerical approaches in Engineering to solve problems (Sun, 2011).This task can be made easier by mastering programming skills (Naraghi and Litkouhi, 2001).It is, therefore, important for Engineering students to study programming. Engineering streams such as IT and Computer Science offer programming courses in Java.The task of programming can be challenging for VILs as the students have to learn how to formulate an algorithm for the program and then convert that into a program with proper syntax and semantics (Smith, Francioni and Matzek, 2000).

Kapadni *et al.* (2013) proposed a bridging tool for a technical language, **Java,** for blind educators, which is an automated reading or talking tutor which can be used on Personal Computers (PCs). The authors considered electronic learning (E-learning) to be very effective to VILs but they also note that it can be confusing for the students when they encounter crowded pages, small characters, pop-up windows, etc. The motivation for the authors to develop this audio-visual learning tool was the fact that properly structured options can avoid the problems mentioned above to an extent. The proposed system is depicted in Figure 2.4. The tool supports features like printing facility, navigation buttons and Java program examples for each topic. This system has play and pause buttons so that the learners can listen and learn Java according to their requirements. The added advantage of this tool is that it does not require any external sound driver to access the output of the tool. The system uses the operating system's audio sound known as Microsoft anna, for better pronunciation.

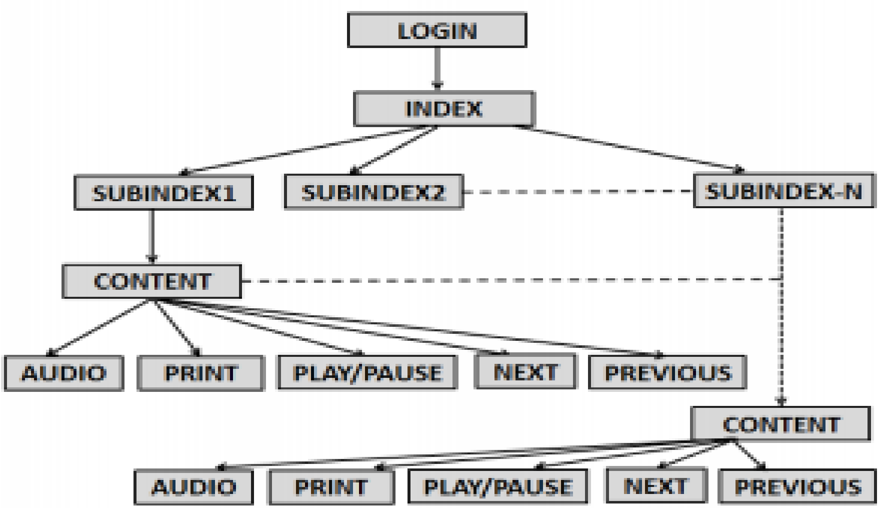


Figure 2.4 Overview of proposed audio-visual tool (Kapadni *et al*., 2013)

The authors claimed that the tool was simple, easy to access, and easy to navigate from one topic to another (Kapadni *et al.*, 2013). The authors developed this audio-visual facility considering the fact that there are only a limited number of E-learning tools available for blind educators. This system was designed with the idea of bridging the gap between visually impaired learners and IT industries. Although the authors claim that this tool has proved to be satisfactory to VILs by making the learning process very easy, the literature review conducted within the limits of the researcher indicates that currently there is no evidence that shows that this tool has been assessed or evaluated.

2.3.6 ICT TOOL 6: MoodleVox

Modern society has seen a growing realisation of the importance of higher education with an increased popularity of distance education (Sokolova *et al*., 2018). However, some students find it difficult to attend courses in higher education institutions as these might be far from the place they stay and they might not have adequate transport facilities to reach the campus (Singh and Agarwal, 2013). Some of the students might be working and find it difficult to attend the classes during their working hours. E-learning was introduced to offer academic courses to students who were geographically distant. This technique allowed the students to access the academic content whenever they wanted to, using ICT tools (Freeman, 2004). Students can also access distant courses through mobile devices, which is known as Mobile-learning. Distance education or E-learning courses are offered in many universities of SA to encourage more student participation in higher education (Badat, 2004). Such courses can prove useful for VILs as many barriers to higher education, like inadequate transportation facilities and inaccessible buildings on campus, do not matter in this educational method. It should be ensured that the virtual learning environment be adapted in such a way that it can address the educational needs of VILs. If proper attention is not given to the accessibility features of the virtual learning environment, it may lead to the marginalisation of VILs (Jaeger, 2012). Developing an accessible E-learning environment may open new opportunities for VILs to pursue the academic course they desire (UNICEF ROSA, 2003).

Da Silva Luna *et al.* (2016) developed a learning tool to promote **E-learning** using a virtual learning environment, called Moodle, for visually impaired students to use on Android smartphones. This E-learning platform allows the learners to ask questions, discuss and share ideas through forums and use chat rooms in real time. The tool is called MoodleVox and it operates only through voice commands. The communication between MoodleVox and the user is through Google Voice and the logic of the interaction menu was based on organisational principles of Moodle. The interaction in the MoodleVox tool environment is as follows: The educator (transmitter) makes available oral messages/oral conversations that can be synchronous/asynchronous to the learners (receivers). Learners can send/receive the message instantly, thereby making a communication loop. Figure 2.5 below depicts the interactive menu in MoodleVox. From the main menu, the user can decide whether to choose the Messages menu or the Disciplines menu.

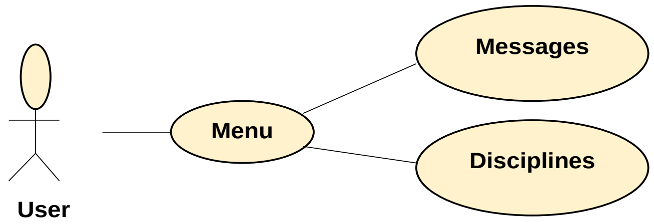


Figure 2.5 Moodle Vox Interaction Menu (Da Silva Luna *et al.*, 2016)

From the Messages menu, the user can proceed with reading or writing options as depicted in Figure 2.6 below.

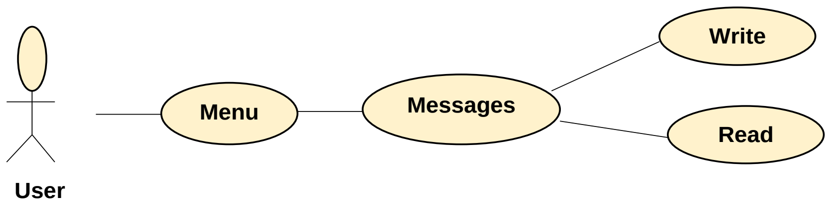


Figure 2.6 Moodle Vox Message Menu (Da Silva Luna *et al.*, 2016)

If the user wishes to send a message to a contact in the system, the user can select the Write option. The user can search the name of the desired recipient from the contact list. If the desired contact is found, the user can write and send a message to the contact. If no matching contact was found, the system generates an error message. If the user selects the Read option, the system notifies the user if there are any new messages for them in the inbox. The system reads the messages for the user on request. The user can record the messages if he/she wishes to reply to the message. Users can go back to the root menu at any time.

The authors created this tool with the aim of improving accessibility in E-learning (Da Silva Luna *et al.*, 2016). MoodleVox assists in providing more educational opportunities for VILs using E-learning resources through a cell phone. It can be considered a feasible substitute to remove the barriers that VILs face in higher education. Even though the authors claim that MoodleVox improved the accessibility of E-learning tools, the literature review conducted provides no extensive evidence that shows that this tool has been assessed or evaluated.

2.3.7 ICT TOOL 7: Haptic Device for robots

Robotics is a field that has gained massive popularity in the past few years (Michaud *et al.*, 2007). It is an area where innovations happen frequently and has an important role in many industries. Students enrolled for courses such as Computer Engineering, Mechatronics, and Electrical Engineering can choose robotics as their field of study. The authors have observed that in spite of the passion of VILs in robotics, they struggle to study this subject because of the lack of proper assistive tools.

Howard, Park and Remy (2012) did a study on the assistive tools to help VILs in **robotics programming**. The authors designed a robot interaction system to assist VILs in robotic programming. Bricx Command Center (BricxCC) was used as the programming interface for the system because of its accessibility features like compatibility with popular screen readers used by VILs. The JAWS reader was integrated with a MAGIC magnifier to assist VILs. A JAWS screen reader was required for totally blind students for text to voice conversion and a magnifier was required for partially blind learners to enlarge text. This system used vibration-based haptic feedback and auditory feedback for user interaction. The user, robot and computer communicated using a Bluetooth connection. The system architecture is depicted in Figure 2.7 below.

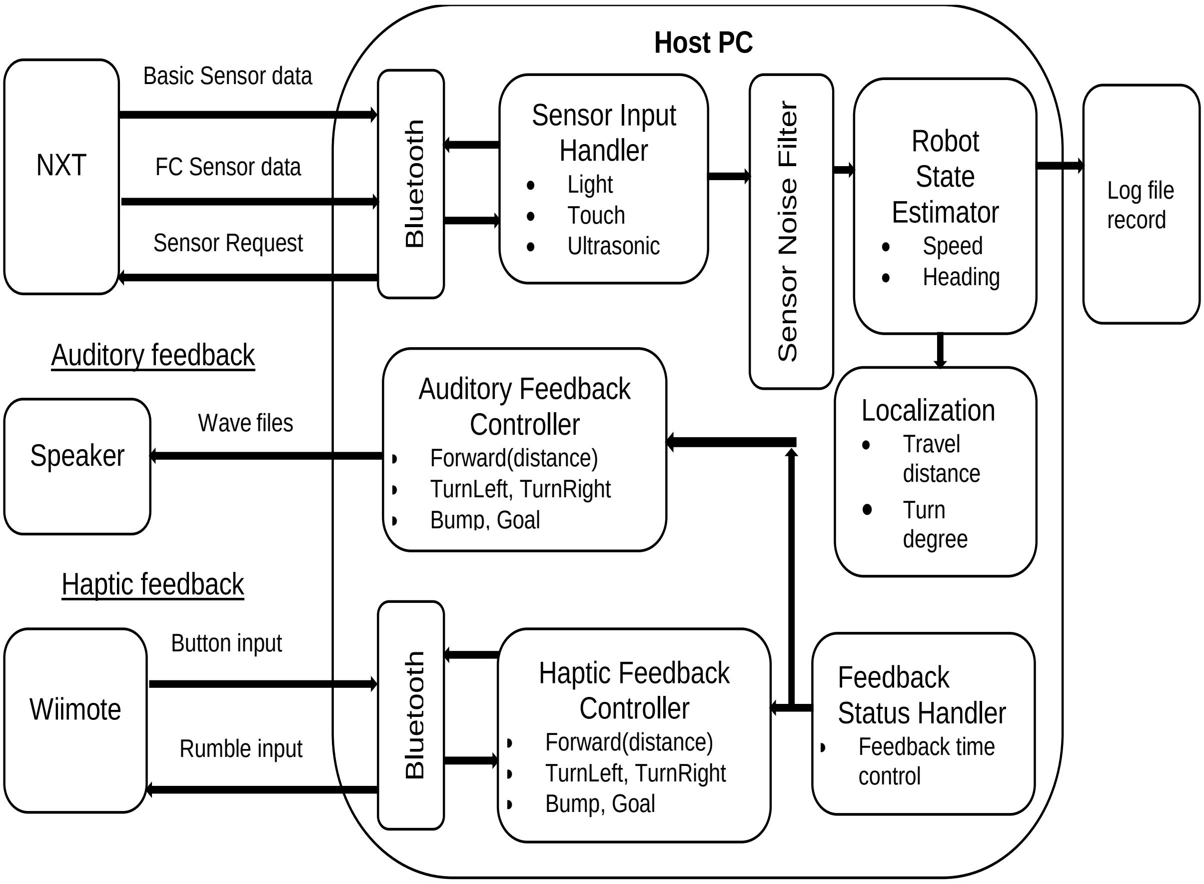


Figure 2.7 System Architecture (Howard, Park and Remy, 2012)

When the host PC sends sensor requests to the robot, the robot transmits sensor data (touch sensor, light sensor, encoder values) to the host PC. The sensor data is then converted into robotic state estimates (speed and heading) by the localisation module. The robotic state estimates are then transferred to the feedback status handler module. These feedbacks assist the VILs to understand the robot movement during program execution. An intelligent agent called Robbie was responsible for interacting between the robot and the student. It analysed the code provided by the student and provided audio feedback to the student based on program output. The example of an audio feedback is depicted in Figure 2.8 below.

I think your robot turned left, 41 degrees. Which is not the correct action.
it then, moved up, 4 centimeters. it then, stopped doing anything.
Do you know how to fix your program?

Figure 2.8 Automated audio feedback (Howard, Park and Remy, 2012)

This system was evaluated during a two-week summer camp held at the Center for the Visually Impaired in Georgia (Howard, Park and Remy, 2012). VILs agreed that the haptic device assisted them in sensing the robot movements. The system proved to be satisfactory for the VILs who participated in the study.

2.3.8 ICT TOOL 8: Logger Pro

According to (Sözbilir, 2016), the purpose of Science education is :"*To give future generations an understanding of scientific and technological knowledge and life skills to help them to be able to make informed decisions in their life and in society*". Practical work is required for Science education as the scientific knowledge can be imparted to the students effectively only by providing evidences (Abrahams, 2009). Certain streams of Engineering, such as Electronics Engineering and Electrical Engineering require many laboratory sessions. Supalo *et al.* (2007) conducted a study in Wisconsin to assist VILs in **Science** laboratories. The authors claim that electronic probes and their associated software packages assist VILs to collect and view real time data using PCs more efficiently. The aim of this study was to resolve the compatibility issues between the data capturing software used in the assistive tools and the popular screen readers used by VILs. any tools were designed to assist VILs in laboratories, for example software that generated speech output while using electrodes and spectrophotometers to measure time, and the power of hydrogen(pH), etc. in Science laboratories (Morrison and Lunney, 1984). The incompatibility of the data capturing software with screen-reading software made it difficult for VILs to access the data.

The Vernier Software and Technology Company were known to be one of the largest suppliers of digital probes that assisted in recording and manipulation of laboratory data. The computer program called Logger Pro from Vernier Software and Technology enabled students to view data graphically, compare hypotheses, and perform statistical analyses. This program was incompatible with the popular and common screen reader used by VILs, JAWS. In order to make the probes (from Vernier Software and Technology) accessible to VILs, new scripts were written for the program (Logger Pro - version 3.5) and screen reader (JAWS -7.0 and 8.0). The hot keys created for navigating through Logger Pro features are depicted in Figure 2.9 below.

JAWS/Logger Pro Hot Key Assignments on Computer Keyboard	
[CONTROL] + [SHIFT] + [S]	Announces all sensors on the status bar sensor line
[CONTROL] + [SHIFT] + [*probe number 1, 2, 3…etc.*]	Announces real-time probe reading based on number-designated probe (found on sensor line)
[CONTROL] + [SHIFT] + [*probe number twice quickly*]	Allows user to set time interval for announcement repetition
[SPACE]	Starts and stops data collection
[CONTROL] + [SHIFT] + [A]	Announces all objects on computer screen; once JAWS announces "table," press [ENTER] to access collected data values. [CONTROL] + [TAB] will then announce real-time readings

Figure 2.9 Hot keys generated using JAWS script for VILs (Supalo *et al*., 2007)

JAWS had the ability to transfer the text to a refreshable Braille display, a device with a matrix of Braille cells. The matrices displayed characters per line of text in rows on the computer screen. VILs could monitor the applications and the probes that were active simultaneously and in real-time. A Braille embosser was used for converting graphical data to raised-line format.

This tool was evaluated by VILs in Wisconsin (Supalo *et al.*, 2007). The VILs reported that the digital probes enabled them to measure temperature, pH and voltage accurately and the dropcounter digital probe assisted them in accurately controlling the rate at which one solution could be mixed with another. The authors stated that this tool was developed to enhance the problem-solving skills of VILs and to promote their interest in Engineering (Supalo *et al.*, 2007).

2.3.9 ICT TOOL 9: Teaching VB

Graphical user interface (GUI) is an interface through which users interact with eletronic devices or applications using visual indicators (icon,menu, etc.) (Khan and Bhat, 2014). Operating systems that support GUIs are preferred over the command line operating system because users need not memorise any commands to perform tasks (Kholil and Wahyudin, 2018). GUIs are also user-friendly and easy to use (Galitz, 2007). GUIs can be created using Visual Basic programming language (Hassan, Matthew Sunday and Jimoh, 2006). The most important object in Visual Basic is a form, but, to even create a simple form with a single button requires the programmer to specify the height, width and position of the buttons in pixels, which is challenging for VILs. Students who are enrolled for Engineering streams like Information Technology, Computer Science, etc., have to learn to design and implement GUIs in their courses. VILs suffer a serious disadvantage because of the visual nature of the content. Visual Basic is a commonly used integrated development environment (IDE) by software developers to design forms.

Franqueiro and Siegfried (2006) conducted a study in New York to assist VILs in creating **GUI-based applications**. The authors developed a scripting language for

VILs with the motive of assisting them by defining the Visual Basic GUI forms and their components verbally. The form was divided into a series of rows or a series of columns with every object being placed sequentially in a row or column. In order to position the object, the form was organised into a 3x3 grid. The positioning used terms like Left, Centre or Right, followed by the terms Top, Middle or Bottom. The size of the object was determined by the number of lines of text. This assisted VILs in specifying the position and size of an object which otherwise they would have struggled to do by manually specifying the height of the object in width and height. An example of the Visual Basic script developed by the authors is shown in Figure 2.10 below. It clearly indicates that the form was organised into rows with horizontal sections.

```
Form frmSample3
Location = Bottom Left
Caption = "Sample 3"
Organization = rows
Section
  DriveListBox Drive1
  End
  DirListBox DirLB1
    Height = 3
    Width = medium
  End
End ' Section
Section
    Frame fraTest
    Caption = "This is a test frame"
    Optionbutton optOne
      Caption = "This is opt one"
      Visible = true
    End ' Optionbutton
    Optionbutton optTwo
      Caption = "This is opt two"
      Visible = true
    End ' Optionbutton
  End ' Frame
End ' Section
End ' Form
```

Figure 2.10 Form script example (Franqueiro and Siegfried, 2006)

The form generated by the above script is shown in Figure 2.11 below.

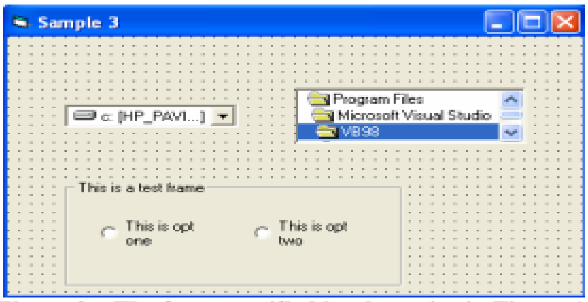


Figure 2.11 Form specified by the author's script (Franqueiro and Siegfried, 2006)

Franqueiro and Siegfried (2006) claim that the scripting language developed in their study has proved to be satisfactory to VILs as it assists them in creating GUI based applications. The literature review conducted within the limits of the researcher indicates that currently there is no evidence that shows that this tool has been assessed or evaluated.

2.3.10 SUMMARY OF ICT TOOLS FOR VILs

Table 2.1 summarises the ICT tools presented above with the subjects that these tools can be used in order to assist VIL in their learning.

Table 2.1 ICT tools for VILs in Engineering

ICT Tool	Discipline	Engineering Subject Example
iNetSim	IT	CCNA
PRISCA	IT, Computer Science	Software Engineering
AudioMath,i-Math, MathPlayer and Math Genie	All	Mathematics
MoodleVox	All	All
Audio visual tool for Java	IT, Computer Science	Computer Science, Programming in Java, Technical Programming
Haptic devices for robotics	Computer Engineering, Mechanical and Mechatronics Engineering, Electrical Engineering	Computer Integrated Manufacture and Robotics
Logger Pro	All	Chemistry Engineering Physics
VB scripts for GUI forms	IT, Computer Science, Mechanical and Aeronautical Engineering	Graphical User Interface Design

This section presented the literature on various ICT tools used for VILs in Network Engineering, Software Engineering, Mathematics, Science, basic computer skills, GUI-based application, robotic programming, Java programming and E-learning. Even though a few studies indicated no evidence regarding the assessment of the proposed tools in their study, the majority of the tools discussed in the literature were assessed and modified based on feedback received from VILs.

The literature review further indicated that ICT tools can play an important role in implementing inclusive education by stimulating the learning process of VILs through easy retrieval and sharing of information (Eguavoen, 2016; Silman, Yaratan and Karanfiller, 2017). Therefore, in order to assist the provision of VILs in Engineering, it is important to identify the appropriate ICT tools that could assist them in Engineering subjects (Borg, Lindström and Larsson, 2009; Grönlund, Lim and Larsson, 2010). If VILs are assisted with proper tools, they could make significant contributions in Science, ultimately increasing their interest in subjects that are essential for Engineering.

2.4 ADDITIONAL ICT TOOLS FOR VILs

In the previous section, ICT tools were discussed that could be used in assisting VILs in Engineering courses. This section discusses popular or common ICT tools that could assist VILs in education generally (Moreland, 2015), regardless of the course they choose at universities.

2.4.1 ICT TOOL 1: Video Magnifier

VILs struggle to perform their daily tasks due to lack of eyesight (Virgili *et al.*, 2018). By providing VILs with low vision devices and training them on these devices may assist them to perform their daily tasks independently (Massof, 1998). Students in higher education institutions are required to use **computers** throughout their course. Their assignment may be posted on a learning management system and sometimes they are required to give online tests for their courses. Partially sighted learners may require an assistive tool that can enlarge the text on the screen to compensate for their low vision capabilities.

Low Vision Devices such as video magnification or Hand-Held Magnifier (Moreland, 2015) use a stand-mounted or hand-held video camera to enlarge an image onto a television (TV) screen, or a computer monitor (American Foundation, 2019). Video magnifiers assist VILs to perform their reading tasks efficiently, and reports indicate that this tool has significantly improved their quality of work (Humphry and Thompson, 1986; Virgili *et al.*, 2018). This visual aid assists partially sighted learners in improving their visual performance (Virgili *et al.*, 2018). Video magnifiers can also enlarge printed text, thereby assisting VILs to read the printed notes provided by their lectures. Figure 2.12 shows an example of a video magnifier. The figure presents Merlin LCD desktop video magnifier that can assist VILs to read and write. Hand-held video magnifiers are also popular and convenient to use for VILs. A hand-held video magnifier is shown in Figure 2.13.

Figure 2.12 Video magnifier (Enhanced Vision, 2019)

Figure 2.13 Hand-held video magnifier (Arkansas Eye Care, 2019)

2.4.2 ICT TOOL 2: Perkins Brailler

Totally blind learners use Braille for **reading and writing** (Khochen-Bagshaw, 2011). Braille code uses a set of raised dots that can be read using finger tips (Shivakumarl and Rajasenathipathi, 2013). The dot positions determine the letters of alphabet. Low-vision aids like video magnifiers may not prove useful to totally blind learners as low-vision aids can be effective to learners who have a certain degree of eyesight (Conn, Rakel and Bope, 2001). Therefore, these learners require their subject content to be in Braille format. The Perkins Brailler is a "Braille typewriter" with keys that correspond to the six dots of the Braille code, line spacing key and backspace key (ATWiki, 2012). Writing Braille code was a tedious and expensive process before the Perkins Brailler was introduced. Study material, examination papers and other resources should be provided to totally blind learners in Braille format. The Perkins Brailler enabled the easy creation of Braille documents for this purpose. A Perkins Brailler is shown in Figure 2.14 below.

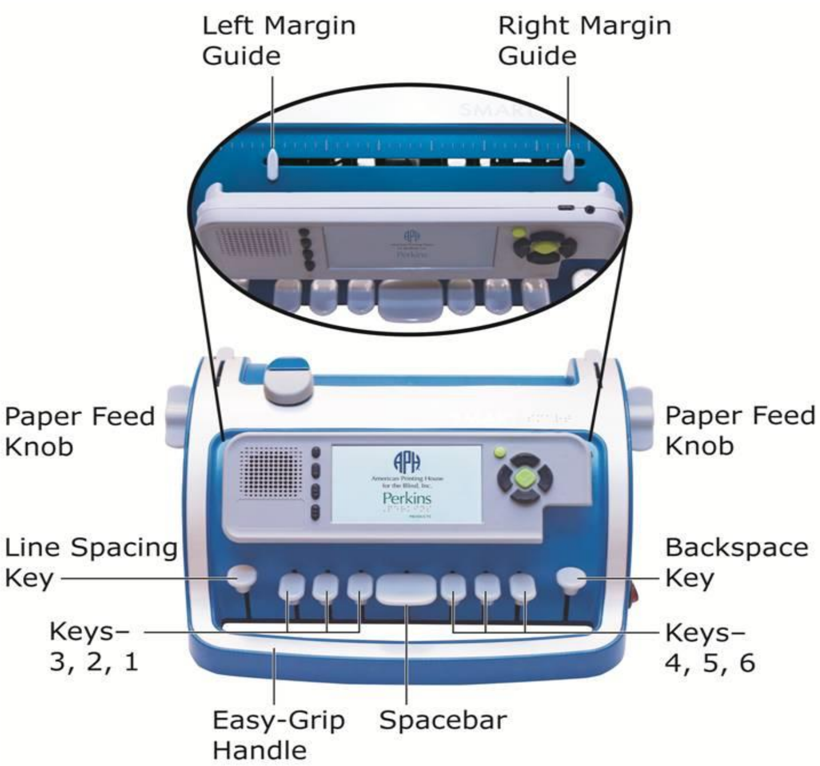


Figure 2.14 Perkins Brailler (The American Printing House for the Blind, 2017)

2.4.3 ICT TOOL 3: Electronic Braille Note / Note Taker

Electronic Braille Notetakers are personal digital assistants that can be used by VILs to **take notes** in class. It uses the input from either a Braille (output from the Perkins Brailler) or a QWERTY keyboard, or both (Moreland, 2015; Linda *et al.*, 2018). These Notetakers can be used to store notes, books and other resources and the stored content is accessed by the user through speech output (American Foundation for the Blind, 2019). Some Braille notetakers have the capability of producing refreshable Braille displays. Notetakers help to keep track of information (for example appointments, contact numbers, etc.) and eliminate the need for sorting and maintaining the printed resources (American Foundation for the Blind, 2019). Figure 2.15 below shows a Braille Notetaker.

Figure 2.15 Braille Notetaker (Boundless Assistive Technologies, 2019)

2.4.4 ICT TOOL 4: Braille Embosser

A Braille embosser is a printer that is capable of **rendering text** as tactile braille cells (Moreland, 2015). Embossers gather data from a computer and print the data in Braille (Chowdhury *et al.*, 2018). Braille embossers also receive information from Notetakers, cell phones and coverts it to Braille format which is useful for totally blind learners (National Federation of the Blind, 2018). An embossers differ from a normal ink printer because it embeds raised dots on Braille paper which can be read by VILs using fingertips. However, embossers have certain drawbacks (Braille Works, 2018).

It has to use special heavyweight paper for printing Braille documents; therefore, it is expensive than normal printers (Chowdhury *et al.*, 2018). As discussed in the previous section, totally blind learners require documents to be in Braille format. Therefore, this tool may prove useful for totally blind learners. Figure 2.16 below shows a Braille embosser.

Figure 2.16 Braille Embosser (Humanware, 2018)

2.4.5 ICT TOOL 5: Slate and Stylus

The slate and stylus are assistive tools used by VILs to **render text** that they can read without assistance (Kalra, Lauwers and Dias, 2019). It is used for Braille character encoding. It is the oldest tool that is used for Braille writing (Kway, Mohd Salleh and Majid, 2010). It is inexpensive, portable and easy to use.A slate and a stylus assist VILs to take down their lecture notes independently without support (Cheadle, 2007).Since the dot positions determine the Braille characters, the user should place the dots precisely. The stylus is used to punch the dots onto the paper and the slate assists VILs to punch the dots on the right position (Cheadle, 2007). After the introduction of the Brailler and notetakers, the use of slate and stylus gradually decreased (Blake, 2003). Researchers such as Eldridge (2005) suggest, however, that VILs should be taught how to use these devices, just as a sighted student learns how to use pen and pencil before using computers. Figure 2.17 shows a slate and stylus.

Figure 2.17 Slate and Stylus (Kalra, Lauwers and Dias, 2019)

2.4.6 ICT TOOL 6: JAWS

Screen reader is an assistive tool used by VILs that is capable of converting text into speech (Wang and Redmiles, 2017). JAWS is a popular **screen reader** used by VILs which converts content on the screen (text, image. Links, etc,) to an audio format (Molina, Ordóñez and Gustavo García Zerda, 2016). This enables VILs to easily navigate and perform tasks without assistance from other people. Keystrokes are used to perform the desired activities of the user using a QWERTY keyboard or a Braille keyboard (Moreland, 2015). VILs in universities have to access a vast amount of information in order to complete their assignments and other academic tasks. Screen readers provide a wide range of options for accessing web content. The users should be given adequate training so that they utilise all the features offered by JAWS (Verma, Singh and Kumar Singh, 2012). This is not an open source software; therefore, the licences should be purchased before installing the software on the system (Freedom Scientific, 2012).

2.4.7 ICT TOOL 7: Talking Calculator

Mathematics plays a very important role in our day-to-day lives and is applied in different sectors, like banking, architecture, etc. (Hodaňová and Nocar, 2016). It is seen that VILs struggle to learn **mathematics** due to the complex calculations (Sánchez and Flores, 2004). A talking calculator is an assistive device that helps VILs to perform mathematical calculations. It works similar to a normal calculator. The only difference is that it generates a voice output to VILs along with an enlarged LCD display (Savoie, Brugler and Bliss, 1976). The numbers and operators selected by VILs are read out loud. This assists VILs to perform mathematical tasks without assistance from other people. The result of the operation is also read out loud to the user.

2.4.8 ICT TOOL 8: Haptic Device with Computer Applications

Studies indicate that VILs use non-visual skills more efficiently than sighted learners (Hollins, 1989). Computer haptics provide VILs with additional information through the sense of touch (Darrah, 2013). This is an added advantage to VILs as they can use both sound and touch to understand the concepts taught in class better. This is especially used for subjects that have a good deal of visual content, such as **Mathematics** and **Science** (Wies *et al.*, 2000; Wijntjes *et al.*, 2008). PHANToM is an example of a haptic device that assists VILs to feel the shape of graphical functions in Mathematics (Van Scoy *et al.*, 2000). VILs can also analyse three-dimensional shapes with the help of a computer and a peripheral device called a haptic force-feedback controller (Panëels and Roberts, 2010).An example of a haptic device is shown in Figure 2.18.

Figure 2.18 Haptic Assistance Device (Schneider et al., 2018)

2.4.9 ICT TOOL 9: Tactile Graphics

Accessibility of graphics and pictures still remains a challenge even though Braille and audio translation software are available to assist VILs (Gupta, Balakrishnan and Rao, 2017). Tactile graphics are used to explain non-textual information to VILs. It can be used to explain pictures, graphs, maps, diagrams, etc. to VILs (Fitch, 2017). Tactile maps are drawings with raised surfaces that assist users to understand the graphics by touching them (de Almeida and Tsuji, 2005). The raised lines and surfaces help the student to obtain the same information that sighted people would get through observing the images, maps or diagrams (Bardot *et al.*, 2017). Tactile maps therefore assist VILs to study subjects with many graphical representations such as **Mathematics** and **Science** (Morash and McKerracher, 2014). An example of a tactile graphic is shown in Figure 2.19.

Figure 2.19 Tactile Graphics (Hasty, 2010)

2.4.10 SUMMARY OF GENERAL ICT TOOLS FOR VILs

This section presented a number of ICT tools that could assist VILs in their academic courses. ICT tools cannot eliminate the learning barriers faced by VILs completely, but ICT tools can be used by VILs to reduce some of these challenges. Accessible tools and ICT devices therefore play an important role in increasing the participation of VILs across different domains of life including education, employment and civic engagement. Table 2.2 summarises the ICT tools presented above with possible subjects in which these tools can be used in order to assist VIL in their learning.

A great many of studies have indicated that ICT has supported education (Grönlund, Lim and Larsson, 2010; Silman, Yaratan and Karanfiller, 2017). A question arises: Would inclusive education be successfully implemented by just introducing appropriate ICT tools in the institutions of SA, or are there other factors to consider?

In order to confirm this, it is essential to determine the current situation of VILs in the educational institutions of SA and identify the barriers that VILs face in higher education institutions. The next section discusses this situation.

Table 2.2 General ICT tools for VILs

ICT Tool	Application	Subject Example
Video Magnifier	Enlarges images on computer	All
Perkins Brailler	Braille typewriter-to write content in Braille format	All
Electronic Notetaker	Used for note taking (notes can be accessed through speech output)	All
Braille Embosser	Renders text as tactile braille cells	All
Slate and Stylus	Used for Braille character encoding	All
Talking Calculator	Performs mathematical calculations by generating a voice output to VILs along with an enlarged LCD display	Mathematics
JAWS	Converts content on the computer screen (text, image. links etc.) to an audio format	All
Haptic device with computer application	Assist VILs to feel the shape of graphical functions in mathematics	Mathematics, Science
Tactile Graphics	Raised lines and surfaces on tactile maps assist VILs to understand graphics (by touching them)	Mathematics, Science

2.5 CURRENT SITUATION OF VILs IN SOUTH AFRICA

SA has embraced an inclusive education policy to address the challenges faced by students with disabilities in the education system (Dalton, Mckenzie and Kahonde, 2012). However, this is not currently the situation in SA (Mutanga, 2017). Just developing policies is not enough; appropriate measures should be taken to implement them. This section discusses the current situation of VILs in special schools and tertiary institutions in SA.

2.5.1 Hodgson and Khumalo study

Hodgson and Khumalo (2016) did a study on the conditions in the Special and Full Service Schools in the Umkhanyakude District, KwaZulu-Natal. The researchers argued that inclusive education would only be possible with proper assistance from the government in redirecting the resources in terms of budget allocation and must be accompanied by investment in the human personnel who must be equipped with sufficient skills, qualifications and competencies and remunerated appropriately.

The result of this study was a product of over three years of research into barriers to accessing education for people living with disabilities in northern KwaZulu-Natal. Interviews were conducted with nearly 100 caregivers of children with disabilities between 2013 and 2015. In late 2015, principals, teachers and other staff of all three special schools and 11 full-service schools in the district were interviewed. The first serious problem discussed by the authors was that large number of children with disabilities in the poor districts did not enjoy any access to school at all. The authors also claimed that some staff members clearly stated that if they spoke openly and publicly in the interests of their learners, they would be subjected to victimisation, intimidation and disciplinary action from state employees and government departments (Hodgson and Khumalo, 2016).

The researchers argued that the results of the study reveal a wide gap between policies and reality (Hodgson and Khumalo, 2016). According to SA's Constitution and the High Court judgment in 2011, learners with intellectual disabilities must be ensured proper accommodation regardless of the expense to educate these learners. While Umkhanyakude District ensured that this policy was being implemented, learners with intellectual disabilities struggled to attend special schools around this area. They had to travel outside the district for schooling. Also, there were not sufficient high schools for VILs in the district in order to accommodate all learners with disabilities. It was also noted during the study that special school teachers struggled to teach the curriculum because they were hired without the requisite skills to teach learners with varying barriers to learning, which results in a very low pass rate. Furthermore, a lack of trained house mothers was noted that resulted in learners being mistreated by the volunteer house mothers in the residences (Hodgson and Khumalo, 2016). A lack of dedicated professional staff, of proper infrastructure and access to basic services, of proper funds for the schools, of proper transport facilities, and ineffective support structures, were some of the challenges identified in this study.

2.5.2 Matshedisho study

Matshedisho (2007) did a study on the status of support services in South African higher educational institutions for the provisioning for disabled students. Furthermore, a comparison was done between these support provisions with those offered in the UK and the USA. The findings were based on a national survey which included higher educational institutions. Twenty-four institutions responded to the questionnaires where the findings revealed that the provision of support for disabled students in SA followed a contradictory path to that of other countries. The author stated that this was due to the lack of commitment to disability issues by government and by the management of tertiary institutions. A lack of funding for DUs in SA was one of the major factors identified that affected the provision of disabled students. It was difficult for the DU staff to assist VILs without enough financial assistance from the management and government. DUs also stated that the funding for disabled students should be similar to that for previously disadvantaged students. Lack of resources, policy and commitment to real disability rights will continue to hinder SA from following the path of other countries.

The author suggested a few recommendations in order to improve the support in SA (Matshedisho, 2007). They are as follows:

- Disability in SA should be explored by the Department of Health (DoH) and Statistics South Africa by conducting a survey on the disabled People in SA;
- Tertiary institutions should conduct surveys of their student profiles to identify the students with disabilities;
- The Department of Education (DoE) should formulate a disability policy for higher education institutions in SA; and
- Funding should be provided equally to all students irrespective of their race and gender.

The authors reported that the challenges faced by DUs and the lack of political commitment to disability issues by government and higher education management affect the provision of VILs in higher education institutions (Matshedisho, 2007). Therefore, the author suggests that there is a need for a disability policy for higher education institutions in order to address the challenges faced in inclusive education in SA.

2.5.3 FOTIM Report

The Disability in Higher Education Project was mandated by the Foundation of Tertiary Institutions of the Northern Metropolis (FOTIM) in 2011 to conduct an exploratory study with the aim of describing and analysing the role and function of these specialised DUs at the different tertiary institutions in SA. FOTIM is a higher education academic consortium in SA. VILs from higher education institutions were interviewed and provided with questionnaires. The FOTIM report indicates that the ratio of disabled students is roughly estimated to be less than 1% of the total student population at the Higher Education Institutions (HEIs). Some of the findings of this study are as follows:

- Disability issues are still managed in a fragmented way in many universities with DUs;
- There is a lack of strong policy to support students with disabilities at higher education institutions;

- The National Disability Policy and Strategy Framework for HEIs should contain long- term objectives and the management at every HEI should take responsibility to implement the policies;
- Most DUs are understaffed and insufficient funds allocated for functioning of the DUs;
- Some of the DUs do not have sign language interpreters;
- Inadequate accommodation facilities for learners;
- There is a lack of accessible learning materials and inadequate infrastructure;
- There is also a lack of awareness about disability issues among the staff;
- Staff are not trained in teaching resources, teaching methodologies and curricula; and
- There should be workshops to assist learners to develop interpersonal skills and to develop the right attitude for disabled students.

The study indicated that DUs have minimal autonomy and direct communication with university management (FOTIM, 2011). Additional challenges indicated in this study were lack of accessible office space, inadequate staff, and lack of commitment from management and academic staff to address the issues of disabled students.

2.5.4 Lourens and Swartz study

Lourens and Swartz (2016) did a study on the experiences of VILs at universities in the Western Cape, SA. The experiences of VILs helped the researcher in understanding the current situation of VILs in South African universities. The data for the study were collected using interviews and focus group discussions with VILs. The findings from the study are as follows:

- VILs have difficulties to transition from school to university and adapting to the new environment;
- VILs lack of self-confidence;
- Most VILs felt excluded and left out by their universities;
- There is a lack of awareness about disability issues by the lecturers;
- There is also a lack of adequate resources to assist VILs in their academics.;
- VILs struggle to cope with the workload and responsibility at universities;

- There is a lack of communication between DUs, management and academic staff;
- A lack of mobility services for VILs on campus;
- A lack of accessible learning materials; and
- A lack of safe accommodation facilities.

The participants also indicated that they had to take a lot of responsibility to manage their academic and social life as they received inadequate support from the university (Lourens and Swartz, 2016). Despite the inclusive education policies, VILs were still excluded from tertiary education.

2.5.5 Naidoo study

Naidoo (2010) did a study on the perceptions and experiences of students with disabilities at the University of KwaZulu-Natal: Howard College Campus regarding the function of the university's DU. The objective was to explore the effectiveness of DUs from the perspectives of students'. A semi-structured interview was chosen for the study, and the results indicated that inadequate staff, resources and funding, and a lack of awareness regarding the social and academic needs of the disabled students were the major challenges. All participants indicated that understaffing in DU affected the academic lives of students with disabilities. The staff in DU could not provide adequate support to all the students. The participants also reported that the universities had inadequate trained academic staff to assist them. There was inadequate equipment to educate the students in their academic courses. Insufficient fund was raised as the most important challenge that affected the provision of disabled students.

The participants also pointed out that they did not receive proper counselling services (Naidoo, 2010). Therefore, the students had to deal with a great amount of emotional stress, and sometimes it was difficult for them to cope with this great deal of pressure. The students suggested that the university should ensure that the student counselling centre is functioning properly. Apart from this, the lecturers in the university should also be aware of their disability issues and should ensure that the students receive their learning resources well in advance. The students with disabilities indicated that they observed lack of coordination between the financial aid office and the DU as well as between the different subject faculties and DU. The researchers stressed the important of proper coordination of DU and other academic departments in the university. Adequate support should be given to the DU so that it can improve the student support services extended to the students with disabilities.

2.5.6 Mayat and Amosun study

Mayat and Amosun (2011) did a study to gain some insights on the perceptions of academic staff towards admission of students with disabilities, and their accommodation once accepted into an undergraduate Civil Engineering programme in a South African university. Academic staff were interviewed, and the findings revealed that students with disabilities were accepted in Engineering courses as a result of the ongoing efforts of DUs to increase awareness about disability issues within the university.

The initiatives taken to enrol students could be considered as a positive move as this would benefit the students with disabilities. However, the authors indicated that there was no evidence to indicate that this initiative was taken out of the willingness or awareness of academic staff about disability issues (Mayat and Amosun, 2011).The authors further stated that the limited knowledge of academic staff about disability and disability issues might be because of the limited contacts and interactions they had with people with disabilities. While conducting the study, the authors were shocked to see that the participants (academic staff) were only aware of a limited number of disabilities. This raised a concern regarding the preparedness of the Engineering departments for the students with different types of disabilities. The educational tools and resources required for students with disabilities vary depending upon their disability.

The students should be aware during the selection process about the resources available in the department that can cater for their needs. According to the authors, these issues should not be dealt with after the students are enrolled in an Engineering course (Mayat and Amosun, 2011). Limited knowledge about disability can prove to be dangerous for students with disabilities. Negative attitude and misconceptions of the community and society about disability and disability issues would adversely affect the academic and personal lives of students with disabilities. The authors reported that such negative attitude is the main challenge that affects the accommodation of students with disabilities in the Civil Engineering program.

2.5.7 Other Related Studies

Mushome and Monobe (2013) did a study on the attitude of lecturers towards VILs at a university in the Limpopo Province. The importance of teaching methodologies, strategies and assistive resources were stressed in this study. The researcher noticed that even though VILs were being registered in universities, there was no indication regarding whether the staff members were trained to educate VILs. The findings of the study indicate that there was inadequate training provided to staff and VILs before commencement of classes; lecturers were not aware of different disabilities and disability issues. The authors reported that the negative attitude from the lecturers affected VILs emotionally and academically. The authors considered that the lack of resources in the university was an indication of the negligence of the university towards VILs.

Nkoane (2006) did a study to analyse the barriers that students with disabilities face in HEIs in the Free State Province. Questionnaires and interviews were used to collect data. The participants for the study were academic staff, support staff, management, and students with disabilities. The participants indicated that there was not adequate representation of students with disabilities on the bodies responsible for policy making. The findings also indicated that there has been little emphasis in the higher education sector when it comes to recruitment of blind students because most institutions do not have policies on issues relating to special educational needs. Students with disabilities feel excluded because of physical environmental arrangements and lack of proper structures and practices.

Chiwandire and Vincent (2017) did a study to assess the accessibility of buildings in South African public universities. The policies in SA state that higher education institutions in SA must ensure easy accessibility for all learners to educational facilities. This study was conducted to investigate the extent to which this policy is being implemented in SA. Semi-structured interviews with DUs was conducted in 10 public universities in SA. The participants indicated that in order to preserve heritage and old buildings, the universities were reluctant to modify the buildings to increase accessibility. Ad hoc approaches were required to improve accessibility to toilets, libraries and transport facilities. The authors reported that universities in SA were still not places that encouraged social interaction of students with disabilities. The authors suggested that South African universities need to adopt a systemic approach to implement inclusive education. The authors further reported that there was a need to prioritise the accessibility of the physical environment regardless of the costs involved so that barriers to full participation of students with disabilities would be eliminated.

Inclusive education can be implemented only when students, regardless of their disabilities, have access to high quality instruction and support offered in the institution (Bui *et al.*, 2010). The idea of inclusive education gained international recognition during the World Conference on Special Needs Education which was organised by UNESCO and the Ministry of Education and Science of Spain in Salamanca (Prinsloo, 2001). Since then, the Salamanca statement has been taken as reference while formulating policies on inclusive education in many countries of the world, including SA (Ainscow, Slee and Best, 2019). The Salamanca statement stated that special needs students should be considered as a part of mainstream educational institutions and by implementing this into practice, an effective inclusive cost-effective educational system can be built (UNESCO, 1994).The legislation and policies in SA protect the rights of people with disabilities and promote their advancement (Republic of South Africa, 1998; Pieterse, 2000). Despite these policies, in reality it is observed that people with special needs are not always included in higher educational institutions in SA (Carrim, 2002).

2.5.8 Addressing the Gap in Literature

Literature indicates that despite having policies on inclusive education , students with disabilities are often being excluded from higher education in SA (Carrim, 2002; Department of Education, 2008). VILs require a lot of support from the academic insituttions to complete their studies. This support is required especially during the first year when they transition from school education to tertiary education. Fotim Report (2011) mentions that the DUs who are responsible for assisting students have minimal autonomy and direct communication with university management. This may adversely affect the effective functioning of these units. Some of the challenges that affected the participation of VILs in higher education identified from the literature include lack of funds, lack of trained staff, negative attitude of fellow non disabled leraners, educators and institutions etc. (Tinklin, Riddell and Wilson, 2004; Rajohane Matshedisho, 2007; Obiozor, Onu and Ugwoegbu, 2010; FOTIM, 2011; Mayat and Amosun, 2011; Zisser, 2011; Khumalo and Hodgson, 2017).

Literature also points out that VILs are under-represented in Engineering courses compared to other courses (Mayat and Amosun, 2011). The studies mentioned in the literature have identified a number of challenges faced by VILs in higher education in general. The question arises "Are these the only challenges experienced by engineering students in SA, or are there other challenges to consider? This study verifies and adds to the identified challenges faced by VILs in SA by conducting a case study at school and university level. The perceptions of VILs at special schools of Free Stae province, educators at special schools of Free Stae province, DU staff at public universities in SA and senior engineering academic staff at public universities in SA were collected in this regard.

Engineering courses are very technical and hands-on compared to other courses such as Management or Education. The technicality of these Engineering courses is what makes them very challenging and difficult for all stakeholders to teach and learn. Therefore, the ICT teaching tools used in Engineering courses may be different from ICT teaching tools used for other courses. Section 2.3 in this thesis discusses ICT tools that could be used in assisting VILs in Engineering courses. Some popular or common ICT tools that could assist VILs in education were also discussed in this thesis (Section 2.4). Literature indicates that lack of proper identification and utilization of ICT tools restricts the access of VILs to academic courses. The role of ICT tools becomes more important for technical courses like engineering. This study has identified a few ICT tools that could assist VILs in certain engineering subjects. Similarly, if the appropriate ICT tools are identified for every engineering subject (for example, fluid mechanics, state space design for control, mechatronics, mine surveying, construction technology, control systems, electronic communications), it would assist the provision of VILs in all engineering courses.

Would inclusive education be successfully implemented by just introducing appropriate ICT tools in the institutions of SA, or are there other factors to consider? The studies metioned in this thesis (Section 2.5.1 to Section 2.5.8) indicates that there are many barriers that affects the participation of VILs in the higher education institutions of SA. The exclusion of VILs in institutions of higher learning in SA may be related to lack of an effective framework to guide faculty members to care for VILs in their classes. This study therefore aims to develop a framework relating to teaching Engineering courses to VILs in higher education using ICTs.

2.5.9 List of factors identified from literature

Some of the key challenges for the provision of education for VILs identified from the literature are lack of resources, inadequate infrastructure, lack of financial support, lack of awareness about disability issues among staff, students and management and negative attitude of academic staff towards these students. Table 2.3 lists these factors that were presented by Tom, Mpekoa and Swart (2018) in a conference paper presented at the ICTAS conference in Durban.

Table 2.3 Factors that affect the provision of VILs in higher education (Tom, Mpekoa and Swart, 2018)

Factor	(Hodgson and Khumalo, 2016)	(Matshedisho, 2007)	(Fotim, 2011)	(Lourens and Swartz, 2016)	(Naidoo, 2010)	(Mayat and Amosun, 2011)	(Mushome and Monobe, 2013)	(Nkoane, 2006)	(Chiwandire and Vincent, 2017)	(Lyner-Cleophas *et al.*, 2014)	(Tinklin, Riddell and Wilson, 2004)	(Şimşek, Altun and Ateş, 2010)	(Tugli *et al.*, 2013)	(Johnson, 2006)	(Obiozor, Onu and Ugwoegbu, 2010)	(Zisser, 2011)	(Howell, 2006b)	(Ntombela and Soobrayen, 2013)
Negative attitude of fellow non-disabled learners, educators and institutions			X			X	X		X		X			X	X	X		
Lack of awareness about disability issues among the staff, students and management			X	X	X	X		X	X	X								
Minimal autonomy of DUs			X							X								
Inadequate Infrastructure	X	X	X				X		X		X			X			X	
Lack of financial support/funding	X	X	X		X			X										
Lack of access support services	X												X					

Factor	(Hodgson and Khumalo, 2016)	(Matshedisho, 2007)	(Fotim, 2011)	(Lourens and Swartz, 2016)	(Naidoo, 2010)	(Mayat and Amosun, 2011)	(Mushome and Monobe, 2013)	(Nkoane, 2006)	(Chiwandire and Vincent, 2017)	(Lyner-Cleophas *et al.*, 2014)	(Tinklin, Riddell and Wilson, 2004)	(Şimşek, Altun and Ateş, 2010)	(Tugli *et al.*, 2013)	(Johnson, 2006)	(Obiozor, Onu and Ugwoegbu, 2010)	(Zisser, 2011)	(Howell, 2006b)	(Ntombela and Soobrayen, 2013)
Lack of trained staff	X	X	X		X		X	X										X
Lack of assistive resources, equipment and tools		X	X		X		X	X			X		X	X	X	X	X	
Curriculum not designed to the needs of VILs			X		X													
Lack of policies								X				X						
VILs struggle to meet the course requirements						X												

2.6 SUMMARY

This chapter has presented an outlook on the current situation of VILs in SA. A detailed literature review was conducted on studies regarding the challenges and barriers faced by VILs while contemplating entry into higher education. Various types of ICT tools and assistive tools for Engineering courses were discussed in this chapter. These tools include iNetSim, PRISCA, AudioMath, i-Math, MathPlayer, Math Genie, MoodleVox, Audio visual tool for Java, Haptic devices for robotics, Logger Pro and VB scripts for GUI forms. Apart from these tools, a few popular ICT tools were also presented in this chapter. These tools include Video Magnifier, Perkins Brailler, Electronic Braille Note, Braille Embosser, Slate and Stylus, JAWS, Talking Calculator, Haptic Device with Computer Applications and Tactile Graphics. Some of the challenges or barriers to inclusive education that has been discussed from the literature are inadequate funding for VILs at higher education institutions, inadequate training facilities for staff to educate VILs, poor infrastructure in South African higher education institutions, lack of awareness about disability issues among staff, students and management, lack of a framework that can assist institutions to plan and accommodate VILs in higher education etc.

The next chapter, Chapter 3, discusses the research methodology utilised to achieve the main goal for this study.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research design process for the development of a framework for VILs in universities in South Africa. This chapter discusses the methodology used while undertaking this study that was chosen based on the objectives of the study. The various stages of the research, which includes strategy, design, methodology, data collection and analysis processes, are also described in this chapter.

Section 3.2 discusses paradigms used in this study from a human computer interaction (HCI) perspective. In section 3.3, the research process of the study is discussed in detail. Section 3.4 presents the research design with its different stages. The ethical considerations for the study are mentioned in section 3.5. The summary of the chapter is presented in section 3.6.

3.2 HUMAN-COMPUTER INTERACTION

Computers have become an essential part of everyday life. They are a vital tool used by people from different fields (such as. doctors, engineers, government officials, teachers, students) for accessing information and for performing their daily tasks (Tosun and Baris, 2011). Technologists have constantly been researching different ways to improve the design and implementation of the interactive systems (computer systems) in order to provide the users with a good user experience (Hassenzahl and Tractinsky, 2006). This motivated the development of a cross-disciplinary research area which is known as Human Computer Interaction (HCI) (Carroll, 2003). HCI can be defined as a multidisciplinary area (for instance, cognitive science, Engineering, sociology, ergonomics, ethnography, design.) that deals with the design, implementation and assessment of computing devices for human use (Lester, 2008). HCI is considered effective if the computers are user- friendly and capable of responding to the user’s needs (Bansal and Khan, 2018).The main goal of HCI is to build usable and functional interactive systems while considering the needs, capabilities and interests of the users interacting with the system.

HCI is a vast field and has varied applications. There is a wide scope for HCI research as it encompasses different fields such as computer science, engineering, psychology, cognitive science etc. Because of the interdisciplinary nature of this field, knowledge from different fields contribute to different views in HCI research (Duarte and Baranauskas, 2016). HCI research contributions can be classified into 7 types: empirical, artifact, methodological, theoretical, dataset, survey and opinion contributions (Wobbrock and Kientz, 2016). HCI research started in the 1980s to study the interaction of people with simple automation programs (Shneiderman, 1983; Norman, 1986). Graphical user interface and usability engineering started to take hold in late 1980s and early 1990s (Lazar, Feng and Hochheiser, 2017). In the mid-1990s, there was a shift in HCI research as the Internet started gaining importance (Liu *et al.*, 2014). From 2000 onwards, HCI research shifted towards user generated information (Buxton, 2007) and then on emotion, collaboration, accessibility and communication (Liu *et al.*, 2014). Today, HCI research not only focuses on whether users like a technological device but also on the environment in which that device will be used (Lazar, Feng and Hochheiser, 2017).

Studies indicate that there are three HCI waves (Harrison, Tatar and Sengers, 2007). The first wave focuses on engineering, human factors, interaction and ergonomics (Harrison, Tatar and Sengers, 2007). The second wave of HCI arises from cognitive science revolution (Norman, 2013). This wave emphasises more on theoretical issues while the first wave emphasised practical results. The third wave of HCI considers different areas like culture and values and gives importance to the researcher's viewpoint (Bødker, 2006). These paradigms or waves can co-exist and researchers can work in multiple areas within HCI. HCI also draws a broad variety of approaches, such as user-centered design, participatory design, human-centered design etc. (Sanders, 2002; Gasson, 2003). Participatory design is an approach that encourages the participation of all stakeholders in the design of a hardware or software product (Dell'Era and Landoni, 2014) while in a user-centered design, designers design an interface or a service while considering the needs of the user (Dearden *et al.*, 2007; Nielsen and Majgaard, 2013). Human-centered design considers the human preferences (physiological and emotional aspects) along with the technical requirements of the users during the design process (Gasson, 2003). According to

Shneiderman *et al.* (2016), traditional approaches may have to be complemented with intense and rigorous case studies in solving complex socio-technical problems.

HCI does not only deal with generic user experience and usability, but also focuses on improving accessibility for VILs, the elderly and physically impaired to ensure that all people, regardless of their disabilities, receive the same experience while interacting with computers (Noirhomme-Fraiture *et al.*, 2019). Accessibility is the practice in which environments are physically, psychologically and socially designed to promote equal interaction for all users despite their individual characteristics (Giles-Corti and Donovan, 2002). Accessing content from computers has been a concern for VILs for decades (Muller *et al.*, 1997), while accessing web pages can be problematic for VILs (Oppenheim and Selby, 1999). The user interfaces should be built in such a way that it is usable for people with varied disabilities and skills (Stephanidis, 2001). However, the situation has changed somewhat with the advent of assistive devices or ICT tools (screen readers, speech recognition software, etc.) that assist VILs to access content from a computer (Iglesias *et al.*, 2004).

Despite the availability of accessible resources, many websites are still not accessible (Lazar *et al.*, 2003). Lazar, Dudley-Sponaugle and Greenidge (2004) introduced a Web Accessibility Integration Model that highlights the accessible and inaccessible in a website. Studies conducted by researchers like Lazar, Feng and Hochheise (2017) focus on web, Information Technology and digital accessibility for people with disabilities. Due to increasing concern regarding the accessibility issues, HCI researchers assert that the user interfaces should be designed to be accessible to VILs (Han *et al.*, 2018).

The main objective of this study is to develop a framework for the provision of VILs in Engineering education using ICTs in SA. In this study, the researcher identified ICT tools and assistive devices that would assist VILs in Engineering courses. VILs require a great deal of assistance in accessing information. ICTs have revolutionised the education sector by changing the way in which people can access, handle and exchange information, and are therefore considered as a means of improving the teaching-learning process (Mikre, 2011). The introduction of ICT in education has created a positive impact on the lives of disabled people with regard to the use of information (Eligi and Mwantimwa, 2017). It can be used as a primary tool for VILs to bridge the gap between the classroom and the rest of their world. In fact, ICT is both a medium and a powerful tool in supporting inclusive education of VILs (ICT Accessibility Progress Report, 2010). In this study, the researcher investigated different technologies that can allow VILs to access their academic content using computers more efficiently. Hence, this study falls under the HCI domain. The next section describes the different paradigms within the HCI discipline.

3.2.1 Research Paradigms within the HCI discipline

The term 'research paradigm' refers to a way of describing the scientific revolution in a particular field of study (Harrison, Tatar and Sengers, 2007). According to Kuhn(1962), a paradigm in the HCI context should contain the following components:

- General understanding of the principal properties of interaction;
- Kind of questions that assists in understanding those properties of interaction;
- Techniques which can be used to provide reasonable answers to those questions; and
- Good understanding of how to interpret the output of those techniques.

There are several paradigms within the HCI discipline. This section discusses the traditional science approach, adaptive management paradigm, economic paradigm, design science and Engineering approach.

3.2.1.1 Traditional Science paradigm

A traditional science paradigm approach is used on small data sets that is gathered and analysed by a researcher with the motive of acquiring new information (Peters *et al.*, 2014). The process of attaining new knowledge in this paradigm might take a long time. It focuses on the facts recorded by the researcher after observations and experiments have been recorded and it is a hypothesis-driven approach. Quantitative data is often collected and is evaluated using simulation models (Pather, Erwin and Remenyi, 2003). Engineers reach conclusions based on the inferences from experimental findings (Peffers, 2006). This approach is not suitable to address complex Engineering problems (Hamilton *et al.*, 2013).

3.2.1.2 Adaptive Management paradigm

An adaptive management paradigm is also known as resilience Engineering or adaptive Engineering (Hollnagel, Woods and Leveson, 2006; VanderSteen, 2011). This paradigm is built on experimentation and continuous revision of policies. A researcher has to deal with many uncertainties while continuously revising strategies and policies (Manley *et al.*, 2000). This approach is widely used in many disciplines,for instance economics, social sciences, and Engineering (National Research Council, 2004). According to Williams, Szaro and Shapiro (2009),adaptive management is an approach that is used for improving the management of resources by thoroughly analysing the management outcomes. This paradigm focuses on involving the community and conducting cross-cultural educational research (Aikenhead, 1997). Adaptive management paradigm is not suitable for studies where decisions have to be made on a large geographical scale (such as environmental decision-making) (Biber, 2014).

3.2.1.3 Economic Paradigm

It is important for researchers in an Engineering discipline to have knowledge about economic fundamentals, as it assists them to link both technology and economics to solve Engineering issues (Merino and Rana, 2004). The choice of tools and technology to be used in a study depends on the researcher's proficiency in Engineering and economics. Engineering curricula include statistics, economic theory, econometrics, etc. (Ashford, 2004). Growth in economy is not just about accumulation of capital, but also an improvement of innovation capacity by gathering appropriate knowledge. Innovation is the collaboration of technology, knowledge, policies and systems (Hoque, 2013). This paradigm is not suitable for addressing moral, psychological and sociological issues (Jacobs *et al.*, 2017).

3.2.1.4 Design Science

Design science is a systematic approach designed to improve teaching and learning practices through a sequence of steps such as analysis, design, development, and implementation in real-world settings, thereby leading to new principles and theories (Wang and Hannafin, 2005).This paradigm involves the design of solutions or artefacts to achieve the research goals (Hevner and Chatterjee, 2010). Hevner *et al.*(2004) list the guidelines for this paradigm as follows:

- Design as an artefact;
- Problem relevance;
- Design evaluation;
- Research contributions;
- Research rigor;
- Design as a search process; and
- Communication of research

The design science paradigm has six stages: problem identification and motivation, objectives for a solution, design and development, evaluation, and communication (Peffers *et al.*, 2006).This paradigm is depicted in Figure 3.1.

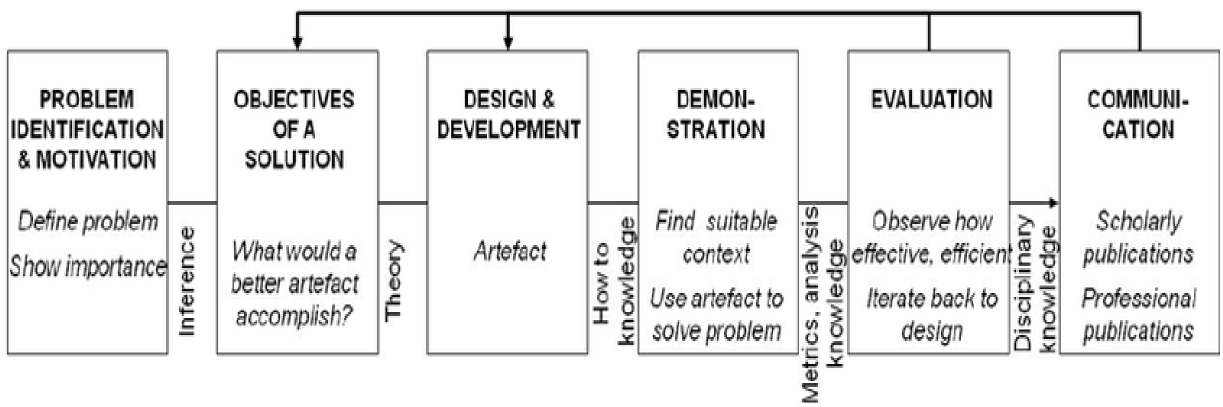


Figure 3.1 Design science research process model (Peffers *et al*., 2006)

Design science is used in many disciplines, including Engineering and Computer Science (Vaishnavi, Kuechler and Petter, 2004) in order to understand and improve human performance (Van Aken, 2005).This paradigm may not be suitable in a business environment as the technology being used by the developed artefact may become outdated within a short timespan (Hevner *et al.*, 2004). Therefore, the organisation may not receive the expected results by investing their resources.

3.2.1.5 Engineering approach

In an Engineering approach, a researcher assesses a list of possible solutions and determines the best solution (Khandani, 2005). In order to determine the best solution for a study, a researcher analyses the solutions based on a research proposal (Eder, 2008). The six steps followed by a researcher to reach the desired solution (Khandani, 2005) include:

- Define the problem;
- Generate concepts using brainstorming techniques;
- Determine the participants, time and budget;
- Design planning;
- Developing and designing the solution for the problem; and
- Release the final prototype.

An Engineering approach uses concepts from design science and from a traditional science approach (Hussain and Howard, 2012). This approach relates the research problem to a social context rather than considering it in a technical context (Liu and Yu, 2002). A researcher can utilise different methods, such as observations and experiments to study the research problem (Magee and Frey, 2007). This approach is not suitable for studies that are expected to be completed within a certain time-frame with limited funds and resources (Khandani, 2005).

3.2.2 Rationale for Design Science approach

The main aim of this study is to develop a framework for the provision of VILs in Engineering education using ICTs in SA. In Chapter 2, some of the barriers that VILs face while contemplating entry into higher education institutions as well as the ICT tools that could be used for assisting VILs in Engineering courses were presented.

The design science research paradigm was used in this study because it is suitable for education research studies that address complex research problems where there are no pre-set guidelines for the available artefacts (Van den Akker *et al.*, 2006). Figure 3.1 speaks about artefacts: this study presents a framework as an artefact. The researcher aims to systematically design and develop a framework for VILs in Engineering education based on the existing literature and feedback from the participants during the study. The design science research guidelines are applied in this study in the following ways:

- **Design as artefact**: this study aims to develop a framework for the provision of VILs Engineering education using ICTs in SA.
- **Problem relevance**: the developed framework may assist in improving academic access for VILs in South Africa.
- **Design evaluation**: the framework is to be evaluated by experts (a group of researchers who had done research in Engineering education, HODs of Engineering faculties, managers of disability centres and a VI engineer).
- **Research Contributions**: there is currently no framework that can assist institutions to plan and accommodate VILs in higher education; this is, therefore, the study's contribution.
- **Research Rigor**: rigorous methods (for example. expert evaluation of the framework) are to be used to evaluate the framework.
- **Design as a search process**: the framework is to be developed by utilising the knowledge gained from the research tools (literature review, questionnaires and focus groups) while satisfying all the laws in the research environment.
- **Communication of research**: the research outcome, i.e. the framework, is to be communicated through international conference proceedings and this thesis.

3.3 RESEARCH PROCESS

Research is a sequence of linked processes that begins with identifying the problem followed by designing the research questions and objectives (Strydom, 2014). Well-designed research questions guide the researcher to follow a systematic plan to answer these questions (Mackey and Gass, 2015). The design science paradigm was used in this study, applying the steps depicted in Figure 3.1 in the following way:

1. Problem identification and motivation

The research problem and justification for the study is defined at the initial stage of the study. Providing the justification for the study motivates the researcher to formulate an appropriate solution and helps the participants to understand the purpose of the study. During this initial stage of the study, the researcher investigated the problem in detail and was aware of the impact of the study on society. This section is covered in Chapter 1 of this thesis. The problem statement for the study is:

Institutions of higher learning in SA may have no effective framework to guide faculty members to care for VILs in their classes. Establishing such a framework relating to teaching Engineering courses to VILs in higher education using ICTs would prove to be a significant scientific contribution.

2. Objectives of a solution

After identifying the problem, the researcher inferred the research objectives. The objectives were both qualitative and quantitative in nature. The main aim of the study is to develop a framework for the provision of VILs in Engineering education in SA using ICTs. This stage is covered in Chapter 1 of this thesis. The research objectives of the study are to:

- Determine the degree to which Engineering faculties in SA are accommodating VILs;
- Identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA;
- Examine the ICT tools that could be adopted to better facilitate the entry of VIL into Engineering courses;
- Incorporate many of these ICT tools into the framework to benefit VILs in Engineering education in SA; and
- Evaluate the framework with specific field experts so as to establish its validity and refine its suitability for higher education in SA.

3. Design and development

This study aims at developing a framework for the provision of VILs in Engineering education using ICTs in SA. This study started with an intensive literature review. The literature review was done by the researcher to investigate the current situation of VILs in SA and the ICT tools that could be used to assist VILs in Engineering courses. This study was based on a case study which was conducted in two parts (Part A and Part B). Part A of the case study utilises focus groups of VILs and questionnaires for educators in special schools. Part B of the case study utilises questionnaires from DUs and senior Engineering staff from universities in SA. The researcher used the knowledge gained from the literature, questionnaires and focus groups to obtain solutions for the research objectives. This stage is covered in Chapters 2, 4, 5 and 6 of this thesis.

4. Demonstration

A case study was used in order to gather data for the development of the framework. The case study was done in two parts: at school and university level. The case study helped to determine the factors that affect the provision of VILs in Engineering. The demonstration stage can involve experiments, a case study, simulation, etc. This stage assisted the researcher in understanding how the framework could solve the research problem. This stage is covered in Chapter s4 and 5 of this thesis.

5. Evaluation

The framework was evaluated by experts in the field, comprising researchers who had done research in Engineering education, HODs of Engineering faculties, DU managers and visually impaired people working in the Engineering /IT field. Evaluating the framework involves comparing the research objectives set in stage 2 with the outcomes of the study. The developed framework was refined based on the recommendations provided by the experts. This stage is covered in Chapter 6 of this thesis.

6. Communication

The researcher communicated the research problem, the conceptual framework developed during the study, its importance and impact to the public and to other researchers and academics. The work was published in academic publications.

3.4 RESEARCH DESIGN

A research design is a plan that is formulated to address a given problem (Placzek and Boyce, 2016). Saunders, Lewis and Thornhill (2011) developed the research onion which describes the different stages of a study. A researcher must follow these steps while formulating the methodology for the study (Balakumar, Inamdar and Jagadeesh, 2013). The research onion is depicted in Figure 3.2.

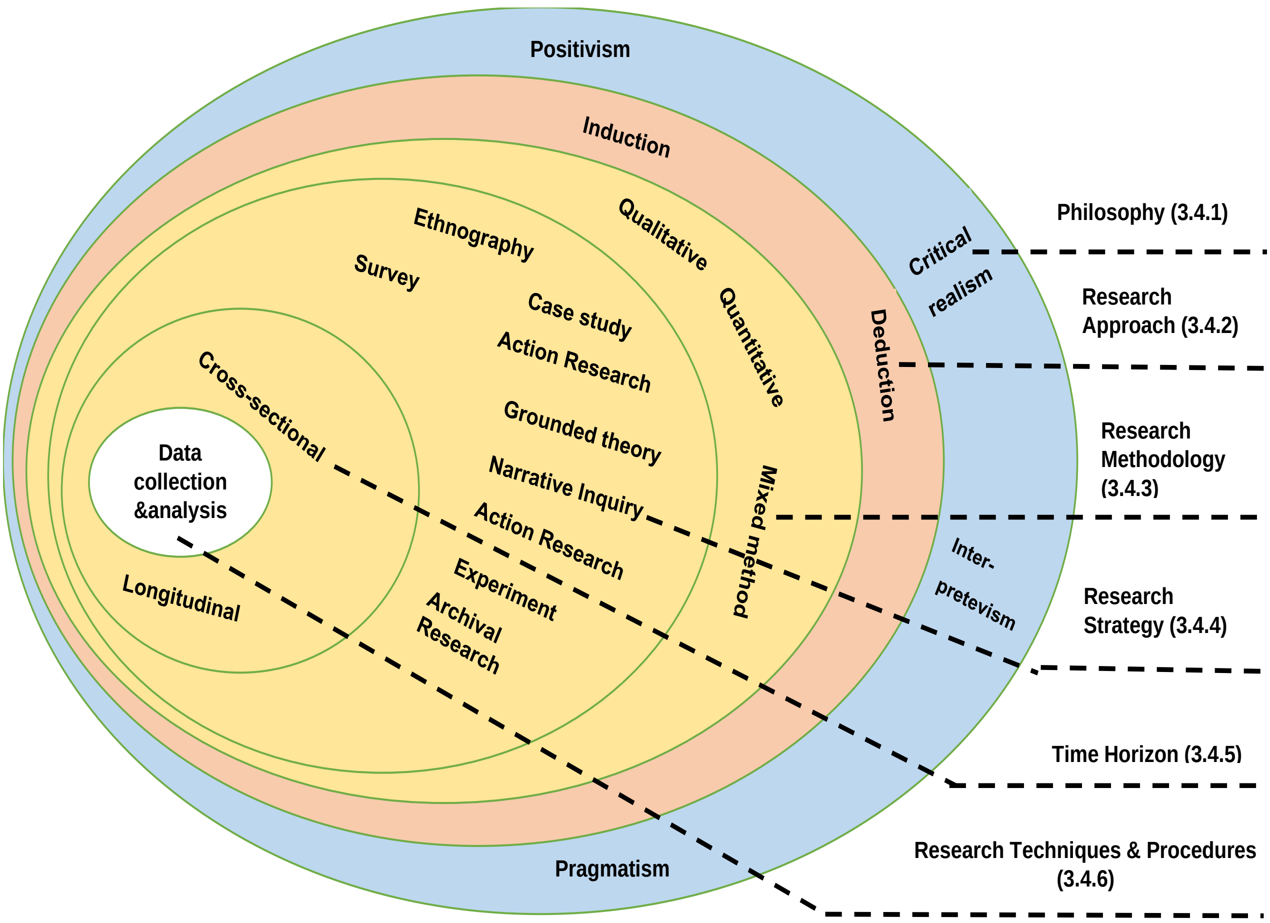


Figure 3.2 Research onion (Saunders, Lewis and Thornhill, 2009)

Figure 3.2 indicates the different stages involved in a research process which includes: research philosophies, research approaches, research choices, research strategies, time horizons, techniques and procedures. The following sections explain each of the layers in the research onion.

3.4.1 Dimensions and Paradigms in Research

Terre Blanche and Durrheim (1999) states that the research aim, research paradigm and research methodology should correlate. The aim of the study was to develop a framework for the provision if VILs in Engineering education in SA. This section discusses the various paradigms and the philosophical assumptions or dimensions of paradigms in research. The research methodology used for the study is explained in the next section.

3.4.1.1 Philosophical dimension of research

The term 'paradigm' is used in research to demonstrate how a researcher views the world (Mackenzie and Knipe, 2006). Lather (1986) interprets research paradigm as the researcher's views and beliefs about the world that he lives in and how he interprets it. In other words, a paradigm can be considered as a conceptual lens through which the researcher studies the different aspects of the project in order to determine the research methods as well as the data collection and analysis process that should be used in the study (Kivunja and Kuyini, 2017). A paradigm has four elements or dimensions, namely: epistemology, ontology, methodology and axiology (Lincoln and Guba, 1985).

Epistemology is derived from the Greek word *episteme*, which means *knowledge* (Foucault, 2002). Epistemology is concerned with the nature of truth, reality or knowledge in the world and how it can be acquired (Cooksey and McDonald, 2019). In order to perceive the epistemological element of one's paradigm, it is important to understand what the truth is and how one knows that it is the truth. It is still a matter of debate whether there exists something called the "truth" (Davidson, 2000).There are four sources of knowledge that researchers rely on, namely: intuitive knowledge, authoritative knowledge, logical knowledge, and empirical knowledge (Slavin, 1984). If the researcher relies on beliefs, faith, and intuition, then the epistemological basis of the study is considered as *intuitive* knowledge (Kivunja and Kuyini, 2017). If the researcher depends on the information gathered from people and books, then the epistemological basis of the study is considered as *authoritative* knowledge (James and Busher, 2009). Logical knowledge is the approach of reaching new knowledge from the existing knowledge, while empirical epistemology is the knowledge derived from facts, experiments and observations (Hale, 2002; Wenning, 2009).

Ontology is derived from the Greek word *ontos*, which means being (Jepsen, 2009). This philosophy examines the beliefs of the researcher, the nature or essence of being and reality (Scotland, 2012). Ontology is concerned about the following: a) nature of reality, b) whether the reality is objective or the result of individual perception, c) whether the reality is one's creation or in the social world (Gray, 2013). The assumptions about reality guides the researcher in interpreting the data collected during the study. This also helps the researcher to identify the approach that should be used to solve the research problem (Scott and Usher, 2004). Ontology plays an important role in orientating the researcher to examine the fundamental concepts in generating themes that are used to determine the meaning of the collected data (Nowell *et al.*, 2017).

Methodology is an umbrella term used to refer to the research approaches and research design techniques used in the research study (Keeves, 1997). Methodology focuses on the logical flow of the different processes involved in the study (Azzone and Pozza, 2004). This helps a researcher to gain a better understanding of the research study. The methodology determines how the researcher plans to collect the data, how the researcher analyses data, decides on sampling the participants and how the data is interpreted in order to answer the research question (Moreno, 1947; Holden and Lynch, 2004; Mertens, 2009).

Axiology is derived from the Greek word *axios* which means value (Biedenbach and Jacobsson, 2016). This approach gives importance to the ethical considerations that should be made while planning a research study (Harris, Holmes and Mertens, 2009).

Finnis (1980) defines axiology as an approach that is used to determine and understand the right behaviours or decisions in research. Axiology considers the values followed by the researcher while conducting the study, the moral considerations addressed by the researcher, measures taken by the researcher to conduct the research in a peaceful manner (Tomar, 2014; Biedenbach and Jacobsson, 2016). There are four criteria of ethical conduct, namely: teleology, deontology, morality and fairness (Mill, 1969). Teleology is the moral obligation that a researcher should have to the participants at every stage of the research study (Perlman, 2004). ;Deontology criteria; refers to the understanding that there is a consequence for very decision that is taken in the research study (Scheffler, 1982). 'Morality' refers to the moral values that the researcher should maintain throughout the study, for example correct interpretation of the data collected from the participants (Greaves and Ord, 2017). Fairness ensures that the participants are given fair treatment during the study (Mcgregor, 2011).

In short, axiology is the "study of value", ontology is the "study of being" and epistemology is the "study of knowledge"(Greyling, 2008).

3.4.1.2 Research Paradigms in Information System

A research paradigm is the researcher's beliefs and principles that guides the research process (Lincoln and Guba, 1985). Paradigms are considered to be important in research because they deal with beliefs that influence the researcher in a particular discipline on the topic that needs to be researched, how the study should be conducted and how the results of the study should be interpreted (Denzin and Lincoln, 2000). There are several research paradigms, but the commonly used ones are the positivist, constructivist/interpretivist, critical inquiry and pragmatist (Krauss and Putra, 2005; Crowther and Lancaster, 2008).

A positivist approach is viewed as being an objective approach and it emphasises facts and considers science to be the only base for knowledge (Biklen, 2003). According to positivists, the reality is objective to the research phenomenon (Hudson and Ozanne, 1988). Positivists use statistical and mathematical tools to reveal the objective reality (Carson *et al.*, 2001). The researcher and participant are considered to be independent, maintaining a fair distance between facts and personal feelings (Hudson and Ozanne, 1988; Carson *et al.*, 2001). Positivists use quantitative methods to conduct research by formulating hypothesis for the study and by implementing an appropriate research methodology (Churchill, 1996; Carson *et al.*, 2001). Insights provided by positivists can be generalised to a larger population (Johnson and Onwuegbuzie, 2004).

An interpretivist approach is also known as a constructivist approach that has a more subjective nature. The researcher provides reasoning by discovering the meaning of events from real life examples(Benz and Newman, 2008). According to interpretivists, a phenomenon can be interpreted in many ways and is not necessarily restricted in determining the single objective reality (Pham, 2018). Importance is given to the understanding of research phenomenon in depth rather than generalising the perceptions to the larger population (Creswell, J., 2007; Cohen, Manion and Morrison, 2011). Key methodologies used in this paradigm are grounded theory, case study, ethnography as these methodologies assist the researcher to gain deeper insights of the research matter (Tuli, 2010).Interpretivists uses qualitative methods to conduct research (Mack, 2010).The research findings are based on the researcher's interpretation and on the participants' perceptions and viewpoints (Wellington and Szczerbinski, 2007).

A critical inquiry approach constructs the reality with the help of social, economic and political elements in the society (Hammersley, 2013).Even though the insights provided by the critical researchers would assist in empowerment and inclusion in the society, it is not easy to put these theories into practice in reality (Pham, 2018). This paradigm is considered as a pivotal bedrock for researchers to understand, explore and resolve the current issues in the society (Kellner, 1993).Key methodologies used in this paradigm are critical action research, ideology critique and critical discourse analysis (Riyami, 2015).

A pragmatic paradigm is an approach used for problem solving (Abdul Rahman, Zakaria and Sardi, 2008). In pragmatic approaches, the researcher uses varied approaches to understand the research problem and the findings are constantly negotiated during the different phases of the study (Creswell, 1994; McLaren and Buijs, 2011). As a result, the researcher ends up with the most appropriate techniques and methodologies for the research (Patton, 1990; Thomas, 2010). This approach uses both qualitative and quantitative research techniques.

3.4.1.3 Research Paradigm used in the study

This study has used a pragmatic research paradigm. This study was conducted without worrying whether the questions used in the research tools were entirely quantitative or qualitative in nature. This study utilised both qualitative and quantitative research techniques: focus groups, questionnaires and expert reviews. The researcher adopted research methods that were best suited in achieving the aim of the study. The pragmatic paradigm is not confined to one philosophy. A pragmatic paradigm gives the flexibility to the researcher to utilise diverse methods and techniques to understand and solve the problem (Teddlie and Tashakkori, 2011).

3.4.2 Research Approaches

A research approach is a procedure that guides the researcher to make the right interpretations from the data, thereby making the research process smooth and efficient (Saunders, Lewis and Thornhill, 2009). There are primarily two research approaches: inductive and deductive (Burney, 2008).

3.4.2.1 Inductive Approach

In an inductive approach, the researcher develops a theory based on the patterns generated from the collected data. The data or facts are observed carefully to formulate a theory and no pre-determined theory is taken into consideration (Thomas, 2003). An inductive approach, also known as inductive reasoning, is a bottom-up approach (Lodico, Spaulding and Voegtle, 2010). Inductive reasoning begins with searching for patterns from observations through a sequence of hypothesis and finally formulating theories based on those observations (Goddard and Melville, 2004;

Saunders, Lewis and Thornhill, 2009). The different phases in an inductive research approach are presented in Figure 3.3.

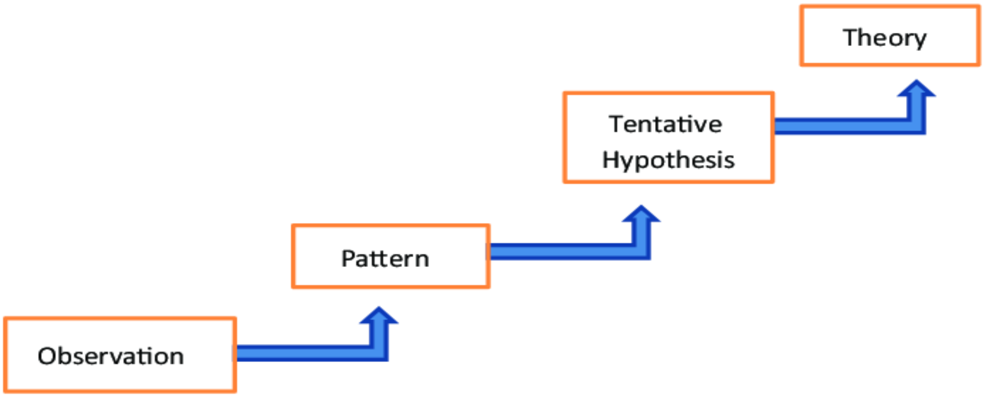


Figure 3.3 Inductive Research Approach (Burney, 2008)

3.4.2.2 Deductive Approach

A deductive approach is done in the reverse order. This approach starts with studying, understanding and investigating the existing theories and a hypothesis is established based on those theories (Milkie and Warner, 2011).The different stages in deductive reasoning are as follows:

- Developing hypothesis from theory;
- Hypothesis testing using quantitative methods (for example.: correlation analysis, mean, mode.);
- Confirming or rejecting the theory based on the hypothesis test; and
- Modifying theory in instances when hypothesis is not confirmed.

Figure 3.4 depicts the different phases in deductive research approach.

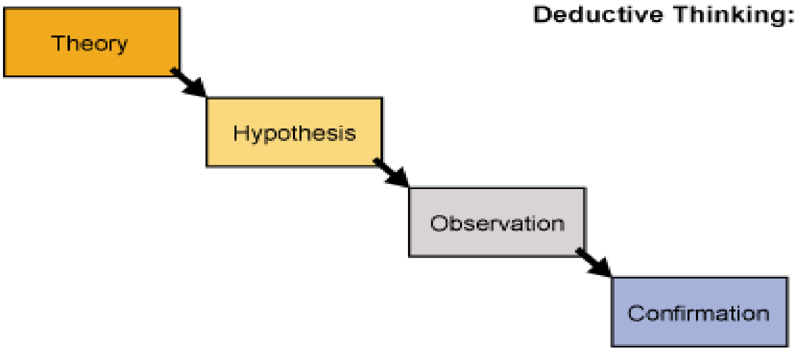


Figure 3.4 Deductive Research Approach (Theran, 2018)

3.4.2.3 Inductive vs. Deductive Research Approach

The inductive and deductive approaches were explained in detail in the previous sections. The comparison between these approaches is depicted in Table 3.1.

Table 3.1 Comparison of research Approaches (Schadewitz and Jachna, 2007; Saunders, Lewis and Thornhill, 2009)

Inductive Approach	Deductive Approach
Bottom up approach	Top down approach
Goes from the specific to general	Goes from the general to specific
Based on observations of specific instances	Based on facts and principles
Conclusion may be probably true	Conclusion must be true
Uses qualitative data collection approach	Uses quantitative data collection approach
Concentrates on understanding the context of the study	Describes causal relationships between concepts and variables

3.4.2.4 Research Approach chosen for the study

This study has used an inductive approach to research. The study utilises data from multiple sources such as focus groups, questionnaires and literature review. Views and perceptions of VILs, DUs, special school educators and HODs and senior lecturers of Engineering faculty are obtained via focus group discussions and qualitative questionnaires. The inductive research approach helps the researcher to establish links between the research objectives and research findings from the data collected. Inductive reasoning assists the researcher to systematically analyse the qualitative data to generate useful meanings from the data. Based on the patterns generated from the collected data, a framework is developed for VILs in Engineering education.

3.4.3 Research Methodology

Research methodology is a technique used to systematically study and solve a research problem through a sequence of logical steps (Sridhar, 2019). The appropriate research methodology for a study is determined depending on the nature of the research question and the topic being researched (Denzin and Lincoln, 2005).The research methodology is a plan of enquiry, which uses philosophical assumptions at every stage of research including research design, and data collection (Myers, 2009). This section discusses the three most common research methodologies: qualitative, quantitative and mixed method.

3.4.3.1 Quantitative Research Methodology

The quantitative research method allows the researcher to collect and analyse quantifiable data (Saunders, 2011). In quantitative research, the researchers use statistical methods to interpret and understand the participants' perspectives (Denzin and Lincoln, 2000). This methodology uses quantifiable data to identify patterns in research. As the interpretation is based solely on statistics, this methodology does not have the capability to capture the characteristics associated with human behaviour and therefore is not recommended for in-depth explorative studies (Creswell, 2013). The statistical data is presented using figures, tables and graphical representations. This research methodology is done on large samples and its findings can be generalised (Babbie, 2010). The common research tools used to collect quantitative data are questionnaires, surveys and experiments (Hittleman and Simon, 1997).

Quantitative researchers examine the relationship between variables within the population using effect statistics such as frequencies, mean, etc. The validity of quantitative studies can be established if the same results are obtained after replicating the research study (Winter, 2000).The disadvantage of using this approach is the lack of perceptions and views from participants, which makes it difficult to make a meaningful interpretation (Gelo, Braakmann and Benetka, 2008; Toomela, 2008).

3.4.3.2 Qualitative Research Methodology

Qualitative research assists a researcher to perceive the social and cultural conditions prevailing in the society (Myers, 2009). Qualitative research uses an interpretative approach in analysing the research matter and attempts to interpret the meaning of the perceptions received from the participants (Denzin and Lincoln, 2003). The research tools used for qualitative research are observation, interviews, researcher's reaction, etc. (Myers, 2009). While quantitative research presents the data as statistical data, qualitative research presents data subjectively in the form of narrations (Denzin and Lincoln, 2003). Qualitative research is conducted when the researcher wants a deep understanding of the perceptions of people on the research matter (Mohajan, 2018). The qualitative and quantitative methods differ in the role of the researcher in the study, the knowledge discovered during the study and the understanding of the purpose of the study (Stake, 1995).

Qualitative research uses an inductive approach while quantitative research uses a deductive approach (Lincoln and Guba, 1985). A researcher is often involved in the data collection and analysis stage of qualitative study. Therefore, there is a good chance that the qualitative study results may be biased based on the researcher's views (Lincoln and Guba, 1985). The disadvantage of using this approach is the lack of ability to generalise the findings to a larger population (Gelo, Braakmann and Benetka, 2008; Toomela, 2008) .

3.4.3.3 Mixed Method Research Methodology

A mixed method research methodology uses quantitative and qualitative methods to explore the research matter (Creswell, 2013). The central proposition of this methodology is that the combination of qualitative and quantitative data can provide better interpretation of the research problem (Creswell and Clark, 2007). The qualitative and quantitative components may be collected sequentially or concurrently (Schoonenboom and Johnson, 2017). Sequential data collection is used if the second phase of the collection requires information from the first phase to proceed (Creswell and Clark, 2011). The second phase of the data collection may also be used to interpret the data collected in the first phase (Creswell and Clark, 2011). Concurrent data collection is considered to be efficient as the quantitative and quantitative data is collected in a small amount of time (Wisdom and Creswell, 2013). Studies employing deductive reasoning may place emphasis more on the quantitative component to explain their study, while those utilising inductive reasoning may emphasise the qualitative component more (Soiferman, 2010).

3.4.3.4 Research Methodology for the study

A mixed design research design was used in this study. A mixed method research methodology combines the strengths of both methodologies (qualitative and quantitative) and reduces the weakness of both approaches (Creswell and Clark, 2007). The study identified the challenges faced by VILs when contemplating entry into Engineering courses in SA. In order to identify these challenges, it was important to conduct the study both at school and university level. Focus group discussions and questionnaires (semi-structured) were used to investigate the research problem. This mixed method research design assisted the researcher to get a more balanced perspective of the study.

3.4.4 The Research Strategy

A research strategy is a systematic plan that guides the investigator in analysing the problem under consideration by choosing the appropriate design and methodology

(Creswell, 2013).The strategies proposed during initial stages of the study might evolve as the study progresses (Babbie, 2013). The strategy adopted for a study depends on the objectives, philosophy, knowledge about the research topic and the time constraints for the study (Saunders, 2011). A research strategy is a plan of how a researcher will answer the research questions(Saunders, 2011).There are numerous research strategies found in research and some are presented in Table 3.2.

Table 3.2 Research Strategies

Research strategy	Purpose	Research Approach
Action research	Inquiry conducted to solve an immediate problem thereby improving the quality of an organisation	Inductive Approach
Ethnography	The purpose of this strategy is to understand the research from the viewpoint of the people involved in the study	Inductive Approach
Archival research	Archival research collects historical data and analyses the data on different parameters to draw inferences and new findings	Inductive Approach
Surveys	Surveys are generally applied for business studies where opinions of participants are collected from a large sample of population. The collected data is analysed using descriptive analysis tools	Deductive Approach
Experiments	Experiments are tests performed through a sequence of steps to identify the links between the variables in a study	Deductive Approach

Research strategy	Purpose	Research Approach
Case study	Case studies are used to understand the views and perceptions of people, organisations etc. on the research problems.	Mixed Approach
Grounded Theory	Grounded Theory initiates the development of new theory without the use of any predetermined theories.	Mixed Approach

3.4.4.1 Research Strategy for the study

This study conducted an in-depth enquiry on the challenges faced by VILs in the provision of education in Engineering in higher education institutions. The investigator therefore made use of a case-study research design as it was the most justified approach for this investigation. The case study was done in two parts: Case One was conducted at special schools in the Free State province and Case Two was done at South African universities. This study combined both quantitative and qualitative information (focus groups and questionnaires) to generate an in-depth, detailed understanding of the challenges faced in the provision of VILs in Engineering education in SA. The fundamental goal of a case study research is to conduct an in-depth analysis of an issue, within its context with a view to understand the issue from the perspective of participants (Yin, 2011; Stake, 2013).

3.4.5 Time Horizon

Time horizon plays a vital role in planning a research study. According to Saunders, Lewis and Thornhill (2009), time horizon is the length of time taken to complete a study. There are two possible choices: cross-sectional and longitudinal (Creswell, 2013).

3.4.5.1 Cross Sectional Studies

In cross-sectional studies, the researcher captures the information from the participants for a specific point in time (Bryman, 2007).Cross-sectional studies are usually conducted when there are time constraints for the researcher to conduct the study (Park and Davis, 2001). The information is collected from participants with varying demographics or variables. The variables depend on the research aim and the type of study being conducted. The correlation between the variables can be determined by conducting statistical tests (Mann, 2003).The data collection, analysis and interpretation are done in a short period of time; therefore, it can be considered just as a snapshot of the current situation (Alexander *et al.*, 2015).The advantages and disadvantages of cross-sectional studies are presented in Table 3.3.

Table 3.3 Advantages and disadvantages of cross sectional studies (Fitzgerald and Moss, 2012)

Advantages	Disadvantages
Used to validate the assumptions made by the researcher	Cannot determine relationship between cause and effect
Quick and easy method to conduct a study	Not suitable for studies that requires long follow-up periods
Inexpensive method of conducting a study	Results may be skewed if there are constraints in time and funds.
Results of this study can be used to generate new theories	Results can be biased due to low response rate

3.4.5.2 Longitudinal Studies

In a longitudinal study, a researcher captures information by repeatedly observing the participants over a long period of time (Caruana *et al.*, 2015a). The researcher repeatedly examines the problem and identify the patterns that emerge during the study and provides succinct results (Menard, 2002). These studies are time-consuming, but the time frame is completely dependent on the researcher (Lerner, Schwartz and Phelps, 2009). The advantages and disadvantages of longitudinal studies are presented in Table 3.4.

Table 3.4 Advantages and disadvantages of longitudinal studies (Caruana *et al.*, 2015b)

Advantages	Disadvantages
Ensures high degree of validity	Data may not be reliable as it is collected at different points during the study
Allows flexibility	Expensive
Helps to determine various data patterns over time	Time consuming

3.4.5.3 Time Horizon for the study

This study was a cross-sectional study, as the researcher had to complete the study within a limited amount of time and with a limited budget. This study collected data from various participants with varying demographics and profiles at a single point in time. The findings for the study are drawn by comparing the responses of the various participants that was collected at the same time.

3.4.6 Research Techniques and Procedures

This section focuses on the data collection and analysis methods used in research. During this phase, the researcher decided on what research tools were appropriate to capture the data that was required for this study. The choice of appropriate data analysis technique was crucial as it determines the result of the study. Since it is not practical to collect data from the entire population, the researcher had to choose a small set of data from the large population using sampling techniques. The sampling techniques, the target populations and the sample size used in the study is discussed in this section. While making decisions regarding the research tools, the researcher had to ensure that the study follows the research philosophy, time horizons and strategies chosen for the study. The section below describes the various popular data collection tools used in research.

3.4.6.1 Data Collection Tools

Data collection is the process of applying research tools to the target population selected for the study (Mouton, 2009). Target population is the group that the researcher is interested in analysing as that group meets all the criteria for the study (Vanderstoep and Johnson, 2008).This section presents, in table format, some of the popular research tools and techniques used to retrieve information from participants (see Table 3.5).

Table 3.5 Popular Research Tools and their purpose

Research Tools	Purpose of the tool
Literature Review	The literature review is a technique used to summarize and examine the relevant documented information produced by researchers and academics in the field of study (Mackey and Gass, 2015). A review is also considered as a method of understanding what has already been researched by other scholars regarding the research problem (Davidson, 2000).
Observations	Observations provides a real world scenario of the hypothesis made by the researcher during the research design phase (Iacono, Brown and Holtham, 2009). The researcher might discover certain important details during observing the participants which he might not have noticed while designing the research study (Driscoll, 2011).
Questionnaires	Questionnaires are the most extensively used research tool for data collection (Teddlie and Tashakkori, 2011). Questionnaires are a means through which the researcher formulates a set of questions depending on his needs to collect the information from the participants (Malhotra, 2006). Questionnaires can be structured, semi-structured and unstructured.

Research Tools	Purpose of the tool
Interviews	A research interview is a conversation used to collect information from a participant (Brown, 2001). This process involves an interviewer, who is responsible to coordinate the interview process by asking questions relevant to the study, and an interviewee, who responds to those questions (Easwaramoorthy and Zarinpoush, 2006). Interviews assist the researcher in collecting in depth information on the participant's opinions, views and feelings (Mathers, Fox and Hunn, 2000).

3.4.6.2 Data Collection Tools used in the study

The researcher started the study with an intensive **literature review**. The literature review focused on the importance of ICT in education, the challenges VILs face in SA, the current situation of VILs in South African universities and the M-tools and E-tools that could assist VILs to learn Engineering. This assisted the researcher in developing a framework for the provision of VILs in Engineering education using ICTs in SA. The literature review was conducted through the collection and analyses of multiple documents (books, articles, case studies, conference papers, newspaper articles and content from the Internet). This study depended heavily on existing studies and theories. The study tried to collect as much literature as possible, but focused more on recent studies to understand the current situation of VILs in South African tertiary institutions.

Focus groups were conducted to collect views and perceptions of high school VILs in special schools about the factors that might affect the provision of education of VILs in Engineering courses at tertiary institutions in SA. Five focus groups with a maximum of seven participants per group were used. Groups of between six and seven participants are large enough to generate rich discussion, but not so large that some may feel left out (Mackey and Gass, 2015). The five focus groups consisted of high school VILs from the special schools in the Free State province. The focus group questions were drawn from the literature to ensure content validity. Content validity is established if the questionnaire reflects the content provided in the literature (Bolarinwa, 2015a). The questions were structured in such a way that the discussion lasted no longer than 90 minutes.

An online self-administered questionnaire was used for this study. Questionnaires are semi-structured in nature, consisting of both closed and open questions. Three questionnaires were used in this study: a) questionnaires for special school educators; b) questionnaires for HODs and senior lecturers in Engineering faculties at tertiary institutions; c) questionnaires for DUs at institutions. The online questionnaire was used to collect data from participants, thereby allowing the researcher to generalise to a larger population. Online questionnaires make it convenient for the participants to respond and administer the questionnaires in an easy process for the researcher. Online questionnaires are a cost-effective way of collecting data (Davidson, 2004).

Expert reviews were used to evaluate the framework. This was done to establish the validity of the proposed framework for VILs. The experts were researchers who have done research in Engineering education, HODs of Engineering faculties, DU managers and a VI engineer. Experts evaluated the framework by using an evaluation tool that was developed through Google forms. Based on the feedback from the experts, the framework was refined and finalised.

3.4.6.3 Piloting the research tools

Pilot testing is a strategy used to pre-test the research tools to understand the expected response rates and comprehensibility of the research tool (Silman and Macfarlane, 2001). It is also a mechanism that helps the researcher to ensure the validity and reliability of the research instrument used (Mackey and Gass, 2015). Piloting is done to ensure that the questionnaires are clear, simple and properly structured for the participants. Therefore, it plays a crucial role in designing and structuring the research instrument for the participants (Saunders, 2011). Piloting allows the researcher to do a test of the hypotheses made by him/her before the actual study (Leon, Davis and Kraemer, 2011). Piloting guides the researcher with ideas and clues that might direct him/her in the right direction thereby leading to precise, clear research outputs (Friesen *et al.*, 2017). The researcher may test different methods during the pilot study and determine the procedures that are appropriate for the study (Hassan, Schattner and Mazza, 2006). Piloting can also assist the researcher to minimise the number of anticipated errors (Driscoll, 2011).

All data collection tools in this study were piloted. The focus group questionnaires were piloted by VILs and Engineering students at the CUT. The questionnaires were piloted by DU managers, HODs and senior lecturers at the CUT. The study also made use of research assistants that were also allowed to pilot all the research tools. Comments and recommendations were used to improve the research tools.

3.4.6.4 Sampling Procedure

Research studies are always directed towards addressing the problems that are relevant to a particular group of individuals known as the target population (Eldredge, Weagel and Kroth, 2014). Since it is difficult to collect data from all the members in the target population due to cost implications and time constraints, a sample or subset is drawn from this population for the study (Fricker, 2008).Sampling is the process of selecting a subset of the population to conduct a study (Luborsky and Rubinstein, 1995). There are primarily two types of sampling techniques: probability sampling and non-probability sampling.

Probability sampling, also known as random sampling, is a sampling technique where all participants have equal chances of being selected as a representative subset of the population (Surbhi, 2019).This sampling technique involves randomly choosing participants for the study, thereby eliminating the chances of bias. As a randomisation approach is used, the sample is considered to be representative of the entire population; therefore, the sample results can be generalised to the population. Probability sample is used for conclusive studies. The different probability sampling methods are presented in Table 3.6.

Table 3.6 Probability sampling methods

Sampling Technique	Definitions
Simple Random Sampling	Simple Random Sampling is a sampling technique where all the participants have an equal chance of being selected.
Stratified Sampling	In stratified sampling, a random sample is selected from subgroups which are already grouped based on certain known characteristics
Cluster Sampling	With cluster sampling, the population is divided and grouped into clusters. The researcher conducts analysis by selecting a random sample of cluster.
Systematic Sampling	In systematic sampling, participants are selected from a sequential sampling frame.

Non-probability sampling, also known as non-random sampling, is a sampling technique where the participant that will be selected as the sample is unknown. The chance of being included in the sample is not known (Morse, 2010). The selection of participants are arbitrary and the sample results cannot be generalised to the population (Fraley and Hudson, 2014). This sampling technique is used for qualitative studies where the researcher focuses on collecting in-depth information from a group rather than drawing statistical inferences from a sample (Matthews and Ross, 2014). The aim of the study determines the choice of sampling technique that is chosen (Morse, 2010). The different non-probability sampling methods and their definitions are described in Table 3.7.

Table 3.7 Non-probability sampling methods

Sampling Technique	Definitions
Convenience Sampling	In convenience sampling, the participants are selected based on their accessibility.
Quota Sampling	In quota sampling, the participants are selected based on certain traits of a population.
Judgment or Purposive Sampling or Purposeful Sampling	In purposive sampling, the participants are selected based on their knowledge of the research study.

Sampling Technique	Definitions
Snowball Sampling	In snowball sampling, the selected participants for the study recommend other participants with the same characteristics.

3.4.6.5 Sampling Techniques used in the study

Four sampling techniques were used in this study. This study started with an intensive literature review. The literature review was conducted by collecting and analysing multiple research studies and papers. Hence, this study relies heavily on existing theory and research. The search terms used for the literature review included: ICT for inclusion, visually impaired learners in Engineering, visually impaired learners in university, ICT in education, inclusive education, government policies on disability, special schools, tertiary institutions etc. (Tom, Mpekoa and Swart, 2018). These search terms helped to focus the search appropriately. This was followed by a case study which was done at school and university level. Focus groups and questionnaires were used as the research tools at school level study.

The school level case study targets the special schools in SA. There are twenty-four (24) special schools in SA, with two in the Free State province. Since it was a case study, the special schools of Free State province were considered for this research. The study population or sample population consisted of the VILs and educators at the two special schools in the Free State province. The first special school had 40 VILs and the researcher intended to collect data from VILs attending Grade 10-12. The high school learners were the apt choice for the study as these students were getting prepared for tertiary education. It was too early for the learners in other grades to analyse and comment on the challenges that VILs face while entering into Engineering courses at universities. Out of 40 VILs, a total of 12 attended Grade 10-12 at the first school. All these learners participated in the study. Out of the 34 VILs (Grade 10-12) at the second school, 19 participated in the study. Therefore, the total number of participants for the focus groups was 31.

Five focus groups of VILs were selected from the Free State special schools using a stratified sampling technique. Based on certain known characteristics, this technique divides the entire population into subgroups and then randomly selects the final participants proportionally from each of the subgroup. Therefore, the participants within each group (6-7 per group) were selected using simple random sampling. The following paragraph discusses the sampling technique used for special school educators which forms part of the school case study.

The special school educators are responsible for preparing VILs for tertiary education. The educators teaching VILs from Grade 10-12 were selected for the study because these participants have knowledge on the topic being researched. Therefore, a purposive sampling technique was used. The purposeful sampling technique is used to select participants that has good knowledge and experience with the research area (Creswell and Clark, 2007). The participants selected through this technique should also be willing to share their views and opinions about the research topic (Bernard, 2017). There is a total of 27 educators in the special schools of the Free State province (Bartimea School and Thiboloha School) who teach VILs. A total of 14 educators from two special schools responded to the study, forming the sample size. Questionnaires were distributed to the special school educators to identify the challenges that VILs face while contemplating entry into Engineering courses at universities. The questionnaires were sent electronically through Google forms to the participants. It was a convenient way for the researcher to reach the participants located at geographically distant locations using online questionnaires. The following paragraph discusses the sampling technique used for DUs which forms part of the university case study.

The initial target population of the university case study was the 26 public universities in SA. The researcher telephonically contacted these universities to determine whether they were willing to participate. Six universities specifically indicated that they were not willing to participate in this study. Therefore, the researcher targeted 20 public universities that did not indicate any specific preference with regard to participating in the study. The DUs are responsible for providing support services to students with disabilities (VILs, deaf students, etc.) in tertiary institutions (Hewett, Keil and Douglas, 2015a). These units are considered to be the primary point of contact for many students with special needs at tertiary institutions (Naidoo, 2010).

The researcher aims to identify the challenges VILs face in higher education, especially in the Engineering stream. Since DUs have a good knowledge about the research topic, they form part of the study population. Therefore, a purposive sampling technique was used. The questionnaires were distributed to the DUs of 20 public universities in SA. However, only five (5) universities participated in the study. This forms the sample size for this part of the study, equalling a response rate of 25%. According to Visser *et al.* (1996), response rates greater than 20% are acceptable for online questionnaires. Emails were sent to the other 15 universities on a number of occasions requesting their participation. However, no response was received from them. Questionnaires were used as the research instrument for collecting data from DUs of South African universities. The questionnaires were sent electronically through Google forms to the participants. The following paragraph discuss about the other participants involved in the university case study.

The functioning of a department in the university depends on how efficiently the HODs handle the resources allocated to them (Dinham, 2007). He/she is responsible for ensuring that the department is committed in delivering the best teaching practices as well as good student learning experience (Hammond, 1998). In order to determine whether the Engineering department is prepared to accommodate VILs in their department, HODs were chosen as the participants for the university case study. Senior lecturers were also included in this case study because of their experience and knowledge in the Engineering field; therefore, their views and perceptions regarding the provision of VILs in Engineering also played a crucial role in this study. Therefore, the participants for university case study involved HODs and senior Engineering staff and were chosen using a purposeful sampling technique. Twenty-five (25) participants (HODs and senior lecturers) from nine universities responded to the study. Questionnaires were used as the research instrument for collecting data from HODs and senior lecturers from Engineering faculties of South African universities. The questionnaires were sent electronically through Google Forms to the participants.

The scientific contribution of the study was to develop a framework for universities in SA to assist VILs in Engineering education. The data collected from the research tools were analysed and triangulated to develop a framework. The framework was evaluated by experts in order to establish the validity of the framework (Cohen, Manion and Morrison, 2011). Compared to real environment evaluation of the framework, expert reviews were chosen based on the fact that the implementation of all the factors in the framework was not feasible for the study. Purposeful sampling was used to choose the experts for evaluating the framework. The experts consisted of researchers who had done research in Engineering education, HODs of Engineering faculties, DU managers and visually impaired people working in the Engineering /IT field. Questionnaires were used as the research instrument for expert evaluation. The questionnaires were sent electronically through Google forms to the experts. Table 3.8 below presents the sampling techniques, the associated research tools and the sample size used in this study.

Table 3.8 Research Tools and Techniques used in the study

Research tools	**Sampling Techniques**	**Targets**
Literature Review	Keywords: inclusive education, ICT, Engineering, visually impaired learners, students with disability, tertiary education	Conference papers, journal articles, books, reports, etc.
Focus Groups	Stratified sampling Simple random sampling	Five focus groups of high school VILs (2 special schools) 6-7 participants per group
Questionnaires	Purposeful sampling	DUs (5 universities) HODs and senior lecturers - Engineering faculty (9 universities) Educators from 2 special schools (14 participants)

Research tools	Sampling Techniques	Targets
Expert Reviews	Purposeful sampling	6 experts - Experts consist of a group of researchers who have done research in Engineering education, HODs of Engineering faculty, managers of disability centres and a VI engineer

3.4.6.6 Data Analysis

Data analysis is the process of organising and inspecting the research materials with the goal of finding meaningful insights from the collected information (Bak, 2003). Schwandt (2007)states that data analysis is the activity of theorizing the collected data that implies a search for general expressions among the various groups of data. In order to interpret the data, the researcher has to apply some sort of logic (Karageorgiou, 2011). Researchers need to apply deductive and inductive logic for interpreting data (Lacey and Luff, 2007).There are two methods to analyse data, namely qualitative and quantitative (Antonius, 2003; Schostak and Schostak, 2007). Kreuger and Neuman (2006) points out the similarities and differences between these approaches. The similarities are as follows:

- The use of reasoning to draw inferences based on evidence;
- Identifying similar patterns in the collected data; and
- Attempts to avoid errors and delusive inferences.

The differences between these approaches are presented in Table 3.9.

Table 3.9 Differences between qualitative and quantitative data-analytical methods (Kreuger and Neuman, 2006)

Quantitative data analysis	Qualitative data analysis
Findings from data collections guides further data collection	Findings and interpretations are not made until the data collection process is completed

Quantitative data analysis	Qualitative data analysis
Manipulate figures to test the hypothesis with different parameters	Creates new theory by gathering abstract statements
Statistical analysis	Analysis is context based

The following section discusses quantitative data analysis methods. The commonly used quantitative methods are descriptive statistics and inferential statistics(Al-Benna *et al.*, 2009).

Descriptive statistics summarises the research sample and provides meaningful inferences from the data (Ali and Bhaskar, 2016). The data is summarised using quantitative measures like mean, percentages, frequencies, etc., and is represented using tables, plots and histograms (Thomas, 2010). Descriptive statistics can be used for performing univariate analysis or multivariate analysis (Mathur and Kaushik, 2014). Descriptive statistics are of two kinds: a) measures of central tendency and b) measures of spread (Sharma*et al.*, 2018). Measures of central tendency identifies the patterns within the data and are presented as mean, median, and mode (Samuels and Gilchrist, 2014). Measures of spread provides information about how the data are distributed and are represented using tables, pie and bar charts (Sharma, 2019b). Descriptive analysis can only be used to interpret the data in the study population (Kemparaj, 2015). This analysis is conducted when the research sample need not be generalised to a larger population (Chaudhari, 2018).

Inferential statistics identifies relationships between multiple groups of data to generalise findings and make predictions (Iivari, 2007). Inferential statistics are also known as multivariate analysis as this method is used to determine the relationship between two or more variables (Allua and Thompson, 2009).
Some of the types of inferential statistics include:

- Correlation
- Regression
- Analysis of variance, etc.

The following section discusses qualitative data analysis methods. The commonly used qualitative methods are content analysis, narrative analysis, discourse analysis, hermeneutic analysis, thematic analysis and framework analysis.

Content analysis is a procedure of analysing textual, verbal or visual data (Cole, 1988). This method analyses the documents by classifying and categorising the content through a systematic process of coding, thereby identifying patterns in the text (Creswell, 2013).The content in the recorded document can be analysed using quantitative or qualitative techniques. The analysis can be done manually or with the help of computer programs like ATLAS.ti, NVivo, MAXQDA etc. (Elo and Kyngäs, 2008). Content analysis makes valid interpretations from the collected data with the motive of generating new insights and knowledge (Krippendorff, 1980). Content analysis provides the researcher with an opportunity to examine theoretical issues to generate a deep understanding of the data (Elo and Kyngäs, 2008). While conducting content analysis, words and phrases with the same meaning are placed under the same category (Cavanagh, 1997).There are various steps involved in conducting content analysis which are as follows (Creswell, 2013; GAO, 2013):

- Identify appropriate data sources based on the research question;
- Develop categories;
- Code data;
- Assess the reliability and consistency of the coded data; and
- Analyse the results and draw inferences from the coded data.

Narrative analysis is used to examine content from multiple sources, such as interviews, observations, or questionnaires (Anderson and Kirkpatrick, 2015). Narrative inquiry refers to capturing the different dimensions of experiences faced by the participants over time, and tries to establish a relationship between participant experience and research context (Clandinin and Connelly, 2000). Narrative analysis focuses on analysing the content by using the stories and interpreting the experiences shared by participants to reach the research objective (Simin, 2019).

Discourse analysis is the analysis of various interactions with people in the social life (Potter and Wetherell, 1987).Discourse analysis considers the different ways of interpreting meaning; can be in conversation or in culture (Traynor, 2006). Discourse analysis also investigates the participant's daily environment and utilises that information during the analysis process.

Hermeneutic analysis helps in investigating an in-depth understanding of human values, culture etc."Hermeneutic" means three things: expression, explication and interpretation (Danner, 2006). Hermeneutics focuses on the meaning of text. The interpretations helps in deeper understanding of the research problem (Pentti, 2007). The hermeneutic analysis does not just reflect on text, but deals with the research problem in a broader way by considering the phenomenon of research (Rittelmeyer, 2013).

Thematic analysis examines reports and documents and identifies the patterns within the data (Judger, 2016). Patterns that describe the phenomenon and contributes to answering the research question are called themes (Erlingsson and Brysiewicz, 2017). There are two categories of themes: semantic and latent (Braun and Clarke, 2006). Thematic analysis at semantic level identifies themes purely based on what the participant has mentioned during the data collection process while thematic analysis at latent level examines the underlying meaning of what has been said or written by the participant (Frith and Gleeson, 2004). Semantic themes are based on surface meanings of the data and latent themes are generated by analysing the content based on certain assumptions and ideas (Braun and Clarke, 2006).

Framework analysis are suitable for qualitative research where the researcher has to complete the study in a limited time period and address all the research objectives (Creswell, 2013). Framework analysis involves five steps: familiarisation with the collected data, identifying themes in the collected dataset, indexing based on the generated themes, charting of the data and interpretation of the themes (Ritchie and Spencer, 1994; Srivastava and Thomson, 2009). The features of a framework analysis approach are (Srivastava and Thomson, 2009):

- It is driven by observations of the participants;
- It is a dynamic process;
- It follows a systematic approach;

- It allows a partial or full review of the data collected during the study;
- It allows easy access to the original textual material; and
- It is an analytical process that can be accessible and judged by others.

3.4.6.7 Data Analysis used in the study

This study utilised both qualitative and quantitative data-analysis methods; therefore, the study used a mixed method data analysis technique. The qualitative data is analysed using content analysis technique and the quantitative data is analysed using descriptive analysis technique. Descriptive statistics was used in this study to interpret the quantitative data in a sensible way. This study used both numerical and graphical statistical descriptive methods. The numerical description of the study was represented by statistics, such as frequencies and percentages. These statistics helps the researcher to identify meaningful patterns in the data. The categorised data was also displayed in the form of tables and charts (pie charts, bar charts, etc.). Graphical representation helped the researcher to depict what proportion each part of the data occupied compared to the whole population.

Content analysis technique was used in this study to interpret the qualitative data through the process of coding and classifying into categories and themes. This study followed Creswell's (2013) steps for conducting the content analysis. Based on the response of the participants, the researcher identified the "key concepts" or "codes" in the data. These codes were then organised into categories and finally consolidated to form the themes of the study. By so doing, this technique assisted the investigator to get a deep understanding and meaningful interpretation of the research phenomena.

3.4.6.8 Data Triangulation

Triangulation is the process of utilising multiple data sources and research techniques to generate a deep understanding of phenomena (Patton, 1990).The overlapping of research techniques provides the researcher with a more balanced picture of the research problem as the researcher has the opportunity to study and analyse the data from different point of views (Krauss and Putra, 2005). The outcome of a study can be strengthened through the triangulation process as the weaknesses of an individual research technique can be decreased by combining different methods (Sharif and Armitage, 2004). Triangulation also helps to reduce several types of bias (for example, measurement bias, sampling bias and procedural bias) that the researcher encounters during his/her study (Kennedy, 2009).

Measurement bias or response bias occurs depending on the method used by the researcher to collect data (Paulhus, 1991). This bias can be reduced by triangulating individual responses (for example questionnaire) with group responses (for example. focus groups) (Kennedy, 2009). Sampling bias occurs when a researcher does not cover all of his/her study population (Panzeri, Magri and Carraro, 2008). The researcher may choose different techniques based on convenience to cover a part of the study population. For example, the researcher may use online surveys to collect data from participants who are geographically distant and may interview local participants. Triangulation reduces sampling bias by combining the strengths of the different data collection techniques used by the researcher (Kennedy, 2009).

Procedural bias occurs when participants are placed in a stressful situation during the data collection process (Miller, 1987). This might generate incorrect results. By combining the data collected by the researcher during the short and long engagements with the participants, this bias can be reduced to a large extend (Kennedy, 2009).

There are four types of triangulation: (a) methodological triangulation, (b) investigator triangulation, (c) theory triangulation, and (d) data source triangulation (Patton, 1999).

Methodological triangulation uses more than one method to understand a phenomenon (Casey and Murphy, 2009). Methodological triangulation are of two types: a) across method, and b) within method (Boyd, 1993). The across method triangulation combines both quantitative and qualitative data collection methods (Casey and Murphy, 2009). For example, across method triangulation can combine the data collected from focus groups (qualitative) and surveys (quantitative).The within method triangulation combines two or more quantitative or qualitative data collection procedures, but not both (Casey and Murphy, 2009). For example, within method triangulation can combine the data collected from two qualitative collection techniques, like focus groups and interviews (Thurmond, 2001). Methodological triangulation assists a researcher in validating the information collected during the study and provides a better understanding of his/her research topic (Bekhet, Zauszniewski and Nakhla, 2009).This technique is often chosen when a researcher is unsuccessful in explaining a technique sufficiently and has to use different methods to understand a phenomenon (Murdock, 2019).

Investigator triangulation uses more than one researcher in a research study (Schippling, 2017). This triangulation technique is useful while interpreting various forms of research materials such as text and audio (Archibald, 2015). Investigator triangulation assists in improving the quality of a qualitative study, as this technique provides a complex and enhanced understanding of the research materials (Schippling, 2017b). This triangulation technique may often lead to contradictions as the data is being approached using different perspectives of different investigators involved in the study (Bauer and Gaskell, 2000).

Theory triangulation uses more than one perspective to interpret data (Turner and Turner, 2009). Investigators from different disciplines of study share their perspective while studying a phenomenon (Brink, 1993).For example, a researcher can share the interview transcripts with researchers outside his/her field of study. If the multiple investigators interpret the collected data in the same way, then the validity is confirmed (Turner and Turner, 2009). This triangulation technique is considered to be time-consuming and may not be feasible for all research studies (Rugg, 2010).

Data triangulation gathers data from multiple sources (qualitative and quantitative) at different times using different sampling techniques (Rugg, 2010). Data collected from multiple sources are triangulated in order to establish the validity of the study (Zohrabi, 2013). The findings can be validated by identifying the repeating patterns generated at different times and using different methods (Denzin, 1978). The feedback generated from multiple sources is compared to ensure the degree of agreement and divergence of the data (Fetters, Curry and Creswell, 2013). This triangulation technique is considered to be the most popular triangulation technique as it is easy to implement

(Guion, 2002). However, it does not necessarily guarantee better results than those techniques that are based on analysing data from a single source (Sarantakos, 2000).

3.4.6.9 Data Triangulation used in the study

This study used three triangulation methods: methodological, investigator and data triangulation.

Methodological triangulation uses multiple methods for data collection. This study also utilised both qualitative and quantitative methods for data collection. The data-collection methods used in this study were literature review, focus-group discussions, questionnaires, and expert reviews. The researcher investigated the research problem from different point of views by using methodological triangulation method.

Multiple investigators were used during the focus group discussions with VILs at Free State special schools. The researcher and the research assistants were responsible for collecting data during the focus group discussions. Utilising multiple investigators assisted in determining the reliability and credibility of the data collection and analysis process of this study.

Data triangulation was used in this study to validate and strengthen the findings obtained from analysing the data collected from multiple data sources. Data triangulation was achieved by collecting data from multiple sources (literature review, focus groups, questionnaires) using different sets of participants under different settings.

3.5 ETHICAL CONSIDERATIONS

Ethics plays a crucial part in a study, especially during the planning and implementation phases of research (Mertens, 1989). There is a certain ethical consideration that should be taken into account while conducting research. The investigator should ensure that the study should not do any harm to the participants and be beneficial to the community. There are five major ethical principles in research:

- Get informed consent from the participants before the data collection process;
- Ensure that the study does not harm the participants;
- Secure the confidentiality of the participants;
- Avoid using misleading practices; and
- Allow the participants to withdraw from the study (Terre Blanche and Durrheim, 1999).

Ethical clearance for the study was obtained from the Faculty Research and Innovation Committee at the CUT. The ethics approval letter is presented in Appendix A. The research problem and research objectives were carefully explained to the participants well in advance before conducting the study. After requesting their participation, the interested participants were allowed to sign the consent forms. The participation for the study was voluntary and the participants were allowed to withdraw from the study whenever they wanted. The study also protected the anonymity and privacy of the participants.

3.6 SUMMARY

The aim of this study was to develop a framework for the provision of VILs in Engineering education using ICTs in SA. This research was based on a case study. A case study research strategy is used as it offers a deep understanding of the research problem. The research tools used for the case study done at school and university level were both quantitative and quantitative in nature (questionnaires, focus groups an expert reviews). Therefore, the study utilised a mixed method research approach. This study was conducted without worrying whether the questions used in the research tools were entirely quantitative or qualitative in nature. Since the study was not confined to a single philosophy, the research paradigm used in this study was pragmatic. The researcher also investigated different ICT tools that could assist VILs in Engineering. The tools were presented in Chapter 2 of this thesis. Hence, this study falls under the HCI domain. The study follows the research steps of the design science process model. The researcher had to complete the study within a certain time frame;

therefore, this study was a cross sectional study. The different stages in the research process and the choices made by the researcher are presented in Appendix B.

The study used both probability and non-probability sampling techniques to determine the study population. Qualitative and quantitative research methods were used to collect and analyse the data. Literature review, questionnaires, focus groups and expert reviews were the data collection tools used in this study. Content analysis and descriptive statistics methods were used to analyse the collected data. Triangulation techniques were used to validate and strengthen the findings obtained from analysing multiple data sources used in the study. A summary of the research tools and techniques used for the study is presented in Appendix C.

The data collection techniques for the study were chosen with the motive of addressing the research objectives of the study. The data-collection tools used at different stages of the study to address the research objectives of the study are presented in Appendix D.

This chapter has presented the research process for the development of a framework for the provision of VILs in Engineering education using ICTs in SA. The philosophical dimension, the research approach, the research strategy, the research method, the time horizon and research tools and techniques were also discussed in this chapter.

Chapter 4 discusses the first case study which was conducted at school level. The chapter discusses the case background and demographics as well as the data collection and analysis process using focus groups and the questionnaires.

CHAPTER 4: CASE STUDY-SPECIAL SCHOOLS

4.1 INTRODUCTION

Education is considered as one of the most important elements for sustaining socio economic growth all over the world. The departments that are responsible for educating the citizens in SA are the Department of Basic Education (DBE) and the Department Higher Education and Training (DHET). One of the objectives of this study is to identify the barriers faced by VILs while contemplating entry into higher education institutions. Higher education (also known as tertiary education) is any type of education pursued after schooling. In order to identify the barriers that the students faced to enter a tertiary academic course, it is necessary to investigate the challenges from school level. This study utilised a case study which was done in 2 parts (one at school level and the other one at university level). This chapter discusses the case study done at school level.

The data collection and analysis tools used in the case study were presented in Chapter 3. The discussion in Chapter 3 also provided a detailed description of the research design, philosophy and sampling techniques utilised in this study. Chapter 4 comprises the following sections: Section 4.2 discusses the importance of schooling and the school governing bodies; Section 4.3 presents the purpose of the case study and the site chosen for the study; Section 4.4 presents the background and demographics of the case study conducted at school level; Section 4.5 presents the data collection and analysis process of this study. This chapter is summarised in Section 4.6.

4.2 IMPORTANCE OF SCHOOLING AND SCHOOL GOVERNANCE

Schooling plays an important role in producing civilized individuals and is considered as the first step in national development and advancement (Suleman, 2011). School level education forms the foundation for higher education (Shah and Masrur, 2011). School education plays an important role in building the characters of the learners as these learners spend most of their time of their initial lives at schools (Marini, 2017).

Thus, school level education should be considered very important (Shah and Masrur, 2011). One of the goals of school level education is to help learners acquire a strong knowledge base and to improve their understanding of the fundamental concepts of various subjects like Mathematics, Science, English etc. (Fry, Ketteridge and Marshall, 2008). If the fundamental concepts are clear to a learner at school level, he/she may not struggle to grasp advanced concepts at university level (Suleman, 2011).

The hierarchy of school governance in SA is depicted in Figure 4.1 below. Different groups of people are responsible for handling the different levels in this hierarchy.

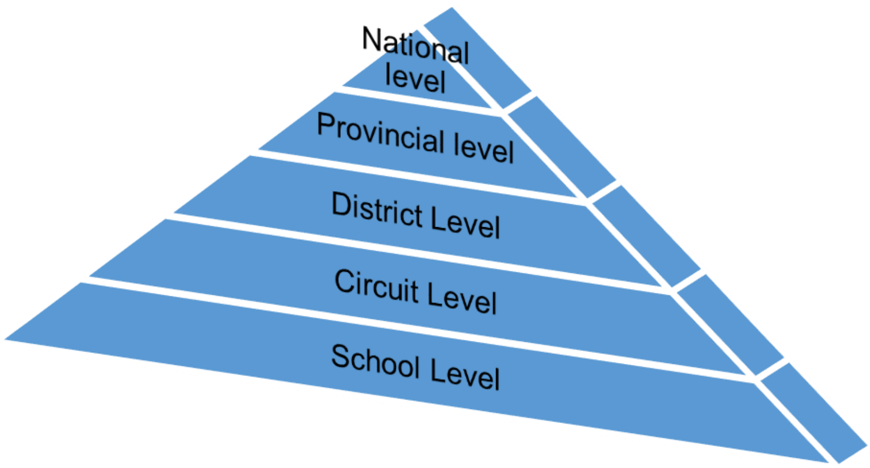


Figure 4.1 School Governance Hierarchy in SA (Mansfield-Barry and Lithalethemba, 2017)

Government officials are responsible for governing schools at national, provincial, district and circuit levels while school governing bodies handle the school level governance (Mansfield-Barry and Lithalethemba, 2017). The responsibility of management of schools on the national level is directed to the DBE Minister while the provincial level is directed to the Provincial Member of Executive Council (MEC) (Skelton, 2013). The district level governance is handled by district directors while the circuit managers handle the circuit level governance (Ndlovu, 2017). Circuit managers act as mediators between district offices and Provincial DBE (Bantwini and

Moorosi, 2018). The parents, learners and community associated with each school are considered as the school governance bodies (Van Wyk, 2004).

The policies followed for governing schools should adhere to the rules in the Bill of Rights in the Constitution (Beckmann and Prinsloo, 2009). Any violation to these rules is considered to be invalid by the court (Olivier, 2003). Section 29(1) in the Bill of Rights states that every individual in SA has the right to a basic education, including adult basic education (Chürr, 2015).

4.3 SELECTION AND PURPOSE OF CASE STUDY

According to the statistics released by the DBE, there are more than 25,000 schools in SA catering for more than 12 million learners (Collective Media Hack, 2016). This research focused on special schools that cater for the needs of learners with disabilities. The minimum entrance requirement for any learner (disabled or not) at tertiary institutions in SA is to have a matriculation certificate with NQF level 4 or a matric equivalent qualification (Govender, Motala and Joubert, 2013a). A matriculation certificate in SA usually has a minimum of six subjects and these will help determine whether the learner qualifies for entry into the first year of university for either a higher certificate, diploma or degree (Spaull, 2014). Faculties and departments, have their own entrance requirements, which both align with the university's minimum requirements for entry as well as their own additional mark requirements. For entry into Engineering courses, there are specific minimum university requirements for subjects like English, Mathematics, Mathematical Literacy and Physical Science (Kent and Noss, 2003). Therefore, a learner is required to have good academic results at school level in order to apply for Engineering courses at universities (Govender, Motala and Joubert, 2013b). The researcher chose the special schools in the Free State province in order to investigate the challenges faced by VILs while trying to enrol into Engineering courses. There are three reasons why the researcher chose this province to be part of the case study:

Firstly, the special schools in the Free State had expressed their interest in assisting the researcher in participating in the study to identify the barriers that their learners faced while considering Engineering courses at universities. Secondly, the VILs in special schools in the Free State are representative of VILs in South African special schools; and once the framework in the special school environment has been evaluated, it can be generalised beyond this. Thirdly, if one assesses the matric results for the past few years, it is noticed that the Free State province has been in the first position in SA for two consecutive years (2016, 2017) (Seleka, 2019). The Matric pass rate for all students (including the students with disabilities) who wrote the National Senior Certificate exams in the Free State province was 93% in 2016 and 86% in 2017 (Seleka, 2019). The Free State lost the first position to Gauteng in 2018 by a small margin. However, in spite of these good academic results, there are only a few VIL engineers in SA, which includes the Free State province (Mayat and Amosun, 2011). A question then arises "Where do VILs go after completing school?"

4.4 CASE BACKGROUND AND DEMOGRAPHICS

Part A of the case study was done at special schools in the Free State province. There are two special schools in the Free State province: Bartimea School for the Deaf and Blind and Thiboloha School for the Deaf and Blind.

4.4.1 Thiboloha School Demographics

Thiboloha School is based in Qwaqwa in the Eastern Free State of SA (Akach, 2010). Qwaqwa is a hilly area of about 655 square kilometre surrounded by the Drakensberg Mountains (Murray, 1981). Qwaqwa was considered to be the homeland for more than 180 000 Sotho-speaking people (Riep, 2011). During the Apartheid period, Qwaqwa had the right of self-government; free from being controlled by external powers (Murray, 1981). Its capital city was Phuthaditjhaba (Akach, 2010). It was also known as "Witsieshoek" (Afrikaans name) (Murray, 1981). The people from the tribes Bakoena and Batlokoa lived in this region (Pitso, 2009). After the Apartheid era in 1994, Qwaqwa joined the Free State province and is now a part of the province with Phuthaditjhaba serving as the seat of Maluti a Phofung Local Municipality (Frankental and Sichone, 2005). Most of the population in this region are composed of blacks, followed by whites, Coloureds and Asians (Akach, 2010).

Thiboloha School was founded in 1975 (Baboo, 2011). The school offers classes for learners with visual impairments, hearing deficiencies and additional special needs, from Grade R to Grade 12, serving a total of 370 learners. The language of instruction used in this school is English. Out of the 370 learners in Thiboloha School, 40 learners were visually impaired at the time of the study. This study focuses on the visually impaired high school learners (Grade 10 to Grade 12). There were a total of 12 VILs attending Grade 10, 11 and 12 at the time of this study. The high school learners were the apt choice for participating in this study as these students were being prepared for tertiary education. It was too early for the learners in other grades to analyse and comment on the challenges that VILs while entering into Engineering courses at universities.

The principal of Thiboloha School, Mr Lerata Khooa had expressed his concern to the deputy minister of higher education that in spite of the school achieving consecutive 100 percent pass rates from 2011, the learners struggled to meet the admission requirement of tertiary institutions (The Weekly, 2016). Figure 4.2 shows a newspaper article (left side of the page) that was published regarding the deputy minister's visit to Thiboloha School. After the visit to the school, the deputy minister's media liaison officer, Ms Busiswa Nongogo, released a statement on the importance of career campaigns in schools (Department of Higher Education and Training, 2016).

Deputy Minister to visit Qwaqwa School

By: Libuseng Nyaka

The principal of Thiboloha Special School for the Deaf and Blind in QwaQwa Lerata Khooa says he is upbeat about the forthcoming visit by the deputy minister of higher education and training Mduduzi Manana to the school as it is gives an opportunity to students to interact with education authorities. Manana is expected to visit the school on Monday.

Khooa said the purpose of the deputy minister's visit to the school is to inform the students about the opportunities available to them in higher education.

"We are very excited about this visit," said Khooa. "As a school, this is a great opportunity for our leaners who have only known Thiboloha from crèche. They will now be able to know about how they can further their studies after completing their matric here," he added.

Khooa said the minister's visit will focus on leaners from grades 10 to 12. The learners will also have an opportunity to interact with students from the University of the Free State and Maluti Technical Vocational Education and Training College who are also invited to the event and are expected to share their higher education experiences with the learners. He said while his school was doing well and had achieved a 100 percent pass from 2011 up 2016, the learners did not meet the requirements of admission at universities.

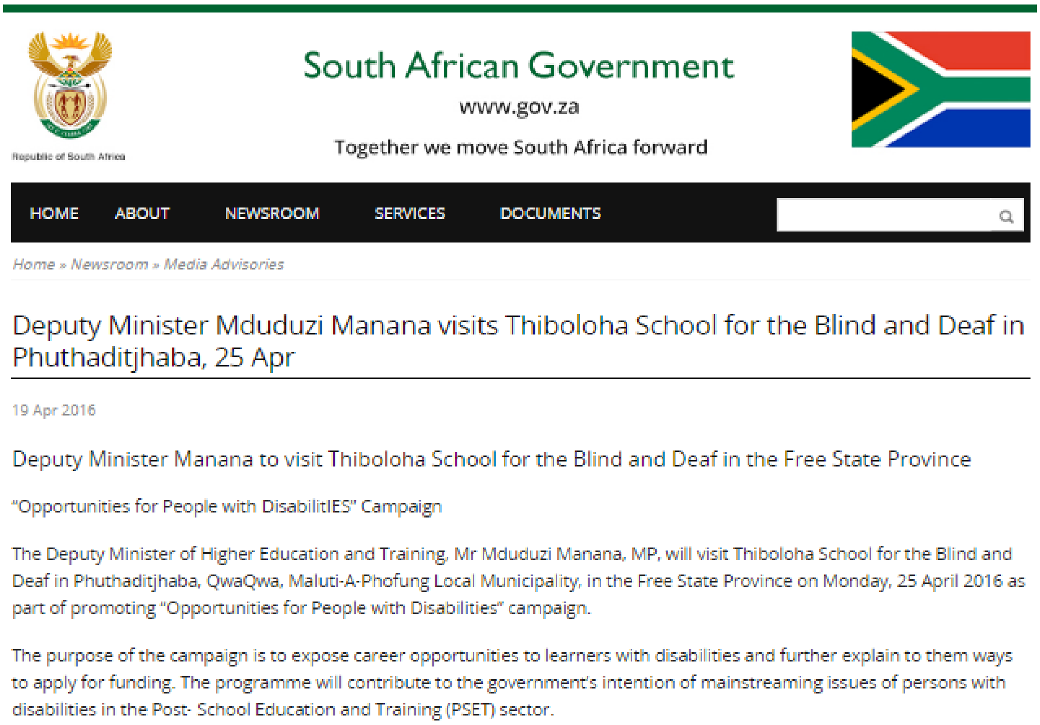
"Last year we had six leaners in matric. Five were deaf while the other one was partially blind and they all passed. But none of them is at an institution of higher learning because sign language is not recognised in the curriculum there. Things are expected to change after 2018 when sign language will be included in the curriculum as a language," Khooe.

A statement released by the deputy minister's media liaison officer Busiswa Nongogo said the purpose of the campaign is to expose career opportunities to learners with disabilities and further explain to them ways of applying for funding.

"The programme will contribute to government's intention of mainstreaming issues of persons with disabilities in the Post School Education and Training (PSET) sector," said the statement.

Figure 4.2 Deputy Minister's visit to Thiboloha School (The Weekly, 2016)

Figure 4.3 shows the news article that was published regarding the 'Opportunities for People with Disabilities' Campaign in Thiboloha School.



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Deputy Minister Mduduzi Manana visits Thiboloha School for the Blind and Deaf in Phuthaditjhaba, 25 Apr

19 Apr 2016

Deputy Minister Manana to visit Thiboloha School for the Blind and Deaf in the Free State Province

"Opportunities for People with DisabilitIES" Campaign

The Deputy Minister of Higher Education and Training, Mr Mduduzi Manana, MP, will visit Thiboloha School for the Blind and Deaf in Phuthaditjhaba, QwaQwa, Maluti-A-Phofung Local Municipality, in the Free State Province on Monday, 25 April 2016 as part of promoting "Opportunities for People with Disabilities" campaign.

The purpose of the campaign is to expose career opportunities to learners with disabilities and further explain to them ways to apply for funding. The programme will contribute to the government's intention of mainstreaming issues of persons with disabilities in the Post- School Education and Training (PSET) sector.

Figure 4.3 DHET initiative for career campaigns (Department of Higher Education and Training, 2016)

This school was known to have produced learners among the 100 top achievers list in the Free State province. Frank Letshesha, a VIL from Thiboloha, had secured a place among the top 100 achievers in the province in 2016 (Bongekile, 2017). Figure 4.4 shows the front building of Thiboloha School of Deaf and Blind. The classrooms for the deaf and blind students are behind this building.

Figure 4.4 Thiboloha Special School (Hey Schools, 2015)

4.4.2 Bartimea School Demographics

Bartimea School is based in Thaba ‘Nchu, in the Free State province of SA (Akach, 2010). Thaba ‘Nchu is mostly populated by Tswana and Sotho people (Twala and Barnard, 2006). This town was established in 1873 (Raper, 1987). It is now known to be the homeland for Tswana people (Aarons and Akach, 2002). Thaba ‘Nchu is also known as Blesberg (Raper, 1987). Bartimea Schoool was established in 1962 by the Dutch Reformed Church for the Tswana- and Southern Sotho- speaking people (Aarons and Akach, 2002). Bartimea School is located approximately 63 kilometres from Bloemfontein, which is convenient for learners to visit universities like the University of Free State (UFS) and CUT on a regular basis and interact with the students and officials at the university (Matobako, 2016).

Bartimea School handles the responsibility of educating students with disabilities from Grade R to Grade 12. The total number of blind and deaf learners in the school is approximately 349. The language of instruction used in this school is English. This part of the case study focused on interacting with high school learners as their views and perceptions on entering into Engineering courses are important. These learners are in the stage of finishing their school level education and are in the process of deciding on what courses they should choose as they study further to build their dream careers. The learners from Grade R to Grade 9 are excluded from the study as it is too early for them to point out their views on the higher education system in SA. The target population for the focus group discussions were the visually impaired high school learners (Grade 10 to Grade 12). The school had about 34 learners that were attending Grade 10-12 during the time of the study. Out of these 34 learners,19 participated in this study. Figure 4.5 shows the front wall of Bartimea School for the Deaf and Blind. The gate to the right side of this wall leads to the beautiful and spacious buildings of the school.

Figure 4.5 Bartimea Special School (Courant, 2016)

4.5 DATA COLLECTION AND ANALYSIS

This part of the case study (Part A) utilised three methods for collecting data. This study started with an intensive literature review which was discussed in Chapter 2 which was followed by focus group discussions with VILs at special schools and questionnaires with special school educators. The researcher used the data collected from the literature and case study to develop a framework. The framework was then evaluated by experts from the field to establish its validity. Table 4.1 gives a summary of the research methods used and how the research questions and objectives are linked to each method as well as the total participants involved in part A of the case study.

Table 4.1 Summary of research methods and participants (Case Study-part A)

Main Aim	**Research Question**	**Research Objective**	**Participants (Count)**	**Institution**	**Research Method**
Develop a framework for the provision of VILs in Engineering education in SA	• To what degree are the Engineering faculties in SA accommodating VILs? • What are the challenges that VILs face when considering entry into Engineering courses? • What guidelines should exist for the effective use of these ICT tools by VILs in Engineering?	• To determine the degree to which Engineering faculties in SA are accommodating VILs. • To identify the challenges that VILs in SA face when contemplating entry into Engineering courses. • To develop a framework to effectively use these ICT tools to benefit VILs in Engineering education in SA.	VILs (19)	Bartimea School for the Blind and Deaf	Focus Group discussions Literature review
			VILs (12)	Thiboloha School for the Blind and Deaf	Focus Group discussions Literature review
			Special school Educators (7)	Bartimea School for the Blind and Deaf	Questionnaires Literature review
			Special school Educators (7)	Thiboloha School for the Blind and Deaf	Questionnaires Literature review

4.5.1 Focus group discussions

The case study at school level utilised focus group discussions to gather data from VILs at special schools. Focus groups provides a better understanding of the perceptions of people and a deeper interpretation of the phenomenology being studied (Williams and Nagle, 2013). The aim of conducting focus group discussions in this study was to understand the views and perceptions of VILs on the provision to tertiary institutions, especially Engineering courses. The focus group discussions with high school VILs helped to generate useful information regarding the challenges they faced while considering entry into Engineering courses.

4.5.1.1 Developing Focus Group Questions

The effectiveness of a focus group discussion depends on the questions being asked to the participants (Epstein, Kernberger and Raffi, 1999). In preparation for the focus groups, the researcher conducted a thorough literature review on the topic. The researcher also ensured that the focus group questions used in the discussions were linked to the research questions and objectives. The focus group sessions usually contain three types of questions: introductory questions (aka engagement questions), exploration questions and ending questions (Krueger and Casey, 2002). The researcher started the discussion with a good introductory question. The engagement questions for the study were designed in such a way that the participants understood the topic that they were going to discuss. By doing so, the participants felt comfortable to express their views during the discussion. For example, in this study, the researcher began the discussion with the question," Can you please tell me what grade are you in?" This was followed by a set of exploratory questions.

The researcher included exploratory questions to get an in-depth information from the participants regarding the topic of discussion. For example, one of the exploratory question used in this study was: "What factors influence your decision to choose a particular course in a tertiary institution?" To ensure that the participants had not missed out anything during the discussion, the researcher included an ending question as the part of the discussion. The researcher ended the discussion by asking the students," Have we missed anything? Any other issues that we have not discussed?" The additional information shared by the participants at the end of the discussions may sometimes turn out to be crucial for the study.

The following guidelines were used for developing the focus group questions for the study (Krueger and Casey, 2002):

- Questions should be brief and precise;
- Use open-ended questions to get in-depth information from the participants;
- Questions should not make the participants uncomfortable;
- Avoid dichotomous questions;
- Avoid asking too many questions that start with "why". Rather ask specific questions on the topic;
- Use questions that motivates their interest in participating;
- Order the questioning should be general question about the topic to more specific in depth questions; and
- Use open-ended questions as ending questions to collect any additional thoughts on the topic.

Relevant literature was carefully studied before developing the questions for the focus groups. The focus group questions and the references linked to each questions are listed in Table 4.2. The introductory and exit questions are not included in this table.

Table 4.2 Focus group questions and their references

Questions	References							
	(Matshedisho, 2007)	(Kochung, 2011)	(Hodgson and Khumalo, 2016)	(Buthelezi, 2014)	(Mayat and Amosun, 2011)	(Engelbrecht and De Beer, 2014)	(Mushome and Monobe, 2013)	(Seyama, Morris and Stilwell, 2014)
1. Do you think that every high school student in South Africa should aspire to a college degree? Why or why not?	X	X						
2. Do you think that every high school student in South Africa should aspire to a college degree? Why or why not?		X						
3. Why is it important to go to college?	X	X						
4. What are your current career goals?					X			
5. What factors may influence your decision to choose a particular tertiary institution?						X		
6a. Do you have career guidance from school?			X	X				
6b. If yes, is it the teacher or career guidance advisor?			X	X				
6c. What kind of career advice have you received?			X	X				

Questions	References							
	(Matshedisho, 2007)	(Kochung, 2011)	(Hodgson and Khumalo, 2016)	(Buthelezi, 2014)	(Mayat and Amosun, 2011)	(Engelbrecht and De Beer, 2014)	(Mushome and Monobe, 2013)	(Seyama, Morris and Stilwell, 2014)
7. Is any of your peers interested in choosing Engineering at university level?					X			
8. What may help to interest you in an Engineering course?					X			
9. Do you feel that you might struggle taking Engineering courses? Explain.					X			
10. What are the factors that might hinder you from choosing Engineering?					X			
11. What do you think should be in place at a university in order to offer Engineering to VILs?					X			
12a. Are you frightened by the thought of going to a university? 12b. If yes, why?						X	X	
13. What are your suggestions that could help alleviate these obstacles and make you feel comfortable on campus?						X		X
14. Have you given thought to attending any university in SA? If yes, which one and why?		X				X		

4.5.1.2 Identifying Participants, Facilitator and Research assistants

The selection and purpose of the case study as well as the choice of participants has been discussed in Section 4.3. The facilitator and the research assistants played a very important role in conducting the case study at school level. The facilitator is responsible for keeping the group focused and promote a healthy and productive conversation (American Statistical Association, 1997; Romm, Nel and Tlale, 2013). The facilitator should motivate everyone to share their views and make everyone comfortable (Nyumba *et al.*, 2018). The researcher was the facilitator for this study. To assist the facilitator during data collection, two research assistants were trained to become part of the data collection process. The research assistants could speak English as well as the local languages, Sotho and Xhosa fluently. While the facilitator was busy communicating with the focus group, it was the responsibility of the research assistants to take notes and record the sessions. This helped the facilitator to focus on the discussion and to obtain a balanced input from the participants.

The facilitator gave the research assistants a detailed overview of the study as it was important that they understand the objectives and motive of the study. The importance of the data collection method and the ethical considerations to be taken during the study were also explained to them by the facilitator.

4.5.1.3 Pilot testing

The designed focus group questions were piloted before scheduling the actual discussion (Breen, 2006). A pilot test was considered the trial-run of the research tool designed to conduct the study (Van Teijlingen and Hundley, 2002). In order to ensure that the questionnaire was clear, simple and properly structured for the participants, it had to be piloted (Tom, Mpekoa and Swart, 2019). While designing the questionnaire, the researcher made sure that the questions were linked to the research aim. VILs from CUT were recruited for the pilot-testing. Because of a low number of VILs in Engineering, the researcher has to recruit sighted Engineering students for the pilot test. This low number of VILs in Engineering indicates that this study was essential for VILs.

The pilot test participants were asked about the questions in general, clarity of the questions, difficult questions, to identify the questions they considered inappropriate and repetitions in question. The feedback from the participants indicated that the questions were clear, appropriate and well structured. Minor changes were required with one question being added based on the feedback received from the participants. This is listed as Question 9: “Do you feel that you might struggle taking Engineering courses? Explain”. The pilot group suggested that before the actual participants were asked about the factors that might hinder them from choosing Engineering, it was necessary to know their viewpoints about Engineering. The next section presents the data collected from the focus groups.

4.5.1.4 Roles and responsibilities for the focus group session

The facilitator visited the special schools (Bartimea School and Thiboloha School) several times prior to the allocated date for conducting the study. It was important to get the parental consent for the VILs to participate in the study. These interactions also helped the facilitator to interact with the educators and principal and also observe how special schools function. The students, parents, educators and the school were all well informed about the study and about the discussions that was going to take place with the facilitator and the students. The facilitator was given a time and day that did not conflict with the students’ academic schedule.

On the scheduled day of the discussion, the facilitator and research assistants arrived an hour early at the venues to set up the room for the discussions. This gave the facilitator and assistants’ time to make the necessary seating arrangements, organise materials and refreshments. The researcher ensured that the necessary preparation (such as room configuration, audio equipment, etc.) was made for the discussion. Focus group discussions were led by the researcher assisted by a research assistant whose responsibility was to note and observe the verbal and non-verbal interactions of the participants. The participants of the focus group discussion were VILs from the special schools in the Free State province attending Grade 10, 11 and 12. Initially the researcher had targeted Grade 12 learners but due to the low number of these learners, the target group was expanded to Grade 10 and 11 learners.

There were five (5) focus groups; with each group having 6-7 members each. The optimal size for the focus group is 6 to 10 participants (Morgan, 1997). The focus groups in this study had the optimal size to promote healthy and productive discussions. The total number of participants was 31 from both schools. Five focus groups of VILs were selected from the Free State special schools using a stratified sampling technique. Participants within each group (6-7 per group) were selected using simple random sampling. The participants in these focus groups had characteristics that represents a larger population and this assists the researcher to gain an in depth understanding of the topic from the participants' perspective.

The facilitator/researcher started the discussion by introducing herself and her assistants and the purpose of the focus group. The time frame for the discussion as well as the rules for the discussion was provided to the participants. They were also assured that their privacy and confidentiality would be secured. The researcher also provided the participants with her contact information so that the participants could contact her in future. The facilitator made them comfortable by promising them that they could withdraw from the study at any time if they wanted to. The facilitator's introduction is provided in Appendix E.

The researcher made sure that the participants were given ample time to think and respond to each question that was asked during the discussion. The researcher also assisted with examples when the participants struggled to understand a question. The researcher converted the audio recording into transcripts and later compared the transcripts with the notes taken by the assistants.

The following sub-objectives were addressed from the focus group data analysis:

- To determine the degree to which Engineering faculties in SA are accommodating VILs.

- To identify the challenges that VILs in SA face when contemplating entry into Engineering courses.
- To develop a framework to effectively use ICT tools to benefit VILs in Engineering education in SA.

4.5.1.5 Focus group data collection and analysis

The focus group questions (Appendix E) were divided into three sections (Part A, B and C). Qualitative content analysis technique was used to analyse the data collected from the focus group discussions. The data collected from the focus group discussions and literature review were then aggregated to confirm whether the research objectives were effectively addressed (Labaree, 2009). The data collected is presented below.

Part A: Demographic Information

Question 1: Can you please tell me what grade are you in?

The focus group was comprised of high school learners, 32% in Grade 10, 39% in Grade 11 and 29% in Grade 12 (see Table 4.3).

Table 4.3 Participants' background information

Grade 10		**Grade 11**		**Grade 12**	
Female	Male	Female	Male	Female	Male
19% 6	13% 4	13% 4	26% 8	6% 2	23% 7

Part B: Views of VILs on higher education

Question 2: Do you think that every high school student in South Africa should aspire to a college degree? Why or why not?

All the participants (100%) indicated that every high school student in SA should aspire to a college degree. The responses of the participants are presented in Table 4.4.

Table 4.4 Do you think that every high school student in South Africa should aspire to a college degree? -Participants' response

	Responses
Resp-1	Yes. I feel like I need to go to the university. If I get an opportunity I want to improve my skills
Resp-2	Yes. We have different careers; we need to build our career for better jobs
Resp-3	Yes, to improve your skills
Resp-4	Yes, I want to have more job opportunities
Resp-5	Yes, for better jobs
Resp-6	Yes. sometimes we want better knowledge. We can also get job easier
Resp-7	Yes. When you apply for a job, every job these days needs a university degree
Resp-8	Yes, for future use of the country
Resp-9	Yes, to gain more knowledge
Resp-10	Yes. We have to study further; improve what we have and have more skills
Resp-11	Yes. It is important; if we need to apply for a job, we need qualification
Resp-12	Yes, to improve your skills
Resp-13	Yes, I want a job
Resp-14	Yes, to learn more

	Responses
Resp-15	Yes, there we learn a lot. My CAT teacher said that some of the things are continued in the university. For example, in HTML, to know better you should go to the university
Resp-16	Yes, to improve ourselves by learning and gaining knowledge
Resp-17	Yes, better job
Resp-18	Yes, job opportunities
Resp-19	Yes, better qualification, better jobs
Resp-20	Yes, learn more, to improve skills
Resp-21	Yes, follow my career
Resp-22	Yes, job opportunities
Resp-23	Yes, I want the career I wish to have
Resp-24	Yes, to improve my skills
Resp-25	Yes, good job opportunities
Resp-26	Yes, good job opportunities
Resp-27	Yes, to learn more and to get a good job
Resp-28	Yes, to improve my skills
Resp-29	Yes, for better job opportunities
Resp-30	Yes, jobs
Resp-31	Yes, for better job opportunities

The responses were analysed according to the types of categories and issues that emerged. Based on the categories that emerged, all the participants agreed that every high school student in SA should aspire to a college degree. Some of the reasons they mentioned to aspire higher education include:

- better job opportunities;
- better knowledge;
- career development; and
- contribution to the country's future.

According to Kochung (2011), higher education enables individuals to attain knowledge and skills and allows them to engage in the development and decision making process of the country. The reasons mentioned by the participants regarding why they aspired for a college degree verifies the already identified factors discussed in the literature.

Question 3: Why is it important for a VIL to go to college?

The responses of the participants are presented in Table 4.5.

Table 4.5 Why is it important for a VIL to go to college?- Participants' response

	Responses
Resp-1	It important for a VIL to go to college, we are just like other normal children
Resp-2	It is important for VILs to learn, to follow their career and talents. It will depend on the units that will be able to accommodate the learners. We expect to get degree, masters and doctorates
Resp-3	Better jobs
Resp-4	To improve your knowledge
Resp-5	University education will help us to compete with others
Resp-6	Job opportunities
Resp-7	Colleges should accommodates VILs and help us improve our skills
Resp-8	There are practicals in college; we need to be exposed, learn new skills and experience
Resp-9	It is a way in which we can adapt to a few challenges in society
Resp-10	We have limited skills;it is important for us to find a qualification so that we can fit in the offices and shops and can be assisted
Resp-11	People say that blind people can't do anything; so I want to prove with my career that I can

	Responses
Resp-12	We need to have knowledge. Disabled people and normal people are equal, but when we are having disability, it is more important to go to university because it helps us to get jobs outside there
Resp-13	We get to meet other students, it's a new environment for us
Resp-14	Job opportunities
Resp-15	Exposure to a new environment
Resp-16	Improve our skills
Resp-17	Improve our knowledge
Resp-18	Better jobs
Resp-19	To build a career
Resp-20	To follow my career
Resp-21	Better qualification and jobs
Resp-22	To build your own career
Resp-23	To compete with others
Resp-24	Jobs
Resp-25	For knowledge
Resp-26	To learn and follow your career
Resp-27	More experience and to improve our skills
Resp-28	Job opportunities
Resp-29	For our career
Resp-30	To compete with others, we need to study
Resp-31	To improve skills

Categorised responses of the participants are depicted in Table 4.6. Higher education offers varied benefits to the individuals like better employment opportunities, better income, improved knowledge and equal participation in the society (Kochung, 2011). The factors listed by the participants regarding the importance of higher education for VILs align with the factors discussed in the literature.

Table 4.6 Why is it important for a VIL to go to college? - Categories

Categories
Build their career
Better job opportunities
Improved knowledge
Improves academic competition
Fit in to society
Improve on their skills
To be treated as equal to others

Question 4: What are your current career goals?

The responses of the participants are presented in Table 4.7.

Table 4.7 What are your current career goals? - Participants' response

	Responses
Resp-1	Teacher
Resp-2	I haven't thought about it. I don't know. I have a passion for helping people, maybe a social worker
Resp-3	Physiotherapist
Resp-4	Social worker
Resp-5	Social worker
Resp-6	Social worker
Resp-7	Artist
Resp-8	Physiotherapist
Resp-9	Language interpreter
Resp-10	Lawyer
Resp-11	Teacher
Resp-12	Sound engineering
Resp-13	Media
Resp-14	HR
Resp-15	Accountant

	Responses
Resp-16	Social worker
Resp-17	Teacher
Resp-18	Translator
Resp-19	Law
Resp-20	Artist
Resp-21	Accountant
Resp-22	Social worker
Resp-23	Fashion designing
Resp-24	Actor
Resp-25	Law
Resp-26	Artist
Resp-27	Accountant
Resp-28	Social worker
Resp-29	Musician
Resp-30	Teacher
Resp-31	Social worker

The participants indicated: Human Resources Consultant/Officer, Accounting, Actor, Artist, Fashion Designing, IT, Language Interpreter, Law, Media, Musician, Physiotherapy, Social Worker, Sound Engineering, Teacher, and Translator as some of their career goals.

Only two participants in the study expressed their interest in the Engineering stream. Mayat and Amosun (2011) indicated in their study that there is a low participation of VILs in the Engineering stream. The responses from the participants support the findings from the literature.

Part C: Challenges VILs face in provision to tertiary institutions especially Engineering courses

Question 5: What factors may influence your decision to choose a particular tertiary institution?

The responses of the participants are presented in Table 4.8.

Table 4.8 What factors may influence your decision to choose a particular tertiary institution? - Participants' response

	Responses
Resp-1	University that caters for blind and partially sighted students
Resp-2	University that offers various careers for various people and various disabilities
Resp-3	Good disability unit
Resp-4	Accommodation facilities
Resp-5	University that provides for our needs and treat us properly
Resp-6	University that provides opportunities or resources to choose the career we want
Resp-7	Maybe you are going to staying in the res, is the building/place good
Resp-8	Standard of education
Resp-9	Equipments
Resp-10	Good disability unit
Resp-11	Infrastructure
Resp-12	Resources
Resp-13	Standard of education
Resp-14	Infrastructure, blind learners have to adapt to the new place
Resp-15	Standard of education.

	Responses
Resp-16	Depends on what requirements are needed to enter that university
Resp-17	Resources to assist me in my course. Teachers should teach the course in a way that we understand.
Resp-18	Good disability unit
Resp-19	Transport facilities
Resp-20	Accommodation
Resp-21	Question papers should be in braille; textbooks should be in braille
Resp-22	There should be someone in the university to guide you, to tell that you are not supposed to go there, but here. The person guiding you should tell us what they see on the way, like a dustbin; because if we go alone we can bump into it. I will prefer a university which has this facility
Resp-23	I need to feel like anyone; so good disability unit should be there in university
Resp-24	Proper resources
Resp-25	Infrastructure
Resp-26	University that caters for our needs
Resp-27	Good infrastructure
Resp-28	Resources to teach us
Resp-29	Good disability unit.
Resp-30	Good disability unit.
Resp-31	Good disability unit.

The participants' responses were carefully studied and analysed. Various codes were identified based on the participants' responses. The codes were grouped into categories. The categories that emerged are listed in Table 4.9.

Table 4.9 Factors that influence the decision to choose a particular tertiary institution- Categories

Categories
Caters to the needs of VILs
Supportive disability unit
Resources & Equipment
Safe and accessible Infrastructure (sidewalks with curb side ramps)
Assistance with mobility around the campus
Transportation facilities
Accommodation facilities
Standard of education offered by the university
Teaching methodologies used
University entry requirements
Treatment given to VILs at the university

Engelbrecht and De Beer (2014) reports that VILs tend to choose universities where they have a good infrastructure, proper student support facilities, adequate educational support facilities and proper treatment from the university management. The participants' response verifies and adds to the already identified factors from the literature. Apart from the identified factors in the literature, this study also reports that VILs are also concerned about the standard of education that is being offered in the universities of SA.

Question 6: a) Do you have career guidance at school?

b) If yes, is it the teacher or career guidance advisor who offers that service?

c) What kind of career advice have you received?

A total of 90% of the participants (twenty-eight participants) indicated that they did not receive any career guidance at school, whereas 10% (three participants) of the participants indicated that they received career guidance from their school. The three participants indicated that they were taken to career fairs when they reached Grade 12 and they were given guidance regarding the requirements at different universities for different courses. They also indicated that some of the universities/colleges around the Free State province did visit their school as a part of the university's marketing strategy.

Hodgson and Khumalo (2016) in their study done at one of the special schools in SA reports that the learners do not receive proper career guidance at schools. The responses from the participants in this study agree to the findings from the existing literature.

Question 7: Are any of your peers interested in choosing Engineering at university level?

A majority of the participants (87%- 27 participants) indicated that none of their peers were interested in choosing Engineering. The remainder of the participants (13%- 4 participants) indicated that they were aware of their peers who were interested in choosing Engineering at university level; but the participants indicated that their peers had to drop their passion in spite of their interest in Engineering. The reason pointed out for this withdrawal was that the said VILs did not do Maths and Science at special schools as it was considered to be a difficult subject. So these VILs would not meet the university requirements in order to study Engineering.

Mayat and Amosun (2011) indicated in their study that there is a low representation of VILs in Engineering in South African universities. The responses from the participants indicated their lack of interest in Engineering, and so validating the existing literature.

Question 8: What may help to interest you in an Engineering course?

The responses of the participants are presented in Table 4.10.

Table 4.10 What may help to interest you in an Engineering course? - Participants' response

	Responses
Resp-1	Many engineers say they can earn money if we choose engineering
Resp-2	You can help the country by taking Engineering, like Eskom is the company that is catering the country with electricity
Resp-3	I don't know much about engineering. Universities should come to our school and make us aware of engineering
Resp-4	Better canvasing from colleges and universities
Resp-5	We don't even know the requirement for engineering courses, we don't know about engineering
Resp-6	If we know that there are resources to help us study the course
Resp-7	We should be given engineering subjects in school
Resp-8	Someone from colleges should come and tell us about engineering
Resp-9	We don't know what needs to be done in school to take engineering at colleges/universities, we thought we can't do
Resp-10	We don't have the background
Resp-11	We thought we need to take extra subjects to take engineering. We are not aware about that. Awareness sessions needs to be done by universities/colleges.
Resp-12	Resources/required subjects at school level so that we can take engineering

	Responses
Resp-13	We are not aware about engineering
Resp-14	We didn’t get the information in time; so we are not interested, we have thought of other careers
Resp-15	Even if we are doing these subjects, there should be weekend classes for those students who are interested in taking engineering for those required subjects. Students can follow their passion
Resp-16	If the department of education can invest more money and resources, then we can study like normal students
Resp-17	Maths and science should be taught to all blind learners in all special schools; not in some special schools
Resp-18	We didn’t know that we could take engineering
Resp-19	Resources at school level so that we can take maths and science. Without maths and science, how can we do engineering
Resp-20	Universities should come to our schools to inform about engineering
Resp-21	Information about engineering should be provided so that we know about engineering
Resp-22	We don’t have background knowledge about engineering
Resp-23	Maybe tell us what engineering is and what are required to enter engineering course
Resp-24	Department of education should provide funding for resources so that we can follow our career
Resp-25	Resources for studying maths & science at school
Resp-26	Our schools don’t have enough resources to teach maths & science
Resp-27	Colleges/universities should come to our school and inform us about engineering
Resp-28	We don’t know about engineering
Resp-29	We need more information about the course

	Responses
Resp-30	At school level we need to be informed about engineering
Resp-31	Blind engineers can help to better the lives of other blind people. These engineers can visit schools to motivate us. Department of higher education should invest more money for proper resources and infrastructure to support us.

It was important for the researcher to get an understanding of the factors that may help VILs in becoming interested in Engineering courses. Responses provided by the participants were carefully examined and categorised. The categories that emerged out of the analysis are listed in Table 4.11 below.

Table 4.11 What may help to interest you in an Engineering course? - Categories

Categories
Awareness of Engineering courses
If successful Visually Impaired Engineers can visit schools in order to motivate VILs that it is possible
Evidence that becoming an engineer who is visually impaired will benefit the society
Availability of tools and equipment that assist VILs to study Engineering
Funding for infrastructure
Colleges and universities marketing their courses at high schools
Awareness of the pre-requisite subjects at special schools
Passion
To earn money

The researchers Mayat and Amosun (2011) identified that there is a low representation of VILs in the Engineering stream. Lack of awareness of VILs about disability issues as well as the poor treatment received by VILs from the academic staff were stated as the reasons for this low representation. However, there is not enough literature regarding the factors that might interest VILs in Engineering. Therefore, the participants' response in this study contributes to the existing literature.

Question 9 and 10 asked the participants' viewpoint on the factors that hinder them from taking Engineering.

Twenty-six percent of the participants (8 of 31 participants) indicated that they would not struggle to complete an Engineering course provided that there are proper tools and equipment dedicated for teaching and learning Engineering courses. The responses of the participants regarding the factors that hinder them from taking Engineering are presented in Table 4.12.

Table 4.12 What are the factors that hinder you from taking Engineering? - Participants' response

	Responses
Resp-1	It depends on your passion and interest
Resp-2	Nothing. We just need proper resources
Resp-3	In computer systems, sometimes you might be asked how to remove RAM. Totally blind students don't know what is RAM, how to feel it, they don't know where to go to change RAM
Resp-4	To program, if you are using JAWS, JAWS don't read everything. JAWS program has limitations. When reading through the internet, JAWS can't read everything and the hyperlinks. Even though if there are specialized software, I think programming will be difficult. Theoretically it will be easy
Resp-5	I don't know much about engineering
Resp-6	We are not aware about engineering
Resp-7	Safety reasons, so can't think of electrical engineering

	Responses
Resp-8	Civil engineering will be difficult if it has to do with measurements, mathematics is the most difficult subject for us. It is difficult because we are not taught properly at school. Teachers say that we don't have equipments at school for maths. I am interested in maths. I am interested in taking engineering, but we need proper equipments and resources to learn these subjects.
Resp-9	No resources to teach maths and science at schools. If we have proper equipments at schools and universities we can do engineering
Resp-10	There are not enough resources to teach mathematics at school especially for totally blind; level of teaching is not adequate for us to do engineering. If we have proper resources, I am confident that we will not struggle to do engineering
Resp-11	We can't see the colour codes; we will struggle if we are totally blind; but partially sighted can do it. We need proper resources to do engineering
Resp-12	That's not my passion, maybe if I knew about engineering before I would have thought about it
Resp-13	We don't know whether there are resources for us in engineering in the university
Resp-14	Safety issues
Resp-15	With proper resources, we can do engineering
Resp-16	We are not informed about engineering; the subjects we need to take at school level/levels required to choose engineering
Resp-17	Awareness is the only reason that stops us from choosing engineering
Resp-18	Our subjects, we are forced to make choices at school. Now, I am not allowed to do pure maths and science because I am totally blind while my totally blind friends

	Responses
	in Princehof school are doing pure maths and science.at times, it is difficult when the teachers say that we can't do pure maths and science, so we can't do engineering. My passion is to do chemical engineering, but my school doesn't allow me to take maths and science saying that I am totally blind, they can't teach me. My school does not trust me, don't have the facilities. They say you have to use braille and teachers will struggle teaching us. They say the graphs in pure maths is the problem; but I am surprised because we also have graphs in maths literacy. I have confidence that I can do maths, I was good in maths till grade 9. From grade 10, my teachers said I can't take maths and science. I know it will strain my eyes; but I am still ready. I am sure that if we have good resources at schools and universities, we can do engineering.
Resp-19	We can't do it because we don't do mathematics and science
Resp-20	We don't do the required subjects for engineering at school
Resp-21	We don't know whether there are enough resources for us in engineering
Resp-22	We are not told about engineering
Resp-23	I am not interested in engineering because we are not informed about engineering
Resp-24	Universities have to come to school to talk about engineering
Resp-25	We should be taught maths and science properly. But we don't have resources. I do not think that I will struggle in engineering if trained properly
Resp-26	It is not my passion

	Responses
Resp-27	I don't think I can because I haven't taken maths and science
Resp-28	I don't know what engineering is.
Resp-29	We don't have enough resources at school ,so we might not meet the requirements for engineering
Resp-30	I think that engineering is difficult
Resp-31	Lack of resources at school to teach us engineering subjects.

Certain responses from the participants caught the researcher's attention. These were participants 3 and 4:

"In computer systems, sometimes you might be asked how to remove RAM. Totally blind students don't know what is RAM, how to feel it, they don't know where to go to change RAM"

"To program, if you are using JAWS, JAWS don't read everything. JAWS program has limitations. When reading through the internet, JAWS can't read everything and the hyperlinks. Even though if there are specialized software, I think programming will be difficult. Theoretically it will be easy"

These responses clearly show that the VILs were aware about the challenges they would face in Engineering. These participants were specific while listing out their challenges. One of the participant (participant 11) indicated that totally blind learners would struggle doing Engineering while partially sighted would not.

"We can't see the colour codes; we will struggle if we are totally blind; but partially sighted can do it"

Twenty-three participants (74%) indicated that they will struggle to complete an Engineering course. The hindering factors indicated by these participants were coded and categorized. The categories were as follows:

- Lack of subject knowledge;
- Thought that Engineering would be difficult;
- No prerequisite subjects being taught at school;
- Lack of awareness about Engineering;
- Safety factors;
- Struggle to do practical due to their lack of eyesight;
- Do not meet the criteria for Engineering;
- Lack of resources at school;
- Lack of passion for Engineering; and
- Lack of resources at university for Engineering.

Mayat and Amosun (2011) indicates in their study that the hindering factors for VILs in Engineering are the negative attitude of lecturers towards VILs and the lack of awareness about disability issues among the university staff, management and students. However, the participants have not mentioned any of these factors as their response. The participants have listed a number of factors that hinders VILs from taking Engineering which includes safety factors, lack of passion for Engineering, and lack of awareness about Engineering. The reason for this contradiction might be due to the lack of research done in VILs in Engineering. This research gap became the motivation for the study.

Question 11: What do you think should be in place at a university in order to offer Engineering to VILs?

The responses of the participants regarding the factors that hinder them from taking Engineering are presented in Table 4.13.

Table 4.13 What do you think should be in place at a university in order to offer Engineering to VILs? - Participants' response

	Responses
Resp-1	Visual aids for teaching VILs
Resp-2	Teachers should be trained to teach us. It will help us.
Resp-3	Proper resources

	Responses
Resp-4	Resources for blind and partially blind
Resp-5	Teachers should be aware about disabilities, they should know how to cater our needs
Resp-6	Proper resources
Resp-7	Proper resources
Resp-8	Need braille resources for totally blind
Resp-9	Infrastructure
Resp-10	Trained teachers
Resp-11	Universities should accommodate us in engineering
Resp-12	Programs
Resp-13	Resources
Resp-14	Trained teachers
Resp-15	Teachers should know how to work with people having difficulties. They should know braille, atleast uncontracted braille.
Resp-16	Proper resources
Resp-17	Need braille resources for totally blind
Resp-18	Good provision of resources
Resp-19	Trained teachers
Resp-20	Teachers should know braille
Resp-21	Programs for blind learners
Resp-22	Should have braille
Resp-23	Resources for blind
Resp-24	Trained teachers
Resp-25	Equipments to teach us
Resp-26	Trained teachers to teach us so that they understand us better
Resp-27	Infrastructure
Resp-28	Infrastructure
Resp-29	Facilities & funding
Resp-30	Support from disability units

	Responses
Resp-31	Good disability units

The participants had a clear list of factors that they thought should be in place at universities so that they could choose Engineering. The factors were coded and categorized. The categories are listed in Table 4.14.

Table 4.14 What do you think should be in place at a university to offer Engineering to VIL?- Categories

Categories
Caters to the needs of VILs
Supportive disability unit
Tools and Equipment that assist VILs in Engineering
Safe and accessible infrastructure
Trained teachers
Funding
Facilities at universities
Accommodate VILs in Engineering

Engelbrecht and De Beer (2014) reports the importance of educational resources, funding and student support services for educating VILs in universities. However, the researcher considers these factors to be important for all higher education courses, not just Engineering. Mayat and Amosun (2011) did a study to understand the situation of VILs in Civil Engineering in one of the universities of SA. Their study reported that proper treatment of VILs by the academic staff and proper awareness about disability issues in the university should be given importance in order to assist VILs in Engineering. The factors mentioned by the participants verifies (for example: accommodate VILs in Engineering) and adds (for example: tools and equipment that assist VILs in Engineering) to the existing literature.

Question 12: a) Are you frightened by the thought of going to a university
b) If yes, why?

Nine participants (29%) indicated that they were not frightened by the thought of going to a university, while the majority of the participants (71%- 22 participants) said that they were frightened. The responses of the participants are presented in Table 4.15.

Table 4.15 Are you frightened by the thought of going to a university? - Participants' response

	Responses
Resp-1	Yes, because we have to start up fresh and new friends. you don't know your classrooms and accommodation
Resp-2	No
Resp-3	Yes, I don't know whether other students will treat me well
Resp-4	Yes, about the treatment from university
Resp-5	Yes, my friend found it difficult at university; so, I am scared
Resp-6	Yes, I think it will be difficult for us with new people, don't know how they are going to treat us
Resp-7	No
Resp-8	No
Resp-9	Yes, treatment that we expect to receive is frightening
Resp-10	No
Resp-11	Yes. My friends at universities had bad experiences
Resp-12	No
Resp-13	Yes, it is a big terror; new environment, I might get lost
Resp-14	Yes,my friends had bad experiences at university
Resp-15	No
Resp-16	No
Resp-17	Yes, scared of how others will treat me

	Responses
Resp-18	Yes,I don’t know whether others can understand me
Resp-19	Yes, I might get lost
Resp-20	Yes,I can’t see,I need help to go to different classes
Resp-21	Yes, scared of the treatment
Resp-22	Yes, everything is new
Resp-23	Yes, here we know our teachers and friends, we are going to a new environment
Resp-24	Yes, I always need assistance
Resp-25	Yes, I don’t know whether the teachers there will understand me
Resp-26	Yes, I will get lost
Resp-27	Yes, I don’t know whether they have enough facilities to assist me”
Resp-28	Yes, there should be someone to assist me
Resp-29	Yes, they might not treat me well
Resp-30	No
Resp-31	No

The categorised responses of the participants indicated the following:

- VILs were scared of the treatment they would receive from the university, teachers and friends;
- VILs struggled to adapt to new environment;
- VILs did not know whether the universities had enough facilities to assist them;
- VILs required assistance for studies and to manoeuvre around the campus;
- VILs have heard of bad experiences from friends studying at university, and this made them think that they would cope in Engineering courses.

Engelbrecht and De Beer (2014), in a study that was conducted to analyse the access constraints experienced by VILs in South African universities, reports that VILs experience attitudinal constraints, physical accessibility constraints, educational support constraints and financial constraints. The participants’ response indicates that they are frightened by the thought of going to a university. The factors mentioned by the participants supports what has been discussed in the literature.

Question 13: What are your suggestions that could help alleviate these obstacles and make you feel more comfortable on campus?

The suggestions listed by the participants were considered to be very crucial to the study as this gives a clear picture of the expectations of VILs towards the universities in SA. The responses of the participants are presented in Table 4.16.

Table 4.16 What are your suggestions that could help alleviate these obstacles and make you feel more comfortable on campus? - Participants' response

	Responses
Resp-1	Orientation is very important
Resp-2	Facilities and moral activities
Resp-3	Treatment we receive from university
Resp-4	Accommodation
Resp-5	Students can come to our school and describe us the life in the university
Resp-6	Proper facilities
Resp-7	Proper infrastructure
Resp-8	Good disability unit
Resp-9	Proper resources
Resp-10	Trained teachers
Resp-11	There shouldn't be steps everywhere. It is difficult for us, should be easy to move around. Infrastructure is important
Resp-12	Lecturers are not well trained to teach VILs, that is one of the reasons why many students drop out. There are no disabled teachers /trained teachers who understand us
Resp-13	Other students should know how to treat us properly/interact with us; they have to be exposed to how to interact with us

	Responses
Resp-14	Braille for totally blind learners and large print resources for partially sighted learners
Resp-15	Funding
Resp-16	Accommodation
Resp-17	Good infrastructure
Resp-18	There should be trained teachers to teach us; so that they understand us better; teachers should learn braille
Resp-19	Universities should encourage the learners for careers before they reach grade 10
Resp-20	I think any teachers can teach the blind learners but it is the mindset that he/she is blind and they can't teach. They should just know what needs to be done
Resp-21	Disability unit should come forward and help us talk to our teachers and professors; it's not that much, their job is to just make sure that the learners receive braille, assignments
Resp-22	Teachers should give us the notes in a memory stick so that we can braille it
Resp-23	Separate classes for disabled learners or teachers should be able to explain to us
Resp-24	Classes should be divided especially for maths but for English there is no problem
Resp-25	Proper infrastructure. Even if the classes are written on the door, there should be someone to guide us
Resp-26	Proper resources
Resp-27	Trained teachers
Resp-28	Good disability unit
Resp-29	University should have proper facilities for us
Resp-30	Proper infrastructure
Resp-31	Proper infrastructure

The categorised responses that emerged out of the analysis are listed in Table 4.17 below.

Table 4.17 Suggestions from VILs

Categories
Orientation
Supportive disability unit
Tools & Equipment that assist VILs
Extra curriculum activities
Safe and accessible infrastructure
Trained teachers
Initiatives from universities to encourage VIL careers
Good infrastructure
Funding
Treatment from other students
Accommodation facilities
Facilities at universities
Separate classes for disabled learners

As noted in the literature, adequate funding facilities, good student services, proper assistive technologies and good infrastructure are essential for VILs to complete a higher education course in universities (Engelbrecht and De Beer, 2014). The participants' response indicates that they support what has been discussed in the literature. Their responses also add to the existing literature. The additional factors discussed in the study regarding the factors that would assist VILs to feel comfortable on campus are initiatives from universities to encourage VIL careers, extra curriculum activities and separate classes for disabled learners.

Question 14: Have you given thought to attending any university in SA? If yes, which one and why?

The responses of the participants are presented in Table 4.18.

Table 4.18 Have you given thought to attending any university in SA? If yes, which one and why? - Participants' response

	Responses
Resp-1	Yes. CUT,I am person who likes technology and it is closer to me
Resp-2	Yes. UFS, I heard that they have good disability unit
Resp-3	Yes. UFS, they cater the partially sighted learners
Resp-4	Yes. UFS, my friend says they have resources for us there
Resp-5	Yes. WITS, good facilities for blind
Resp-6	Yes. WITS, proper resources
Resp-7	Yes. UFS, there is a career I want there
Resp-8	Yes.WITS,accommodates partially sighted learners
Resp-9	Yes .UFS,there is a teacher that I know in UFS
Resp-10	Yes .University of Limpopo,proper resources
Resp-11	Yes .University of Pretoria, proper resources
Resp-12	Yes. WITS, standard of education is good
Resp-13	Yes. UJ, standard of education is good
Resp-14	Yes. Stellenbosch university, based on my career-accounting
Resp-15	Yes. UFS, good disability unit; there are many blind learners
Resp-16	Yes. CUT, I know a few people there
Resp-17	Yes. WITS, high quality of education
Resp-18	Yes. UJ, accommodates VILs
Resp-19	Yes. UFS, good disability unit
Resp-20	Yes. UFS, has the course I need
Resp-21	Yes. WITS,good disability unit

	Responses
Resp-22	Yes. WITS,good disability unit
Resp-23	Yes. UFS, there is a good disability unit
Resp-24	Yes. UJ, there is a good disability unit
Resp-25	Yes. WITS, good facilities for blind
Resp-26	Yes. WITS, good disability unit
Resp-27	Yes. WITS, they cater for our needs
Resp-28	Yes. WITS, good disability unit
Resp-29	Yes. WITS, standard of education
Resp-30	Yes. UFS, good disability unit
Resp-31	Yes. UFS, good disability unit

All the participants responded that they had thought of attending a university in SA. Central University of Technology, University of Free State, University of Witwatersrand, Stellenbosch University, University of Johannesburg, University of Limpopo, and University of Pretoria were some of the universities listed by the participants. The participants chose these universities because these universities offered the courses they preferred, provide proper resources, accommodates VILs, has a good disability unit and offers a good standard of education and cater for the needs of VILs. Few participants (2 participants) indicated that they chose these universities because they had contacts (such as another VIL they knew) at those universities.

As seen in the literature, VILs consider that it is important to attain higher education for personal development as well as for contributing to the country’s future (Kochung, 2011). VILs prefer to choose universities that have adequate student support services, appropriate assistive technologies and a good infrastructure (Engelbrecht and De Beer, 2014). The participants’ responses support what has been discussed in the literature. The participants in this study mentioned a few additional factors that they would consider while choosing a particular university. The majority of the participants indicate that they prefer to choose universities that offered their preferred courses.

4.5.2 Questionnaire

The case study at school level utilised a semi-structured questionnaire for educators at special schools. Semi-structured questionnaires are quintessential for exploratory studies (Ponelis, 2015). Such questionnaires may guide the researcher to gain a better understanding of the study and may assist in planning the later stages of the study (Blandford, 2013). The aim of the questionnaire used in this study was to understand the perceptions of educators at special schools in the provision of VILs in Engineering courses at tertiary institutions in SA.

4.5.2.1 Developing and Piloting the Questionnaires

An online self-administered questionnaire, which included open-ended questions, was used for the data collection process. This questionnaire was benchmarked against similar studies undertaken internationally (Mayat and Amosun, 2011). The target population for this study was the educators from special schools in the Free State province (Bartimea School and Thiboloha School). These schools accommodate students with different disabilities (VILs, deaf learners, etc.). Our target population were educators teaching only VILs. There were a total of 27 educators in both special schools (Bartimea School and Thiboloha School) who teach VILs. 52% of the educators (14 educators) from the two special schools responded to the study, so forming the sample size.

The questionnaire focused on gathering the perceptions of special school educators on the challenges that VILs in SA face when contemplating entry into higher education. While designing the questionnaire, the researcher made sure that the questions were linked to the research aim and that it would cover the content discussed in the literature review (Tom, Mpekoa and Swart, 2019). Content validity is achieved when a questionnaire reflects the literature that is linked to the research topic (Bolarinwa, 2015b). The questionnaire is presented in Appendix F. The questions and the references are presented in Table 4.19.

Table 4.19 Questions and their corresponding references

Questions	**References**														
	(Section27, 2015)	(Spungin and Ferrell, 2000)	(Agesa, 2014)	(Fotim, 2011)	(Omede, 2014)	(Hodgson and Khumalo, 2016)	(Maguvhe, 2014)	(Department Of Basic Education, 2014)	(Mushome and Monobe, 2013)	(Matshedisho, 2007)	(Mayat and Amosun, 2011)	(Puukka, 2012)	(Park and Davis, 2001)	(Riep, 2011)	(Charles and Carstensen, 2010)
Section A:1-4)Demographic information of the participants(gender, age, home language, race)												X		X	X
Section A:5) Years of experience in teaching									X						
Section A:6)How long have you been involved in educating VILs?									X						
Section B:1) As a teacher yourself, what role should a teacher play in the development of VILs		X													
Section B:2) How does visual impairment affect learning?			X												
Section B:3) Did you receive any training in teaching VILs?				X					X						
Section B:4) What was the duration of the training course if you received any?				X					X						
Section B:5) Was the training you received effective?				X					X						

Questions	References														
	(Section27, 2015)	(Spungin and Ferrell, 2000)	(Agesa, 2014)	(Fotim, 2011)	(Omede, 2014)	(Hodgson and Khumalo, 2016)	(Maguvhe, 2014)	(Department Of Basic Education, 2014)	(Mushome and Monobe, 2013)	(Matshedisho, 2007)	(Mayat and Amosun, 2011)	(Puukka, 2012)	(Park and Davis, 2001)	(Riep, 2011)	(Charles and Carstensen, 2010)
Section B:6) Indicate reasons if the training was ineffective.				X					X						
Section B:7) Which subject(s) are you offering?															
Section B:8) Rate the following subjects in terms of the levels of difficulty for VILs? (1-most difficult, 15-least difficult)?													X		
Section B:9&10) Do VILs take the same examination as mainstream schools? If no, please explain								X							
Section B:11 &12) Do the VILs in special schools follow the same curriculum as mainstream schools? If no, please explain								X							
Section B:13 &14) Does the standard of education of VILs at school assist VILs in entering tertiary education. If no, please explain						X									
Section B:15) What teaching methodologies (speech delivery, arrangement of classroom, preparation of handouts…etc.) do you follow to assist VILs?					X										

Questions	References															
	(Section27, 2015)	(Spungin and Ferrell, 2000)	(Agesa, 2014)	(Fotim, 2011)	(Omede, 2014)	(Hodgson and Khumalo, 2016)	(Maguvhe, 2014)	(Department Of Basic Education, 2014)	(Mushome and Monobe, 2013)	(Matshedisho, 2007)	(Mayat and Amosun, 2011)	(Puukka, 2012)	(Park and Davis, 2001)	(Riep, 2011)	(Charles and Carstensen, 2010)
Section B:16) What technologies (Audio Books, Braille, Slate and Stylus …etc.) do you use to assist VILs?	X				X										
Section B:17) How do you assess the level of visual impairment in your students?	X				X	X									
Section B:18) Based on your assessment, which technologies do you use for the different levels?	X				X										
Section B:19) How are assessments and evaluations for VILs done at special schools?								X							
Section B:20 & 21) Do you think that the assessment method can be improved? If yes, please explain.								X							
Section B:22 & 23) Are there initiatives taken to improve your skills to train VILs?									X						
Section C:1 &2) Are you concerned about the preparedness of your scholars for tertiary education? If yes, why?										X					

Questions	References														
	(Section27, 2015)	(Spungin and Ferrell, 2000)	(Agesa, 2014)	(Fotim, 2011)	(Omede, 2014)	(Hodgson and Khumalo, 2016)	(Maguvhe, 2014)	(Department Of Basic Education, 2014)	(Mushome and Monobe, 2013)	(Matshedisho, 2007)	(Mayat and Amosun, 2011)	(Puukka, 2012)	(Park and Davis, 2001)	(Riep, 2011)	(Charles and Carstensen, 2010)
Section C:3 &4) Do you know the criteria for the scholars to be able to enter university? If yes, please indicate the criteria followed.						X									
Section C:5a &5b) In your opinion, how many of your students pursue tertiary education after completing high school education? In your opinion, what could be the cause for this low number?										X					
Section C:6 &7) Have your alumni students ever complained about the struggles they face in the universities? If yes, please indicate the complaints they have shared.									X						
Section C:8) Do you think that VILs should consider Engineering course?											X				
Section C:9 &10) Do you know of any university that provides for the needs of VILs in any Engineering course? If yes, explain.											X				
Section C:11) In your opinion, what should the university do in order to accommodate VILs in Engineering?															

Questions	References														
	(Section27, 2015)	(Spungin and Ferrell, 2000)	(Agesa, 2014)	(Fotim, 2011)	(Omede, 2014)	(Hodgson and Khumalo, 2016)	(Maguvhe, 2014)	(Department Of Basic Education, 2014)	(Mushome and Monobe, 2013)	(Matshedisho, 2007)	(Mayat and Amosun, 2011)	(Puukka, 2012)	(Park and Davis, 2001)	(Riep, 2011)	(Charles and Carstensen, 2010)
Section C:12) What suggestions would you like to provide to the universities for effective learning and teaching of VILs in Engineering /IT courses?											X				
Section C:13) Is there any other comment, question or thought that you would like to raise in this regard?															

The questionnaire was electronically distributed through the use of Google Forms to the educators. The advantage of using online questionnaires includes convenience for the participants in responding to this research tool which would provide a good response rate for each item (Wright, 2005). The investigator had to ensure that the study instrument is designed in such a way that it is clear for all participants (Krosnick, 2018). Even though the questionnaires were online, the researcher visited the schools to ensure that the participants did not experience any difficulty in completing them. This allowed some of the participants to interact with the researcher and provide additional comments which they would have missed out while completing the questionnaire alone. The researcher took note of all the additional suggestions received from the participants.

In order to ensure that the questionnaires were properly structured for the participants, it had to be piloted. Questionnaire were validated by experts in the field as part of a pilot study before the actual research was done. The experts consisted of senior lecturers from the Engineering faculty at the Central University of Technology (CUT). The researcher made sure that the pilot study was conducted exactly the same manner as it was planned for the actual study. The pilot participants took approximately 20 minutes to complete the questionnaire. The experts, to the best of their ability, ensured that the items were accurate, relevant, clear, simple, complete and not biased. The experts mentioned that the questionnaire was clear and they felt that the questions were relevant to the topic being researched. Therefore, no modification was made to the questionnaire.

4.5.2.2 Data collection and analysis

The questionnaire was distributed to the target population after pilot testing. In an email sent to the participants, there was a short description of the research and the researcher’s contact information. Participants were also emailed an informed consent form along with the questionnaire. Ethical clearance was obtained from the Faculty Research and Innovation Committee at the Central University of Technology. Data was analysed using both qualitative and quantitative analysis techniques. The findings were then analysed with reference to the literature that was collected for this research, in order to investigate whether the research questions were effectively addressed. The data collected is presented next.

PART A: BACKGROUND INFORMATION

This section of the questionnaire captured the background and the biographical information of the participants, which includes the participants' age, gender, race, home language, years of experience in teaching and educating VILs.

Questions 1-4 were asked to collect the participants' background information such as gender, age, race and home language.

The total number of participants for the questionnaire was 14. In terms of gender, 50% (7 participants) were females and 50% (7 participants) were males. These percentages indicate that the participants from both genders are equally represented; therefore, there is no gender bias. As indicated below in Figure 4.6, 50% of the participants (7 participants) were in the age group 40-44 years; while 43% of the participants (6 participants) were in the age group 45-49 years and only 7% of the participants (1 participant) were in the age group 35-39 years.

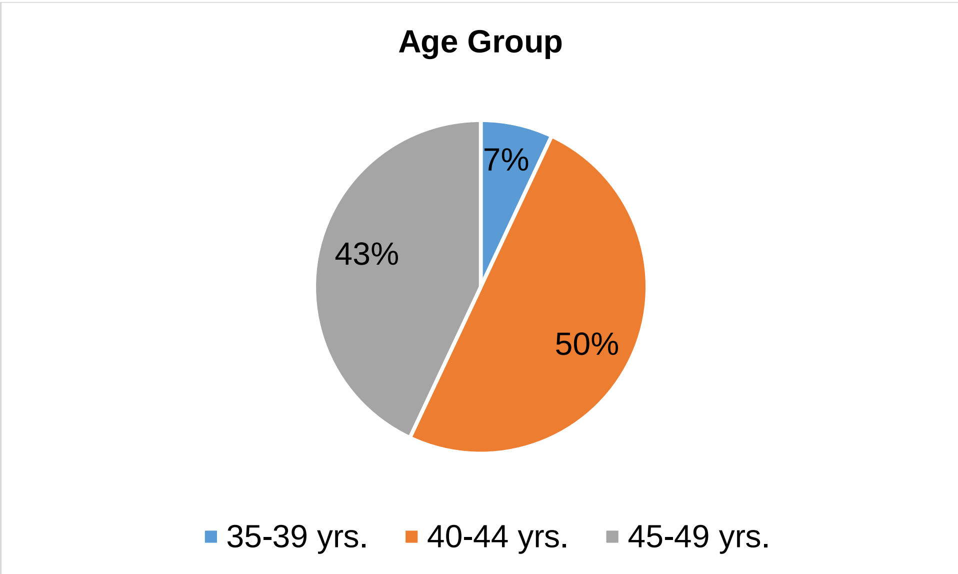

Figure 4.6 Participants' age group

The statistics indicates that the majority of the participants are from the older generation. Older generations have a greater deal of life experiences as compared to the younger generation (Berčan, 2014). Their experiences have helped them to voice their opinions on significant aspects of life and handle issues in social environments (Charles and Carstensen, 2010). Therefore, the viewpoints of these experienced participants would prove beneficial to this study. Some researchers also consider the viewpoints of older generation to be outdated and encourage participation of younger generation in their studies (Duncan and Schaller, 2009; Christian *et al.*, 2014).

The majority of the participants (93%) were Africans, followed by 7% who were Coloured. The school level case study was done in the Free State province. Africans form the largest population group in this province (Puukka, 2012). Most of the participants (50%) indicated that Southern Sotho was their home language, followed by Zulu at 14% and also Tswana at 14%. English, Afrikaans and Northern Sotho was last at 7.1%. Figure 4.7 depicts the home language of the participants.

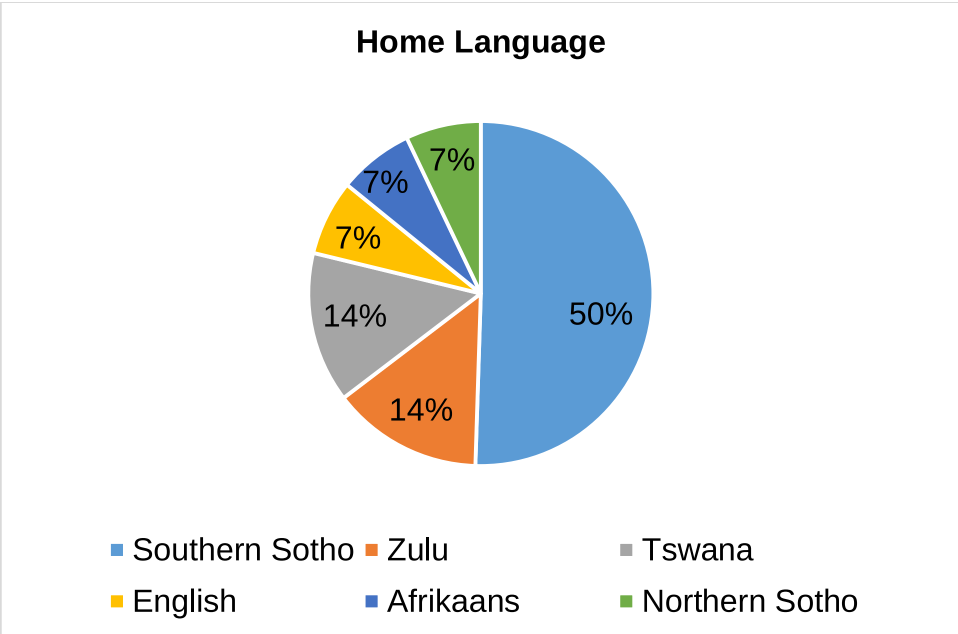

Figure 4.7 Participants' home language

The special schools in the Free State province are located in Thaba 'Nchu and Qwaqwa. These towns are mostly populated by Sesotho- speaking people (Twala and Barnard, 2006; Riep, 2011). The results from Figure 4.7 supports this.

Question 5: Years of experience in teaching

Studies indicate that teaching experience has a positive impact in the learning process of students (Hansen, 2000). Therefore, the researcher considered it important to gather information regarding the work experience of the participants in this study. Figure 4.8 indicates the participants' work experience.

Most of the participants (93%) were well experienced with a working experience of 6 years and above and only 7% of the participants indicated their work experience as 4-6 years. The teaching methodologies and strategies followed by experienced teachers have proved to be effective for the learners as years of experience have made these teachers experts in their field (Mushome and Monobe, 2013). Policymakers and researchers consider the perceptions of experienced teachers as a crucial factor in shaping the educational policies that ensure effective functioning of the educational system (Rice, 2010). The suggestions of these experienced participants are vital to the development of a framework for this study. On the other hand, viewpoints of younger teachers are also considered to provide meaningful insights to a study as they adapt themselves easily to new and innovative ways of thinking and also have an urge of improvement compared to the older generation (Shah and Udgaonkar, 2018).

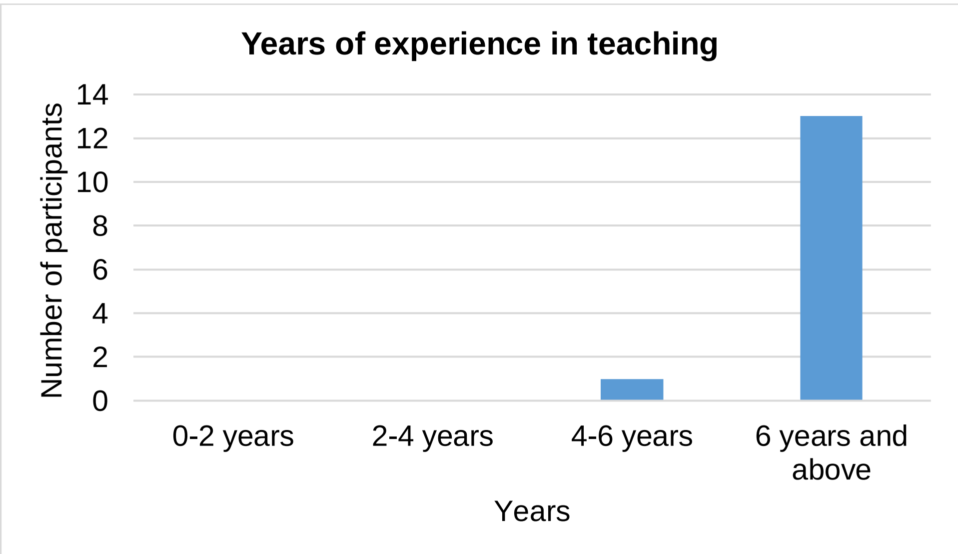

Figure 4.8 Participant's work experience

Question 6: How long have you been involved in educating VILs?

Studies have indicated that lack of experienced and trained lectures can affect the learning process of VILs adversely (Mushome and Monobe, 2013). Figure 4.9 indicates the participants' work experience. A bigger proportion of the participants (50%) indicated that they have been involved in educating VILs for 6 years and above, while 29% of participants indicated that they have been educating VILs for about 4-6 years. 14% of the participants have been involved in educating VILs for 2-4 years, while 7% of participants indicated that they have been educating VILs for less than 2 years. These result indicate that most of the participants have an experience of 6 years and above. As seen in the literature, this experience is crucial as teachers are expected to assist VILs in their schooling (Negash, 2017). By so doing, this experience will assist the teachers to develop tools that can be used in teaching VILs and in understanding VILs. Younger faculty may try to be more innovative with the tools and try to adopt newer techniques and methods compared to older generation (Geeraerts, Tynjälä and Heikkinen, 2018). Their viewpoints may also be interesting and informative to the researcher.

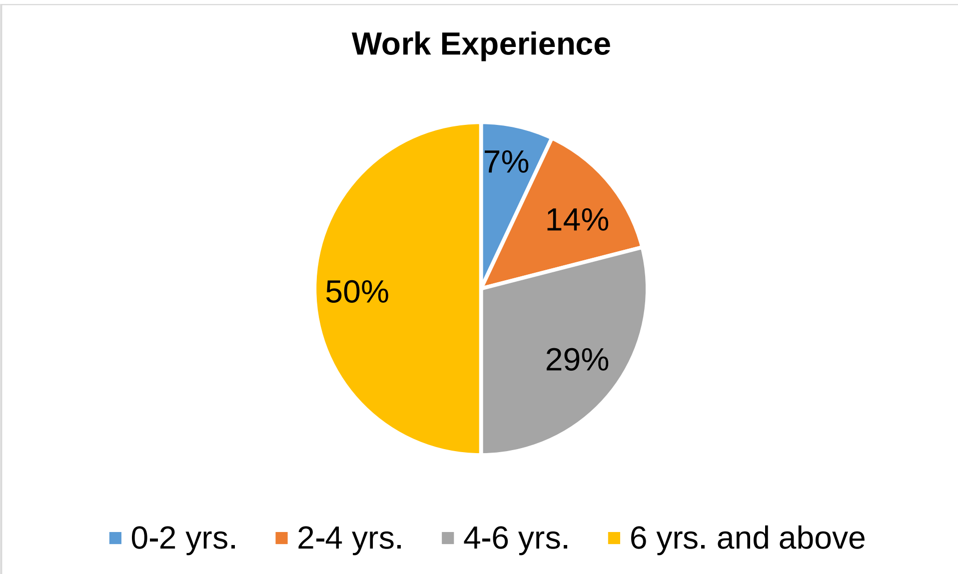

Figure 4.9 Participants' work experience with VILs

PART B: CURRENT TEACHING STRATEGIES IN SPECIAL SCHOOLS

This section of the questionnaire captured the information on the current teaching strategies used in special schools.

Question 1: As a teacher yourself, what role should a teacher play in the development of VILs?

Various codes were identified based on the participants' response. The codes were grouped into categories. The codes that were not relevant to the question were discarded during the process. The responses were analyzed according to the types of categories and issues that emerged. Based on the categories that emerged out of the analysis, the participants indicated that the role of a teacher in the development of VILs was:

- To assist and provide guidance for VILs;
- Help VILs build self-confidence and self-sufficiency; and
- To offer emotional support to VILs.

According to Spungin and Ferrell (2007), the role of a techer in the development of VILs is to assist them by providing the required resources and good emotional support. The participants in the study agree to the findings from the literature.

Question 2: How does visual impairment affect learning?

Qualitative data analysis was done according to the types of categories that emerged. The categories that emerged out of the analysis were as follows:

- Visual impairment slows down the learning process;
- VILs become dependent on resources, technology and staff; and
- Visual impairment creates psychological effects on VILs.

According to Agesa (2014), visual impairment slows the learning process of VILs and creates cognitive effects on VILs. The participants in the study agree to the findings from the literature.

Questions 3 and 4: Did you receive any training in teaching VILs? What was the duration of the training course if you received any?

A study conducted by Mushome and Monobe (2013) indicates that lecturers find it difficult to teach VILs due to a lack of training that they receive from the institution or department. This study also points out the need for creating a research centre to assist the lecturers.

The responses from the participants regarding they received training in teaching VILs is presented in Figure 4.10. From a total of 14 participants, 9 participants indicated that they received training. From the 9 participants who received training, 5 of them stated that they received training for 6 months to 1 year. Two out of the 9 participants said that they had training for a period of 1 year and one participant said that they attended training which took less than 2 months. The remaining participants did not receive any training in teaching VILs.

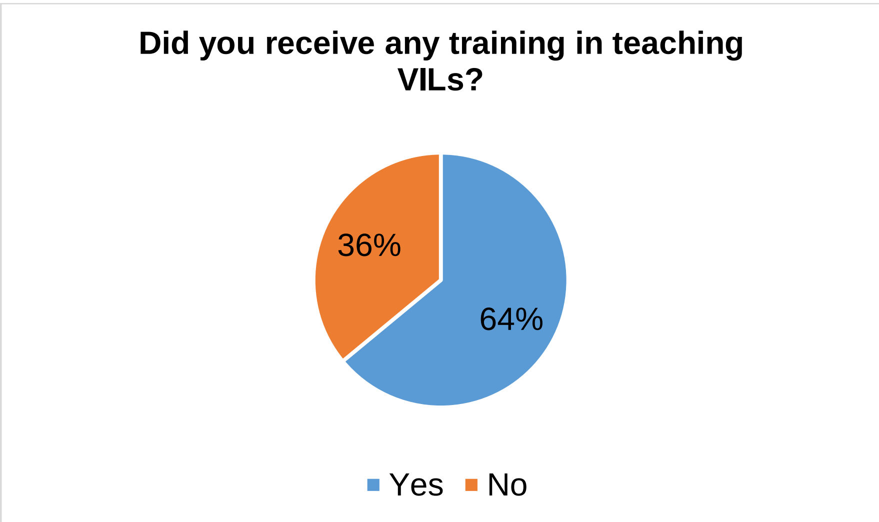

Figure 4.10 Training in teaching VILs

It should be noted that not all of the participants received training to teach VILs. Five out of the 14 participants indicated this. This can be very problematic as these participants are solely responsible for teaching VILs. As noted in the literature, these lecturers might experience difficulties in teaching VILs.

Questions 5 and 6: was the training you received effective? Indicate reasons if the training was ineffective.

Most of the participants (90%) indicated that the training they attended was effective and only 10% of the participants indicated that the training they attended was not effective. The participants suggested that they should be given thorough training to teach VILs so that they can provide effective assistance to the learners. They also stated that such training should be longer (more than six months) and it should include sessions where they can discuss topics other than teaching basics.

The Fotim report (2011) states that some academic staff did not receive adequate and quality training workshops for educating VILs in SA. Figure 4.11 indicates the participants' response regarding the effectiveness of the training programs they have attended. The participants' response supports the literature. The lecturers might find it difficult to educate VILs due to this lack of training.

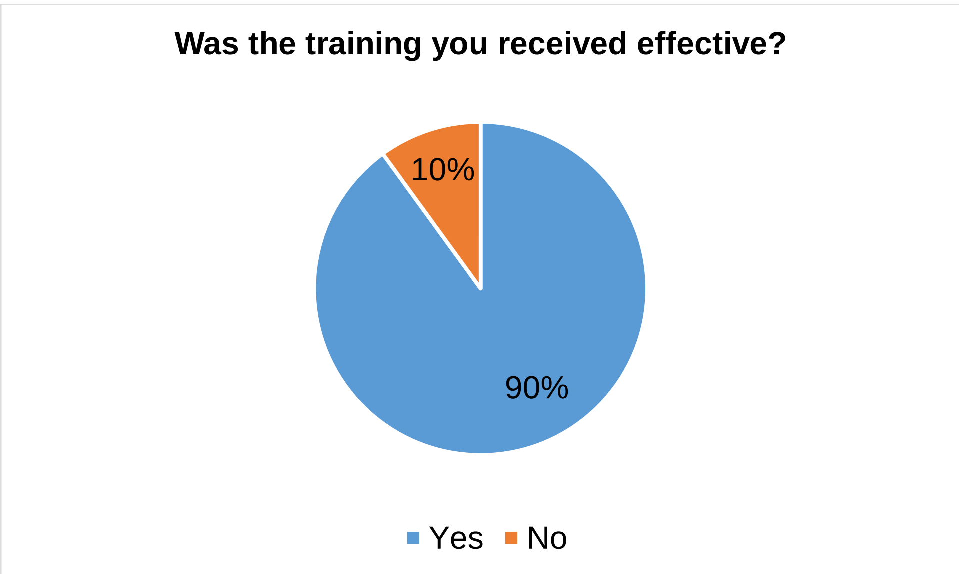

Figure 4.11 Effectiveness of training

Question 7: Which subject(s) are you offering?

The participants comprised of teachers teaching various subjects like Life Orientation, Computer Application Technology, Sesotho, Mathematics, English, Physical Science, Afrikaans, Mathematical Literacy and Life Science.

Question 8: Rate the following subjects in terms of the levels of difficulty for VILs? (1-most difficult, 15-least difficult)?

Table 4.20 lists all the subjects that were provided to the participants for them to rate. The ratings were as follows: 1 being the most difficult subject and 15 being the least difficult subject. The subjects that were rated between 1 and 8 were categorized as the most difficult subjects and the subjects that were rated between 9 and 15 were categorized as the least difficult subjects.

Table 4.20 Subject Ratings

Subject	Most Difficult	Least Difficult
Afrikaans	0%	100%
English	7%	93%
Business Studies	46%	54%
Consumer Studies	50%	50%
Sotho	0%	100%
CAT	69%	31%
Mathematics	93%	7%
Mathematical Literacy	100%	0%
Economics	69%	31%
Accounting	93%	7%
Physical Science	100%	0%
Life Orientation	7%	93%
Tswana	0%	100%
History	43%	57%
Life science	50%	50%

Physical Science, Accounting, Economics, Mathematical Literacy, Mathematics and CAT were categorised as the most difficult subjects, whereas Afrikaans, English, Sotho, Tswana, Life Orientation were categorized as the least difficult subjects.

For any learner to be accepted in any Engineering course at university, they are expected to have studied Mathematics, English and / or Physical Science (Park and Davis, 2001). It is very interesting to note the ratings given by the participants to subjects like Mathematics, Physical Science and Mathematical Literacy. All these subjects have been rated as the most difficult subjects by the teachers themselves.

Questions 9, 10, 11 and 12: Do VILs take the same examination as mainstream schools? Do VILs in special schools follow the same curriculum as mainstream schools?

All the participants (100%) indicated that VILs take the same examination as mainstream schools, although, adaptations to the exam paper were made according to the needs of the VILs (for example, enlarging the question paper). The Department Of Basic Education (2014) also reports that VILs take the same examination as mainstream schools. All the participants (100%) indicated that VILs follow the same curriculum as mainstream schools. These findings are supported by Maguvhe (2014).

Question 13 and 14: Does the standard of education of VILs at school assist VILs in entering tertiary education? If no, please explain

A large number (79%) of the participants pointed out that the standard of education of VILs at school assists them in entering tertiary education while a low number of the participants disagreed with that sentiment. Some of the participants gave reasons why they felt the standard of education provided to VILs was inadequate, the responses were analysed and categorised. The categories are listed below:

- Lack of resources at special schools;
- Lack of trained personnel for VILs; and

- VILs take only a few subjects at school which might not be sufficient to choose their stream of interest at university.

Literature does mention that there is a lack of trained staff, a lack of proper resources and poor conditions at special schools (Hodgson and Khumalo, 2016). In addition to these factors, the participants mention that VILs take only a few subjects at school which might not be sufficient to choose their stream of interest at university. This additional factor should be given utmost importance as this may restrict the career options for VILs.

Question 15: What teaching methodologies (speech delivery, arrangement of classroom, preparation of handouts etc.) do you follow to assist VILs?

Teaching methodologies are principles used for instructing students based on the content of the material to be taught and on the needs of the learners (Rüütmann and Kipper, 2011). Some of the popular methodologies used to assist VILs indicated in the literature are audio-visual presentations, group exercises, classroom handouts (with pictures or diagrams), seating arrangements depending on the level of impairment etc. (Omede, 2014). The teaching methodologies listed by the participants to assist VILs were: handouts (braille and / or enlargement), group exercises, audio lessons, oral lessons, storytelling and the use of equipment like a magnifying glass. The responses of the participants align with the literature.

Question 16: What technologies (Audio Books, Braille, Slate and Stylus, etc.) do you use to assist VILs?

Educational technology refers to area of digital technology devoted to facilitate learning (Davies and West, 2014). Some of the popular technologies used to educate VILs mentioned in literature include large print access, speech access (speech synthesizer, screen review software, etc.), Braille access (Braille translation software, Braille embossers etc.), scanned material access (open book, expert reader etc.) (Omede, 2014; Section27, 2015). The participants indicated computers, reading devices (e.g.: magnifying glass), Braille, audio lessons and interpreter (for example, JAWS interpreter) as technologies they used to assist VILs. The responses of the participants align with the literature.

Question 17 and 18 were asked to determine how the participants assessed the level of visual impairment of their scholars and what technologies they used to assist scholars with different levels of visual impairment.

Visual impairment can be assessed in the following levels: partially sighted learners, moderately blind learners, severely blind learners, completely blind learners (WHO, 2018). The participants indicated that they assessed the level of visual impairment in VILs with the help of a therapist or eye specialist, or by observing the scholars' reading difficulties, by classwork discussions and performance in class.

The participants also advised that they used different assessment methods for different levels of visual impairment in VILs, they are as follows:

- Braille for totally blind learners;
- Use a reader or increase the font size while the scholars use computer;
- Read out loud for scholars who struggle;
- Use yellow colour coded pages for scholars as white pages affect their reading;
- Arrange the classroom setting in such a way that it is not too bright for the scholars;
- Seating arrangements according to the level of visual impairment;
- Printouts for partially blind learners with enlarged text; and
- Exercise books were reprinted with additional space for the learners to write.

Khumalo and Hodgson's (2017) study conducted at special schools of the Umkhanyakude District reports that special schools employ specialists to assess the level of visual impairment in VILs. This study also mentions different assessment methods for VILs such as the use of Braille for totally blind learners, screen reader software for VILs, enlarged notes for partially sighted learners and the use of computers to assist VILs etc. The participants utilised a number of assessment methods which verifies what has been discussed in the literature.

Question 19: How are assessments and evaluations for VILs done at special schools?

The responses were coded and categorized and the categories are as follows:

- By adapting the question paper;
- Using oral assessment methods;
- By using an interpreter or scriber;
- By arranging the classroom setting in such a way that it is not too bright for the scholars; and
- By providing them extra time.

The policy document on screening, identification, assessment and support which was released by the Department of Basic Education (2014) presents a list for the type of modifications that needs to be made during assessments in special schools. These include adaptation of questions, additional time, oral examination, breaks in between exams, use of personal assistant and scriber. The participants' response indicates that they have been following the guidelines that has been provided by the Department of Basic Education.

Questions 20 and 21: Do you think that the assessment method can be improved? If yes, please explain.

A total of 93% of the participants indicated that the assessment can be improved, while 7% of the participants felt that the assessment method needs no improvement. Various codes were identified based on the participants' responses. The codes were grouped into categories. The participants indicated that the assessment method could be improved by:

- Adapting the question paper before they are distributed to special school;
- By providing proper resources/facilities;
- By oral assessment methods; and
- By using an interpreter or a scriber.

In question 19, the educators listed the assessment methods used in their schools while in question 20, the participants had to indicate how these methods could be improved. The responses of the educators to these questions suggest that the identified methods were not being used effectively, as they needed to be improved.

Participants complained that they are not getting enough support from the Department of Education (DoE). One of the things they mentioned is that the DoE is supposed to adapt the question paper before it is distributed to special schools but this is not done. Special schools receive the question paper and they are expected to adapt the question paper themselves without being given enough time to do so. This leaves special school staff with very few options on how to assist the VILs during exams, like reading the question paper aloud to the blind students. However, according to Section 27's Left in the Dark report (Khumalo and Hodgson, 2017):

"All forms of assessment, including National Senior Certificate Examinations, Annual National Assessments and Common Papers must be provided to schools for visually impaired learners appropriately adapted and printed in Braille."

However, the educators reported that the question papers were given to the schools by the DoE to be adapted and printed only on the day of the examination or a day before the examination. This does not give the school enough time to adapt and print the question paper and this affected the assessment process adversely.

Questions 22 and 23: Are there initiatives taken to improve your skills to train VILs? If yes, please explain.

A majority (64%) of the participants indicated that they took initiatives to improve their skills in order to teach VILs. Some of the initiatives they took included attended braille classes, training and workshops, as well as attending meetings to discuss issues and problems faced by VIL teachers. The remaining participants (36%) indicated that they did not take any initiative to improve their skills.

The literature indicates that there is a shortage of facilitators to train academic staff to educate VILs (Mushome and Monobe, 2013). However, the educators in this study are willing to be trained. This indicates that there is indeed a need of more facilitators to train teachers to improve their skills in order to effectively teach VILs.

PART C: OPINIONS AND CONCERNS OF EDUCATORS REGARDING THE PROVISION OF VILs IN TERTIARY INSTITUTIONS, ESPECIALLY FOR ENGINEERING COURSES

This section of the questionnaire captured the views of educators regarding the provision of VILs at tertiary institutions, especially for Engineering courses.

Questions 1 and 2: Are you concerned about the preparedness of your scholars for tertiary education? Please explain

With regards to this question, the participants were opposing each other; some pointed out that they were concerned about the preparedness of their scholars for tertiary education, whereas the other group were not concerned. Table 4.21 presents the response of the group that registered their concerns.

Some of the participants hinted that the scholars were not emotionally ready for university due to the negative attitude VILs receive from university staff. Participant 1 stated:

"***Staff at university are known to have negative attitude towards VILs***."

Table 4.21 Preparedness of scholars for tertiary institutions

Categories
Lack of initiative by the government to hire teachers
Lack of resources (tools, equipment etc.)
Negative attitude/negligence at the university

Categories
Teaching VILs is time consuming
Teaching methodologies at university level differs from school level

Matshedisho (2007) indicates that VILs struggle in tertiary institutions due to lack of support services, funding, lack of resources, lack of proper treatment by the academic staff towards VILs and lack of proper institutional policies for VILs. The participants'' response adds to the existing literature. The participants also commented on the teaching methodologies and time taken to teach VILs. The participants indicated that VILs were not ready to face the mentioned challenges that existed in the universities of SA.

Questions 3 and 4: Do you know the criteria for the scholars to be able to enter university? Please share the criteria.

A total of 71% of the participants said that they knew the criteria for the scholars to be able to enter university. Only three participants responded when they were asked to mention the criteria, which was as follows:

- a point system; and
- good grades in their matric exam.

Good grades in a matriculation exam will help the learners to score good points which will determine the entry of VILs in tertiary institutions. For example, a student should score 27 or more points in order to study at CUT (Central University of Technology, 2019). Table 4.22 presents the point system followed by this university. Apart from meeting the minimum score of 27 points, a student is also expected to meet individual subject requirements for the learning programme he/she desires to study.

Table 4.22 Admission points at CUT(Central University of Technology, 2019)

Matriculation exam percentage	30 - 39%	40 - 49%	50 - 59%	60 - 69%	70 - 79%	80 - 89%	90 - 100%
Points	2	3	4	5	6	7	8

Hodgson and Khumalo (2016) reports that educators were not properly trained and were incapable of assisting VILs in SA. Only 3 out of 14 participants in this study knew the criteria for the scholars to be able to enter university. This indicates a further need to train teachers of VIL regarding the entry requirements of different universities.

Questions 5a and 5b: Can you estimate the number of scholars that pursue tertiary education after completing high school education and indicate the reason for this number

As seen in Figure 4.12 below, the majority (29%) of the participants indicated that more than 50% of VILs pursued tertiary education. It is interesting to observe that the second highest percentile of participants (21%) indicated that less than 5% of VILs pursued tertiary education. There seem to be a contradiction in terms of the responses received from the participants.

The responses for the low number of scholars pursuing tertiary education after high school were analysed according to the types of categories and issues that emerged. The categories are presented in Table 4.23. Matshedisho (2007) indicates that universities in SA do not provide adequate support (adequate funding, proper resources, institutional policies, proper treatment from academic staff) for VILs. These factors may lead to the low ratio of scholars pursuing tertiary education after high school. Along with these factors, the participants have indicated that the poor results of VILs at high school and the subjects taught at special schools may also lead to the low ratio of VILs in higher education.

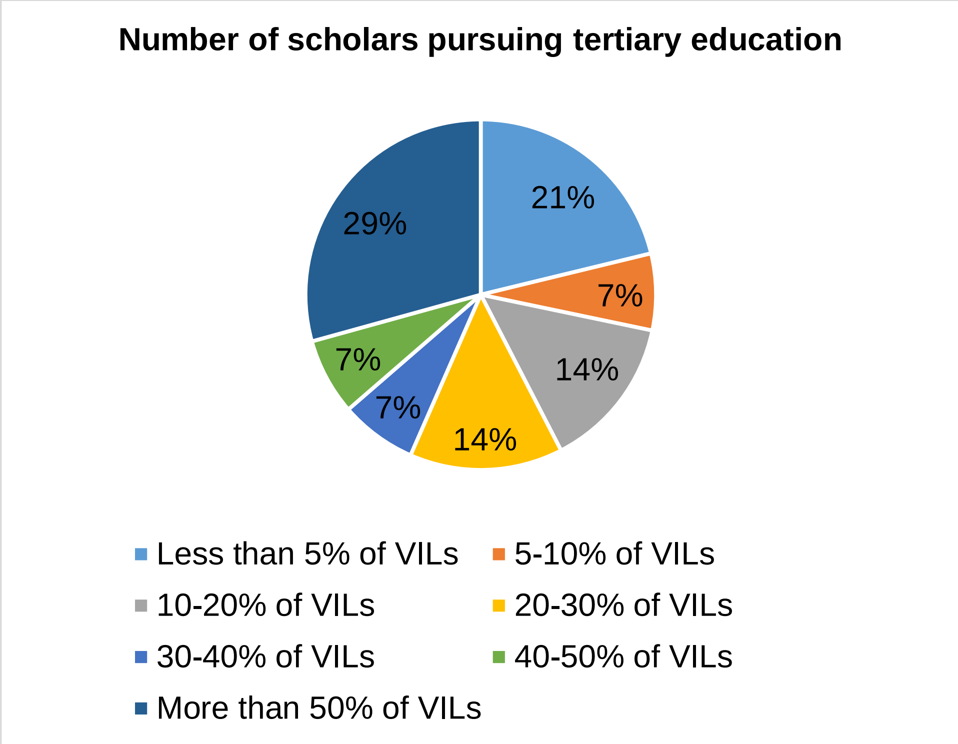

Figure 4.12 Number of scholars pursuing tertiary education after high schools

Table 4.23 Reason for the low ratio of scholars pursuing tertiary education after high school – Categories

Categories
Low results at high school
VILs scared of being neglected and not being assisted at universities
VILs struggle to adapt to new environments
Lack of resources at universities
Subjects taught at special schools do not help the scholars meet their course choices at university

Questions 6 and 7: Do your alumni scholars complain about the struggles they face at university? What were their complaints?

Sixty-four percent (64%) of the participants indicated that their alumni scholars complained about the struggles they faced at university. The complaints listed by the participants were coded and categorised and are provided in Table 4.24.

Table 4.24 Complaints by alumni scholars about struggles at university

Categories
Lack of resources
VILs not catered well for at universities
VILs struggle to adapt to the new environment
Lack of trained lecturers
Difficult to cope with the workload and technology used at universities
Lack of support from teachers and disability unit

Mushome and Monobe (2013), in their study done at one of the universities in Limpopo, report that there is a lack of trained staff, a lack of the proper attitude from lecturers and a lack of resources in the university. The participants' responses align with the literature. The difficulty of VILs to cope with the workload and technology used at universities is an additional factor that was been mentioned by the participants.

Question 8: Do you think that VILs should consider Engineering course? Please explain.

The majority of the participants (86%) agreed that VILs should consider Engineering courses and a few disagreed (14%). The explanation from the participants who agreed were categorized. The categorized responses indicated that VILs should consider Engineering:

- If VILs have passion for Engineering; and
- Because of the potential of VILs to cope just like any normal learner.

Of the 12 participants who agreed; 4 participants indicated that they would support VILs to consider Engineering only if the tertiary institutions had enough resources to teach them. Three of the participants felt that totally blind learners would struggle in Engineering, but supported that partially sighted learners could pursue Engineering.

A small proportion of the participants (14%) stated that VILs should not consider Engineering courses. The categorised responses from the participants are as follows:

- Lack of safety measures at the university; and
- VILs struggle to cope with the Engineering curriculum.

The researchers Mayat and Amosun (2011) indicated that there is a low representation of VILs in Engineering due to the negative attitude of some educators towards VILs. However, the educators in this study supports the entry of learners in Engineering, and are therefore not really discouraging VILs from studying Engineering. The participants' response does not fully agree with the research by Mayat and Amosun (2011).

Questions 9 and 10: Do you know of any university that provides for the needs of VILs in any Engineering course? Please list those universities.

Half (50%) of the participants indicated that they knew of universities that specifically provided for the needs of VILs in Engineering courses. Some of the universities that were mentioned include the University of Free State, University of Pretoria, University of Venda and University of Cape Town. The participants mentioned that these universities catered for the needs of VILs and they offered provisions for VILs.

There is a low representation of VILs in Engineering in the universities of SA (Mayat and Amosun, 2011). 50% of the participants in this study were not aware about the universities that specifically provided for the needs of VILs in Engineering courses. It should be noted that even though the educators supported the entry of VILs in

Engineering (Question 8), they were not aware about the institutions that accommodated VILs in Engineering. This lack of awareness can only be resolved by providing training workshops for the educators regarding the institutions that accommodate VILs in Engineering and the facilities provided by these universities.

Question 11: In your opinion, what should the university do in order to accommodate VILs in Engineering?

The responses from the participants were analyzed according to the types of categories and issues that emerged. Table 4.25 presents the various categories that were identified based on the participants' response.

Table 4.25 Provision of VILs at universities

Categories
Properly functioning and accessible disability unit
Well trained/blind lecturers for VILs
Safe and accessible infrastructure
Introduce Engineering at an early stage
Proper tools, resources and equipment
Initiatives from management to assist VILs
Proper funding
Proper facilities to assist VILs
Proper accommodation facilities
Good attitude from teachers, scholars and university

One of the categories that emerged after analyzing the participants' response was ***"introduce Engineering at an early stage".*** Introducing Science, Technology, Engineering and Mathematics (STEM) at school level can assist young learners to understand and better prepare themselves to enter STEM academic programs at tertiary institutions (DeJarnette, 2012). From the discussions with the participants, it was observed that the participants were trying to convey that proper career guidance was not provided to the scholars on time before entering tertiary institutions.

Mayat and Amosun (2011) reports that awareness should be created about disability issues in universities and VILs should be treated properly by academic staff in order to accommodate them in Engineering. Universities in SA should have a properly functioning DU that is capable of resolving the disability issues faced by VILs. Lecturers should also be well trained regarding how to treat VILs. The participants' response support the research by Mayat and Amosun (2011).

Question 12: What suggestions would you like to provide to the universities for effective learning and teaching of VILs in Engineering /IT courses?

Qualitative analysis was done and data was coded and categorized. The categorized items mentioned by the participants are as follows:

- Proper tools, resources and equipment;
- Well trained staff;
- Support from the Engineering departments, Faculty and university;
- Proper infrastructure;
- Introduce Engineering to learners at school; and
- Create awareness about blindness.

Mayat and Amosun (2011) in their study that was conducted to understand the perceptions of academic staff towards accommodating VILs in Civil Engineering in South African universities stated that awareness should be created about disability issues among staff, students and management and VILs should be treated properly by academic staff in order to assist VILs in Engineering. VILs require adequate support from the Engineering departments, Faculty and university to succeed in their academic courses. This can be made possible by creating create awareness about disability issues at universities. Academic staff should be trained to treat VILs properly. The participants' response support Mayat and Amosun (2011).

Question 13: Is there any other comment, question or thought that you would like to raise in this regard?

Only a few participants (29%) responded to this question. These participants mentioned that:

- there should be awareness given to the universities about blind learners;
- more initiatives from the government to assist VILs;
- provide necessary resources and equipment for VILs;
- career expo and campaigns; and
- brailed pamphlets to raise awareness about courses to VILs.

4.6 SUMMARY

This case study focused on collecting the perceptions, opinions and views of VILs and educators at special schools on the challenges VILs face in higher education institutions especially for Engineering courses. The educators and learners in the special schools of Free State province (Bartimea School for the Deaf and Blind, Thiboloha School for the deaf and Blind) expressed their interest in participating in the study. The data were collected using focus groups and questionnaires. After analysing the data, the researcher identified the barriers or challenges that affected the provision of VILs in Engineering courses at universities. Qualitative content analysis and quantitative techniques were used to analyse data and organise them into themes and categories. The challenges identified from the focus groups are as follows:

- Lack of resources at school;
- Lack of resources at university;
- Lack of supportive disability units at universities;
- Lack of safety measures;
- Lack of passion for Engineering;
- VILs consider Engineering difficult;
- Lack of subject knowledge;
- No prerequisite subjects for Engineering taught at school;

- Inadequate marketing of Engineering courses;
- Lack of good infrastructure at universities;
- Lack of facilities at universities;
- Lack of funds;
- Lack of trained teachers;
- Poor treatment of VILs at the university;
- Lack of proper accommodation facilities
- Fear of VILs to adapt to the new environment;
- Need for separate classes for disabled learners;
- Lack of mobility services around the campus; and
- Inadequate transport facilities for VILs.

The researcher collected data from five focus group discussions consisting of 5-6 members. The data was gathered from focus group discussions until data saturation was reached. In our focus group discussions, data saturation was achieved after four focus group discussions, with 5-6 participants in each session.

A semi-structured questionnaire was used for collecting data from the educators of these special schools. Questionnaires were analysed using content analysis and statistical analysis techniques. The researcher continued collecting data until no new perspectives and insights emerged out of the collected data. The challenges identified from the special school educator questionnaires are as follows:

- Lack of initiative by the government to hire teachers;
- Negative attitude at the university towards VILs;
- Teaching VILs are time consuming;
- Subject taught at special school don't meet the course choices at university;
- Fear of adapting to the new environment;
- Difficult for VILs to cope with the workload and technology used at universities;
- Lack of proper infrastructure;
- Lack of Initiatives from management to assist VILs;
- Lack of accommodation facilities;
- Lack of facilities at universities;
- Lack of awareness about disability;

- Engineering not being introduced to learners at school level;
- Lack of support to VILs from the departments at university;
- Lack of trained lecturers;
- Low School results;
- Lack of resources; and
- Lack of support from disability unit.

The results from this case study indicated that there is a lack of awareness about Engineering among the learners at school level. It was also evident that the higher education courses were not properly campaigned in special schools. VILs were not aware about the different streams and the entry level requirements at different universities in SA. The barriers and challenges indicated by the participants were presented in this chapter. The data from this case study and the case study at university level were triangulated to form the framework for this study.

The next chapter, Chapter 5 presents the case study done at university level. The different stages involved in the case study like developing questions, piloting, data collection and analysis are discussed in Chapter 5.

CHAPTER 5: CASE STUDY-UNIVERSITIES

5.1 INTRODUCTION

Tertiary education contributes to social and economic development of a nation by providing an opportunity for intellectually skilled, but sometimes impoverished citizens, to be put alongside wealthy individuals. However, for all individuals to prosper, there should be suitable guidelines for every higher education institution that ensures that no individual is deprived of the opportunity to attain a tertiary degree. This study seeks to develop a framework for the provision of VILs in higher education, especially for Engineering courses. The case study done at school level was discussed in Chapter 4. This study aimed at identifying the challenges that VILs face in SA when considering entry into Engineering courses. The focus group discussions with VILs at special schools and the questionnaires collected from educators of special schools assisted the researcher to understand their perceptions in this regard. To gain a better understanding on the challenges faced by VILs in tertiary institutions, it was necessary to conduct a study at the university level. This chapter presents the case study done at university level.

Section 5.2 discusses the importance of tertiary education and the governing bodies at tertiary institutions while section 5.3 presents the case study background and demographics. Section 5.4 presents the data collected and the analysis process. This chapter is summarized in section 5.5.

5.2 IMPORTANCE OF TERTIARY EDUCATION AND GOVERNANCE AT HIGHER EDUCATION INSTITUTIONS

Education attainment of individuals has a significant impact on the society and economy of a nation. The higher the level of education, the higher the income (Card, 1999). Studies have indicated that if a good percentage of individuals in a country are employed, it would eventually improve the safety, life expectancy and greater civic engagement in the country (Lochner, 2011). Statistics released by the U.S. Bureau of Labor (2012) indicated that individuals without a tertiary qualification experienced an unemployment rate of 14.1% in 2011 and earned less than the individuals with a tertiary qualification. There are both economic and social benefits of attaining a tertiary qualification. Some of the public economic benefits include higher generation of tax revenues, increased productivity and less dependency on government financial assistance, while the private benefits include increased income, good working conditions, and more employment opportunities (Merisotis, 1998).Some of the public social benefits include reduced crime in the country and improved quality of life while the private social benefits include improved life expectancy, improved decision-making capability and better personal status (Merisotis, 1998).

The Department of Education in SA was divided into two departments in 2009: Department of Basic Education (which is responsible for the management of the schools in the country) and Department of Higher Education and Training, abbreviated as DHET (which is responsible for managing the post school education in the country) (DHET, 2016). DHET's vision is to provide an inclusive post-school education system in SA to ensure full participation of all individuals towards the social and economic goals of the nation (CHIETA, 2017). Despite the efforts of the DHET, students with disabilities still feel excluded in higher education institutions (Mutanga, 2017). It is therefore important to identify the challenges that the students with disabilities face in higher education. The literature review on the studies done by various researchers on the current situation of VILs in higher education institutions as well as the challenges they face in higher education institutions are described in detail in Chapter 2.

The DHET derives its directive from section 29 of the Constitution of SA. This Section recognises the right of every individual in SA to be educated regardless of the disabilities they have (Useh, 2015). It is important that the education systems are governed efficiently to ensure that all individuals benefit from the education provided at higher education institutions. Students might be deprived of services at the institutions if the education systems are managed inefficiently (Bardhan, 1997). Students with disabilities in SA enter tertiary education after their schooling at special schools. They have to adapt to the new learning environment provided by the universities. Every tertiary institution in SA should ensure that students with disabilities do not face a situation where they are deprived of university services. The governance structure at higher education institutions is depicted in Figure 5.1.

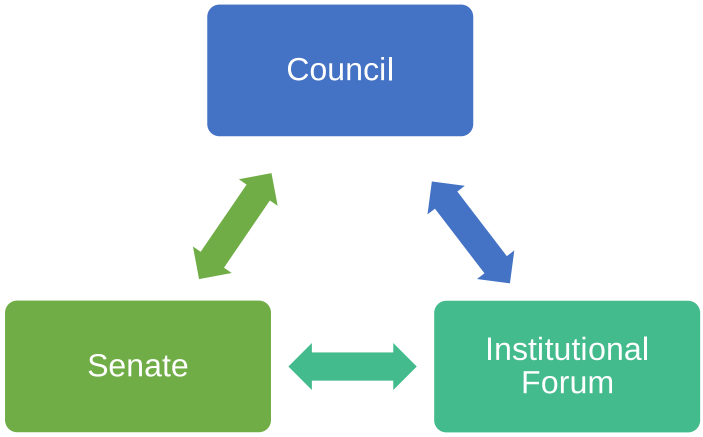

Figure 5.1 Governance in South African Higher Education (Hall, Symes and Luescher, 2002)

The University Council is the highest governing body of the institution, as stipulated by section 27 of the Higher Education Act (Hall, Symes and Luescher, 2002). The governance of the Council should be in accordance to the Act and the institutional statute (Harper *et al*., 2000). Institutional statute refers to any statute made by the council of a higher education institution in SA as contemplated in section 32(Minister of Education, 2001).The institutional statutes should be approved by the Minister and published in the Gazette before implementing it into practice (Republic of South Africa, 1997). The Council is responsible for policy-making at the University as well as to decide on guidelines for efficient strategies, financial management, monitoring the disciplinary issues regarding staff and students as well as the admission policies of the university. According to section 27 of the Higher Education Act, at least one member of the Council must have relevant knowledge and experience about governing the university and the council members must ensure that they do not indulge in any activities against the favour of the university that might result in a conflict (Republic of South Africa, 1997).

The Council comprises the Principal, the Vice-Principals, Senate members, members appointed by the Council based on their knowledge and expertise in the fields of education, financial management, human resources, etc., members appointed by the Convocation, students, members appointed by the Minister as per 27(4)(c) of the Act, academic staff, non-academic staff, etc. (Republic of South Africa, 1997).

The Senate has to function under the Council and is answerable to the Council for any matter related to academic, research and community as stipulated in section 28(1) (Republic of South Africa, 1997). Senate is responsible for all academic activities in the university, which include planning, administration, teaching, learning, quality assurance of the university services, infrastructure etc. (Republic of South Africa, 1997). The Senate comprises the Chairperson of Council, the Deputy Chairperson of the Council, the Principal, the Vice-Principals, the Executive Directors, the Deans, the deputy Deans, academic staff, HODs, Registrar, Chairperson of the Institutional Forum, members nominated by SRC, non-academic staff, etc. (Republic of South Africa, 1997).

The Institutional Forum is responsible for advising the Council on matters regarding implementing the policies on higher education, equity policies, codes of conduct, promoting cultural diversity and resolving conflicts. The Institutional Forum is composed of executives of the university appointed by the Principal, Council members, Senate members, members from trade unions, member appointed by the President of the Convocation, a disabled person, not more than ten student representatives in accordance with an appointment, students, staff members, etc. (Republic of South Africa, 1997).

5.3 CASE BACKGROUND AND DEMOGRAPHICS

The case study at university level targeted the DUs of the universities as well as the Heads of Departments (HODs) and senior lecturers of Engineering faculties.

The higher education institutions in SA are divided into four categories (The Department Of Higher Education And Training, 2016):

- Public technical and vocational education and training colleges;
- Public community education and training colleges;

- Public universities; and
- Private colleges.

The study focused on the public universities as these offer a diverse range of programmes and courses compared to the other institutions (Chan, 2016). Public universities in South Africa are divided into three categories (Government of South Africa, 2019):

- Traditional universities;
- Universities of Technology; and
- Comprehensive universities.

The initial target population of the study were the 26 public universities in SA. However, six universities indicated telephonically that they were not willing to participate in this study. The researcher therefore targeted the remaining 20 public universities that did not indicate any explicit decline.

Online questionnaires were used as the research tool to collect data for the case study. These questionnaires were used to collect the perceptions and views of the participants (DU managers, HODs and senior lecturers) regarding the provision of VILs in Engineering courses. Twenty-five percent (25%) of the institutions (5 institutions) responded to the DU unit questionnaire, forming the sample size of this part of the study; 45% of the institutions (9 institutions) responded to the HOD and senior lecturer questionnaire, and that formed the sample size of this part of the study.

5.3.1 Participants

This study used a purposeful sampling technique (Silverman, 2005) to select the research sample. The sampling techniques are discussed in detail in Chapter 3. The participants for this case study were from two categories; DUs formed one category and HODs and senior lecturers formed another category from Engineering faculties at the universities.

5.3.1.1 Disability Units

Support to students with disabilities in tertiary institutions is coordinated by DUs (Hewett, Keil and Douglas, 2015). These units are considered to be the primary point of contact for many students with special needs at tertiary institutions (Naidoo, 2010). The primary purpose of these units is to provide these students with the services they require, while simultaneously protecting the integrity of academic programs and services. DUs support disabled students by ensuring the provision of assistive devices and services, as well as assisting them with administrative procedures. DU staff also provide indirect support to the students by training the lecturers to work with students with different categories of disabilities (Matshedisho, 2007). In order to develop the framework for this study, it was necessary to identify the challenges that affected the provision of education to VILs in Engineering. Since DUs are responsible for assisting students with disabilities, their views and perceptions regarding the provision of VILs in Engineering played a crucial role in this study.

5.3.1.2 HODs and senior lecturers – Engineering faculty at universities

The HOD is responsible for ensuring that the department is committed to delivering the best teaching practices as well as good student learning experiences (Hammond, 1998). The HOD is also responsible for handling the department's resources efficiently (Dinham, 2007). HODs of universities also make an effort to build good relationship between the department and professional organisations (Melville and Wallace, 2007).The researcher had to investigate whether Engineering departments were prepared to accommodate VILs in Engineering. It was also important to know whether the departments were fully equipped with resources to assist VILs. Therefore, the HODs were chosen as the participants for the university case study. Senior lecturers were also included in this case study because of their experience and knowledge in the Engineering field; therefore, their views and perceptions regarding the provision of VILs in Engineering also played a crucial role in this study.

5.4 DATA COLLECTION AND ANALYSIS

This part of the case study (Part B) utilised questionnaires for collecting data. This study started with an intensive literature review that was discussed in Chapter 2. Online questionnaires were used to obtain the perceptions of the DUs and HODs and senior lecturers from Engineering faculties on the provision of education for VILs in SA. Table 5.1 presents the research method used and how the research questions and objectives were linked to Part B of the case study.

Table 5.1 Case study (Part B) research methods and participants

Main Aim	Research Question	Research Objective	Participants	Institution	N	Research Method
Develop a framework for the provision of VILs in Engineering education in SA using ICTs	1. To what degree are the Engineering faculties in SA accommodating VILs? 2. What are the challenges that VILs in SA face while contemplating entry into Engineering courses? 3. What guidelines should exist for the effective use of ICT tools by VILs in Engineering?	1. Determine the degree to which Engineering faculties in SA are accommodating VILs. 2. Identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA. 3. Incorporate many of the ICT tools into the framework to benefit VILs in Engineering education in SA.	DU managers	Tertiary institutions of SA	5	Questionnaires
			HODs and senior lecturers of Engineering faculties		25	

5.4.1 Questionnaire

Questionnaires are useful tools for gathering perceptions of individuals in a large group (Jones, Baxter and Khanduja, 2013). The aim of the questionnaire used in Part B of the case study was to understand the perceptions of DUs and HODs and senior lecturers in Engineering faculty at tertiary institutions in the provision of VILs in Engineering courses in tertiary institutions at SA. The following sub-objectives were addressed from the questionnaires:

- Determine the degree to which Engineering faculties in SA are accommodating VILs;
- Identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA; and
- Incorporate many of the ICT tools into the framework to benefit VILs in Engineering education in SA.

5.4.1.1 Developing the Questionnaires

After determining the target population for the study and formulating the research aim and objectives to be achieved from the study, the next step was to design the questionnaire. The researcher followed three steps to design an effective questionnaire for the study. The steps were as follows:

- The information that was required by the researcher from the questionnaire was determined. A checklist of the issues that needed to be discussed with the participants had to be prepared at this stage. The questions were linked to the research objectives as well as to the relevant studies done on this area.
- The researcher determined the order of the questions in the questionnaires. The questions were ordered in such a way that answers to previous questions would not influence answering the next one.
- The researcher decided what type of question formats should be used in order to obtain the information needed. The questions were designed based on the information the researcher wanted to retrieve from the participants. The questionnaire consisted of a small number of closed-ended questions where the participants were asked to choose one option from a list of options, for

example, yes/no questions, age and gender. Ranking questions were also included in the questionnaire. The participants were asked to rank several options, for example, Rank the subjects based on the difficulty. Most of the questions used in the questionnaire consisted of open-ended questions. The participants were asked to describe a certain issue or list certain factors based on their viewpoints.

The questions and the references for the DU are presented in Table 5.2. The questions designed for HODs and senior lecturers are presented in Table 5.3.

Tables 5.2 and 5.3 indicate that the questions were linked to the literature review. The questions were also developed keeping the research objectives in mind. The questionnaires were benchmarked against several relevant and similar studies done nationally and internationally (Mayat and Amosun, 2011). Content validity is achieved when the questions in the research tool are a representative of the literature studies and the research objective that the study seeks to achieve (Bolarinwa, 2015). Some of the questions (for example, C3, C4, C5 and D5) included in this questionnaire do not have a reference as they were asked to obtain a better understanding of the challenges faced by VILs in Engineering education.

There is limited research regarding Engineering modules that are challenging for VILs. The perspective of a senior Engineering staff regarding this would assist the researcher in identifying the factors that would assist in developing the framework for the study. The DU questionnaire is presented in Appendix G and the questionnaire for HOD and senior lecturer at Engineering faculties of South African universities is presented in Appendix H.

Table 5.2 DU questionnaire and references

Questions	References													
	(Mayat and Amosun, 2011)	(Polit and Beck, 2013)	(Charles and Carstensen, 2010)	(Ciobanu, 2013)	(Mushome and Monobe, 2013)	(Lyner-Cleophas *et al.*, 2014)	(Ontario Human Rights Commission, 2004)	(Mutanga, 2017)	(Tugli *et al.*, 2013)	(UNESCO, 1997)	(Puukka, 2012)	(Eguavoen, 2016)	(Broeder, Extra and Maartens, 2002)	(Fotim, 2011)
Section A:1-5) Demographic Information (age, gender, home language, university, race)		X	X								X			
Section A:6) How long have you been involved in working for the disability unit?				X										
Section B:1) Give us a brief background on what the disability unit does														X
Section B:2) How many students with special needs do you cater for per year in your university?								X						
Section B:3a) How many VILs do you cater for per year in your university?	X													
Section B:3b) How many VILs do you cater for per year in your university for Engineering?	X													
Section B:3c) From the number indicated in 3a, how many VILs were interested in doing Engineering?	X													

Questions	References													
	(Mayat and Amosun, 2011)	(Polit and Beck, 2013)	(Charles and Carstensen, 2010)	(Ciobanu, 2013)	(Mushome and Monobe, 2013)	(Lyner-Cleophas *et al.*, 2014)	(Ontario Human Rights Commission, 2004)	(Mutanga, 2017)	(Tugli *et al.*, 2013)	(UNESCO, 1997)	(Puukka, 2012)	(Eguavoen, 2016)	(Broeder, Extra and Maartens, 2002)	(Fotim, 2011)
Section C:1) Which resources do you have in place for the provision of VILs?					X									
Section C:2) Which resources do you have in place for the provision of VILs in Engineering?	X													
Section C:3-4) Do you support VILs to do Engineering? If no, explain	X													
Section C:5a) What courses do you usually recommend to VILs? Why?							X							
Section C:5b) What courses do you recommend when the VIL has a desire to do Engineering? Why?	X													
Section C:6) In your opinion, do you think that VILs find Engineering challenging? If so, why?	X													
Section C:7) What are the factors that hinder VILs in pursuing Engineering	X													
Section C:8-9) If the resources mentioned in Question 1 and 2 were in place, would you still recommend VILs to take Engineering? If no, explain												X		
Section D:1) What are the challenges faced by the disability unit to assist VILs?														X

Questions	References													
	(Mayat and Amosun, 2011)	(Polit and Beck, 2013)	(Charles and Carstensen, 2010)	(Ciobanu, 2013)	(Mushome and Monobe, 2013)	(Lyner-Cleophas *et al.*, 2014)	(Ontario Human Rights Commission, 2004)	(Mutanga, 2017)	(Tugli *et al.*, 2013)	(UNESCO, 1997)	(Puukka, 2012)	(Eguavoen, 2016)	(Broeder, Extra and Maartens, 2002)	(Fotim, 2011)
Section D:2) What percentage of VILs approach the disability unit if they need assistance?						X								
Section D:3) What could be the reasons for some VILs not approaching the disability unit?									X					
Section D:4) For teaching VILs, which of the following do you recommend? a) Training of current lecturers in the university; b) Recruit special lecturers for VILs					X									
Section D:5) What resources are used in the university to assess VILs?					X									
Section D: 6a-b) Are you collaborating with disability units of other universities? If yes, please mention the universities										X				
Section D: 6c) Are the other disability units cooperative?										X				

Table 5.3 Questions for HODs and senior lecturers and their corresponding references

Questions	**References**												
	(Mayat and Amosun, 2011)	(Berčan, 2014)	(Lyner-Cleophas *et al.*, 2014)	(Boudersa, 2016)	(Mushome and Monobe, 2013)	(Spencer, 2008)	(Spungin and Ferrell, 2007)	(Agesa, 2014)	(Omede, 2014)	(Department of Education, 2011)	(Dalton, Mckenzie and Kahonde, 2012)	(Tugli *et al.*, 2013)	(Nkoane, 2006)
Section A:1-4) Demographic Information (gender, age, university, department)		X											
Section A:5) Years of experience in teaching			X										
Section A:6-7) Do you have a teaching qualification (e.g. PGCE)? If yes, please mention.				X									
Section B:1) Currently, are you accommodating any VILs in your department? Please explain	X												
Section B:2) How many VILs do you have in your department?	X												
Section B:3) Please give your options and perceptions on the following statements which will be measured on a 4-point scale, from strongly agree to strongly disagree: a) There are few VIL engineers in South Africa. b) Universities should accommodate VILs. c) My department is equipped with proper resources to educate VILs.	X				X	X			X				

Questions	References												
	(Mayat and Amosun, 2011)	(Berčan, 2014)	(Lyner-Cleophas *et al.*, 2014)	(Boudersa, 2016)	(Mushome and Monobe, 2013)	(Spencer, 2008)	(Spungin and Ferrell, 2007)	(Agesa, 2014)	(Omede, 2014)	(Department of Education, 2011)	(Dalton, Mckenzie and Kahonde, 2012)	(Tugli *et al.*, 2013)	(Nkoane, 2006)
d) My department is prepared to accommodate VILs. e) Proper training is provided to staff in my department in order to educate VILs. f) The current curriculum is challenging for VILs. g) Computer literacy should be a prerequisite for students with visual impairments to succeed in most Engineering courses. h) VILs are prepared for tertiary education.													
Section C:1) As an academic yourself, what role should an academic play in the development of VILs?							X						
Section C:2) How does visual impairment affect learning?								X					
Section C:3) What subject are you offering in your department?													
Section C:4) What modules do you offer that will be challenging to VILs?													
Section C:5) Why would these modules prove challenging?													

Questions	References												
	(Mayat and Amosun, 2011)	(Berčan, 2014)	(Lyner-Cleophas *et al.*, 2014)	(Boudersa, 2016)	(Mushome and Monobe, 2013)	(Spencer, 2008)	(Spungin and Ferrell, 2007)	(Agesa, 2014)	(Omede, 2014)	(Department of Education, 2011)	(Dalton, Mckenzie and Kahonde, 2012)	(Tugli *et al.*, 2013)	(Nkoane, 2006)
Section C:6) What teaching methodologies do you think should be used to assist VILs?									X				
Section C:7) Which of these identified methodologies are you currently using, if any?									X				
Section C:8) What type of educational technologies could be used to assist VILs?									X				
Section C:9) Which of these identified technologies are you currently using, if any?									X				
Section C:10) What assessment strategies may be used to assist VILs?										X			
Section C:11) Which of the identified strategies do you use, if any?										X			
Section C:12) How do you assess the level of visual impairment (partially sighted learners, moderately blind learners, severely blind learners, completely blind learners) in your students?											X		
Section C:13) Based on your assessment, which technologies do you use for the different levels (partially sighted learners, moderately blind learners, severely blind learners, completely blind learners)?											X		

Questions	References												
	(Mayat and Amosun, 2011)	(Berčan, 2014)	(Lyner-Cleophas *et al.*, 2014)	(Boudersa, 2016)	(Mushome and Monobe, 2013)	(Spencer, 2008)	(Spungin and Ferrell, 2007)	(Agesa, 2014)	(Omede, 2014)	(Department of Education, 2011)	(Dalton, Mckenzie and Kahonde, 2012)	(Tugli *et al.*, 2013)	(Nkoane, 2006)
Section C:14) What can be done by your department in order to accommodate VILs?	X												
Section D:1) In your observation, what are the current challenges that the VILs are facing in the university?												X	
Section D:2) In your opinion, what could be the reason for minimal intake of VILs in Engineering courses at universities?	X												
Section D:3) For my department, to accommodate VILs would require: a) Too much time b) More resources (Trained lecturers, equipment, infrastructure etc.) c) Inclusivity d) Financial expenses													X
Section D:4) What suggestions would you provide to universities for effective learning and teaching of VILs in Engineering courses?	X												

Questions	References												
	(Mayat and Amosun, 2011)	(Berčan, 2014)	(Lyner-Cleophas *et al.*, 2014)	(Boudersa, 2016)	(Mushome and Monobe, 2013)	(Spencer, 2008)	(Spungin and Ferrell, 2007)	(Agesa, 2014)	(Omede, 2014)	(Department of Education, 2011)	(Dalton, Mckenzie and Kahonde, 2012)	(Tugli *et al.*, 2013)	(Nkoane, 2006)
Section D:5) Is there any other comment, question or thought that you would like to raise in this regard?					X								

5.4.1.2 Piloting the Questionnaires

It is necessary to conduct a pilot survey before distributing questionnaires to the target population. It is done to identify any anomalies and inconsistencies in the questionnaire. Pilot testing is conducted due to the following reasons (Wright, 2005; Krosnick, 2018):

- To check whether the questions are ordered logically;
- To determine whether the participants can understand the questions easily;
- To determine the time duration that the participants would take to complete the questionnaire;
- To understand the difficulties faced by the participants in answering the questions;
- To understand whether the responses provided by the participants actually are the responses to the questions we think we are asking them;
- To identify any mistakes in the questionnaire;
- To determine whether the participants can answer the questions provided in the questionnaire;
- To determine whether the participants can follow the routeing instructions provided in the questionnaire; and
- To determine whether the questions retains the participants' attention.

Questionnaires were validated by experts in the field as part of a pilot study before the actual research was done. The experts consisted of DU staff and HODs and senior lecturers from the Engineering faculty at CUT. The DU questionnaire was piloted by DU staff at CUT. The experts took approximately 20 minutes to complete the questionnaire. The experts, to the best of their ability, ensured that the items were accurate, relevant, clear, simple, complete and not biased. The experts mentioned that the questionnaire was clear and they felt that the questions were relevant to the topic being researched. Therefore, no modification was made to the questionnaire.

The questionnaire for HOD and senior lecturers at Engineering faculties in South African universities was piloted by the HOD and senior lecturers in the Engineering faculty at CUT. The experts took approximately 20 minutes to complete the questionnaire. The participants of the pilot survey provided the researcher with their feedback that indicated that the questions were clear, appropriate and well structured. Minor changes were required with one question being modified based on the feedback. In question 4 under section A of the questionnaire, geomatics/land surveying was added along with other Engineering departments based on participant feedback. The pilot study participants suggested that geomatics is being offered in many South African universities, so it should be included in the list.

Ethical clearance was obtained from the Faculty Research and Innovation Committee at the CUT. Data was analysed using a qualitative content analysis technique.

5.4.1.3 DU questionnaires

The questionnaires were distributed to the target population after pilot testing. The target population of this questionnaire were the managers of DUs of the 20 public universities in SA. Although there are 26 public universities in SA, six specifically indicated telephonically that they were not willing to participate in this study. The questionnaires were distributed electronically to the 20 universities using Google Forms, of whom five responded. Emails were sent to the the other 15 universities many times, but the researcher did not receive any response from these universities. In an email sent to the participants, they were provided with a brief description of the research. The researcher's contact information was also included in the email. The participation was purely voluntary. Participants were emailed an informed consent along with the questionnaire.

The collected data was analysed using a qualitative content analysis technique. The results were then carefully analysed to determine whether the research objectives were effectively addressed. The data collected from the DUs of public universities in SA are presented below.

PART A: BACKGROUND INFORMATION

The university details and years of experience are presented below.

Question 5: University

Table 5.4 indicates the list of universities who responded to the study, forming the sample of the target population. The DUs of the University of Stellenbosch, University of the Witwatersrand, Central University of Technology, University of Fort Hare and University of the Free State participated in the study.

Table 5.4 Participants' university

	Responses
Resp-1	University of the Free State
Resp-2	University of Fort Hare
Resp-3	Central University of Technology
Resp-4	University of the Witwatersrand
Resp-5	University of Stellenbosch

Question 6: How long have you been involved in working for the disability unit?

- **0-2 yrs.**
- **2-4 yrs.**
- **4-6 yrs.**
- **6 yrs. and above**

Table 5.5 indicates the participants' work experience. Most of the participants (80%) were well experienced with a working experience of 6 years and above and only one participant indicated their work experience as 2-4 years.

Table 5.5 Participant's work experience

	Responses
Resp-1	6 years and above
Resp-2	2-4 years
Resp-3	6 years and above
Resp-4	6 years and above
Resp-5	6 years and above

In his study, Ciobanu (2013) stresses the importance of experienced staff at student support services at universities. Well experienced DU staff play an important role in improving the experience of students with disabilities at universities. The viewpoints of experienced DU staff are crucial for this study. Younger generation are more innovative and continuously try to learn and improve their services in their workplace (Shah and Udgaonkar, 2018). So, viewpoints of young staff may also provide meaningful insights to the researcher.

PART B: BACKGROUND INFORMATION-DUs

This section of the questionnaire captured the background information of the DUs. Table 5.6 presents the answers to Question 1.

Question 1: Give us a brief background on what the disability unit does

Table 5.6 Function of a DU – Participants' responses

	Responses
Resp-1	Provide holistic, individualized support to students with disabilities. Raise awareness amongst students, academic and support staff. Provide input towards transformation of the institution into a more universally accessible institution
Resp-2	Assist with basic needs – extra time, Assistive device

	Responses
Resp-3	Offers service to PWDs (people with disabilities) from emotional support to technical.
Resp-4	The role of the Wits Disability Rights Unit (DRU) is to work with all university departments (academic and non-academic) to ensure that students and staff with disabilities have equal access to the total campus environment.
Resp-5	We facilitate support to students with disabilities, and work with all kinds of disabilities

The responses were analysed according to the types of themes and issues that emerged. Counting frequency of recurrent events helps the researcher to look for patterns in the occurrence of the codes and then generate explanations for those patterns. Various themes were identified based on the participants' response. Table 5.7 presents the categories identified by the researcher.

Table 5.7 Function of a DU – Categories

Themes	Frequency	Percentage
Support to students with disabilities	4	60%
Equal access to the campus environment	3	40%
Raise awareness among students, academic and support staff.	1	20%
Assist with resources	1	20%

From the responses obtained from participants' regarding the function of a DU, it was evident that by far the majority (60%) of the participants indicated that the primary goal of the DU is to provide support (technical/emotional etc.) and equal access to a campus environment to students with disabilities. One participant indicated that the

DU should raise awareness amongst students, academic and support staff and another participant indicated that DU should assist the students with adequate resources. Students have different learning needs and are members of diverse communities; providing them the required resources helps to avoid pigeonholing students into specific groups. The overall responses indicate that the participants considered their unit as the starting point for coordinated support for students with disabilities.

The Fotim report (2011) states that the DU has various roles such as assisting students with disabilities both on an academic and emotional level, providing the students the required resources, tools and equipment and promoting awareness about disability among the staff, management and students. The participants of the study agree to the findings from this literature.

Question 2: How many students with special needs do you cater for per year in your university?

The participants indicated that they had been catering for a good number of students with special needs (range: 25-1250) at their universities, as depicted in Figure 5.2.

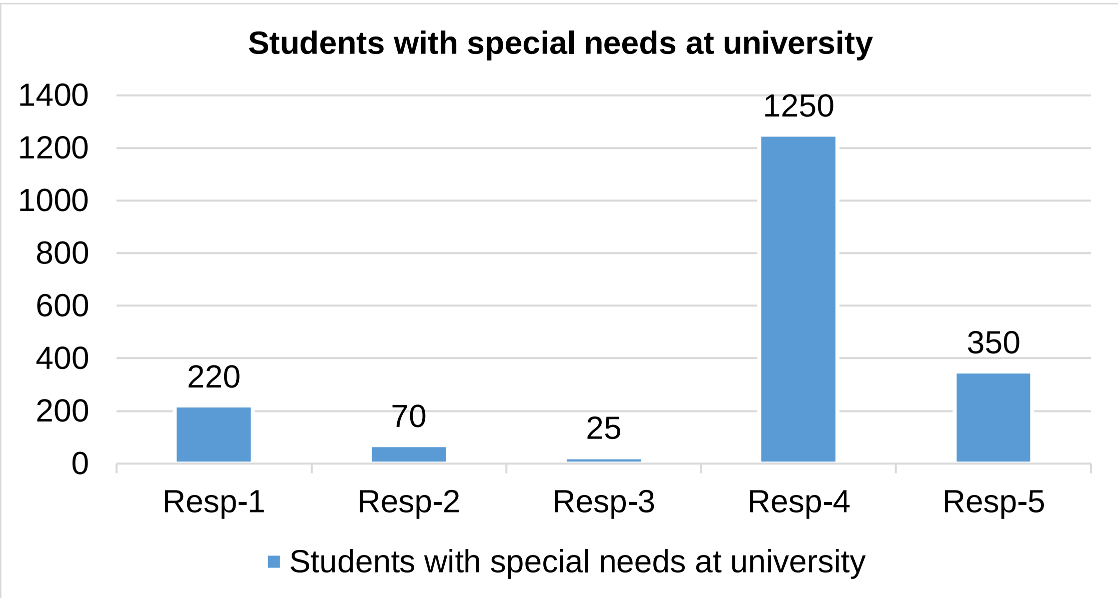

Figure 5.2 Number of students with special needs at university-Participants' response

Students with special needs refer to those learners that have learning, physical and behavioural disabilities (Kryszewska, 2017). VILs form part of students with special needs. In his study, Mutanga (2017) indicates that higher education institutions in SA struggle to accommodate students with special needs due to many factors like infrastructural constraints, financial constraints etc. Despite the challenges that higher education institutions face in accommodating students with special needs, the figures in this study indicate that the universities cater for a good number of students with special needs which should be appreciated.

Question 3a: How many VILs do you cater for per year in your university?

Table 5.8 indicates the number of VILs the participants' universities catered for per year (range: 5 to 203). Two of the participants' also mentioned that they do not have a restriction on the intake of VILs per year in their university. This indicates the preparedness of these universities in accommodating VILs.

Table 5.8 Number of VILs catered per year at the university - Participants' response

	Responses
Resp-1	No limit per se, currently 31
Resp-2	30%
Resp-3	5
Resp-4	We do not have a restriction on how many VILs we support, the student must have a documented disability and register with us and we will do our best to support the student as best we can. Currently there are 203 VILs registered in 2017
Resp-5	About 30 per year

Question 3b: How many VILs do you cater for per year in your university for Engineering?

Figure 5.3 indicates the statistics regarding the number of VILs catered for per year in Engineering at the participants' university. The statistics demonstrates a sharp decline in the number of VILs catered for per year in Engineering courses compared to the total intake of VILs in the entire university.

Mayat and Amosun (2011) in their study done in one of the universities of SA states that VILs are under-represented in Engineering. The participants' response agrees to what has been noted in the literature. The figures indicated above, further strengthens the purpose of this study that aims to identify the barriers that VILs face in Engineering and to design a framework for the provision of VILs in Engineering education in SA.

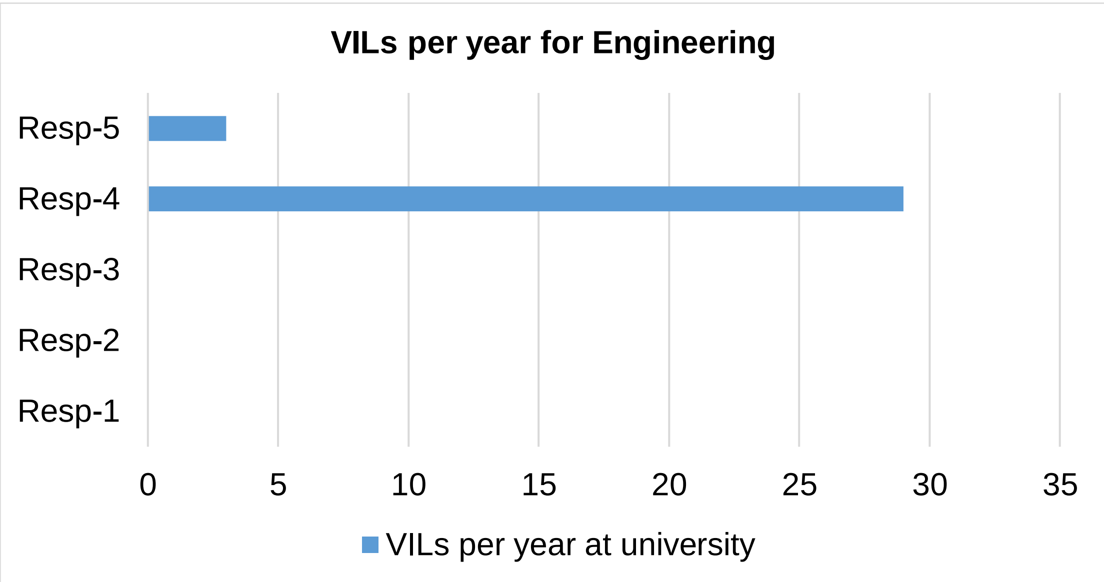

Figure 5.3 VILs catered per year for Engineering – Participants' responses

Question 3c: From the number indicated in 3a, how many VILs were interested in doing Engineering?

Table 5.9 indicates the participants' response regarding the number of VILs interested in Engineering. The participants' responses indicated that either "none of the VILs were interested in pursuing Engineering" or they were "unsure" about the number of VILs who were interested in pursuing Engineering.

Table 5.9 Number of VILs interested in Engineering – Participants' responses

	Responses
Resp-1	None
Resp-2	N/A
Resp-3	0
Resp-4	I do not know the number
Resp-5	Unsure

As noted in the literature, only a few VILs pursue Engineering (Mayat and Amosun, 2011). The response of the participants raises concerns as to what factors lead to the disinterest in VILs to pursue Engineering.

PART C: CHALLENGES VILs FACE IN HIGHER EDUCATION

This section of the questionnaire captured the participants' viewpoint on the challenges VILs faced in universities. The first question in this section asked the participants to list the resources used in the universities for VILs. The responses are presented in Table 5.10.

Question 1: Which resources do you have in place for the provision of VILs?

Table 5.10 Resources for VILs – Participants' responses

	Responses
Resp-1	Braille, Screen-reading software, E-text, Enlarged print, Text enlargers, Talking calculators, hand-held text enlargers
Resp-2	Computer software and magnifying equipment (Zoom text etc). Tape recorders if necessary. Readers and scriber if required and brain printers and translating software.

	Responses
Resp-3	Jaws, enlarged screens
Resp-4	Various assistive technologies - screen readers and magnifiers (software and hardware), OCR (optical character recognition) software, braille devices (e.g. notetakers, embossers, graphic embossers, tactile machines, etc.)
Resp-5	We have text conversation services. Assistive software such as WYNN (What You Need Now), JAWS, Zoom Text and magnifiers are available for use. Students are inventive and find their own software for use. MathType and Latech are used by some academics as well as students

The participants used various resources to assist VILs. All (100%) of the participants indicated that they used computer software and magnifying devices to assist VILs. Some of the participants also indicated that they used scribers, braille devices, audio equipment and enlarged prints to assist VILs. Some of the resources used by DUs as mentioned in the literature are Braille, enlarged print ,screen readers, magnifiers, etc. (Mushome and Monobe, 2013).The participants' response indicates that they have been using the resources as noted in the literature.

Question 2: Which resources do you have in place for the provision of VILs in Engineering?

Table 5.11 indicates the participants' response regarding the resources they used for VILs in Engineering. The response from the participants indicated that they did not use any specific resources for VILs in Engineering.

Table 5.11 Resources for VILs in Engineering – Participants' responses

	Responses
Resp-1	Not sure what is specifically needed for Engineering - will depend on discussion with student
Resp-2	N/A
Resp-3	none
Resp-4	Various assistive technologies - screen readers and magnifiers (software and hardware), ocr software, braille devices (e.g. notetakers, embossers, graphic embossers, tactile machines, etc.)
Resp-5	They get enlarged print and can use magnifiers and ZoomText. Latech gets used as well.

The participants' responses were analysed and codes were identified. The patterns in the codes were identified by counting the frequency of occurrence of these codes. Table 5.12 presents the codes identified by the researcher based on the participants' response.

Table 5.12 Resources for VILs in Engineering – Codes

Code	Frequency	Percentage
Magnifiers	2	40%
Screen-reading software	1	20%
Student requirements	1	20%
Braille devices	1	20%
Enlarged print	1	20%

A total of 40% (2 out of 5) of the participants indicated that they used magnifying equipment to assist VILs in Engineering. The other resources that they listed include: screen-reading software, Braille devices and enlarged prints. One of the participants also mentioned that the resources used for VILs for Engineering depended on the students' requirement. There is not much literature on VILs in Engineering. Mayat and Amousun (2011) mentions the use of screen readers, magnifying devices and braille devices for VILs in Engineering. It must be noted that Engineering subjects are technical in nature and VILs may require specialised tools depending on the nature of each Engineering subject. The participants' responses also indicate that they were not aware about Engineering specific resources for Engineering.

Question 3: Do you support VILs to do Engineering?

Figure 5.4 indicates the participants' response regarding their support towards VILs doing Engineering. Most of the participants (80%) indicated that they support VILs when they want to do Engineering and only one participant indicated that they did not support VILs doing Engineering.

The literature indicates that there is a lack of academic support for VILs in Engineering (Mayat and Amosun, 2011). Even though, only one participant indicated that they do not support VILs to do Engineering; this attitude may still prove discouraging to some VILs in Engineering.

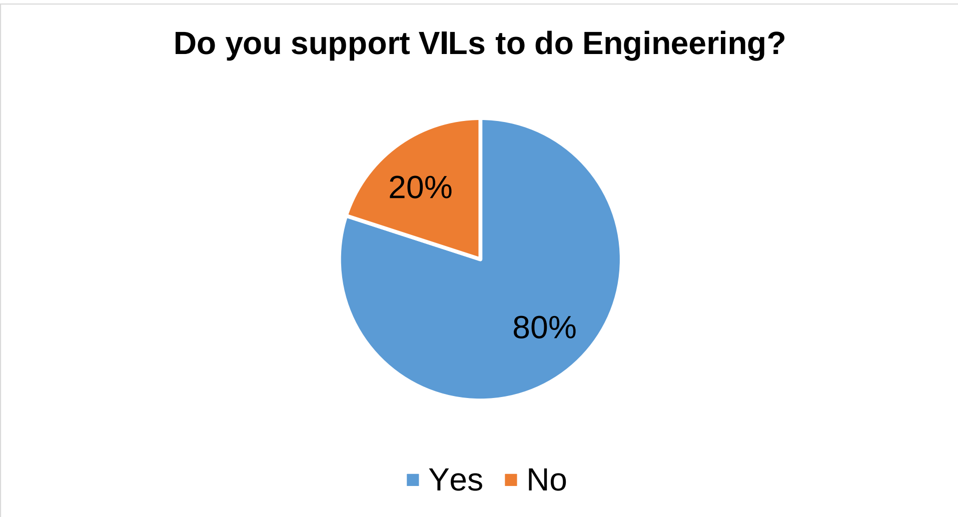

Figure 5.4 Support for VILs to pursue Engineering – Participants' response

Question 4: If no, explain.

This was a sub-question for the participants who indicated that they do not support VILs to do Engineering in the previous question. Only one participant indicated his/her response to this question: that they do not support VILs to do Engineering because they do not offer Engineering in their campus.

Question 5a: What courses do you usually recommend to VILs? Why?

Table 5.13 presents the participants' responses regarding the courses they would recommend to VILs. Most of the participants (80%) indicated that VILs decide which course they want to do at university and it is purely based on their interest. One participant indicated that they would not discourage VILs from choosing a particular course, but they would look at the subjects from an accessibility perspective to see what resources can possibly be provided by the universities for these students. A participant mentioned that usually arrange meetings with the students and course lecturers to discuss about the challenges and the accessible resources available for them for that course.

Table 5.13 Courses for VILs – Participants' Responses

	Responses
Resp-1	We do not recommend. Students decide.
Resp-2	It depends on the wishes of the student
Resp-3	Depends on his/her interests
Resp-4	We do not discourage any courses but rather look at the subjects from an accessibility perspective to see what is possible for conversion/adaptation.
Resp-5	Students are free to choose what they want to study provided they meet the entry requirements for their chosen programme. Naturally for VILs courses that

	Responses
	contain lots of graphic content can be extremely challenging. In cases such as these we will arrange a meeting with the course lecturers and the student to discuss any difficulties or challenges they might face in the course and then try find an alternative accessible way to test the students' knowledge on the subject. We are lucky that most academic departments are always open to making their courses accessible to our students.

The Ontario Human Rights Commission (Ontario Human Rights Commission, 2004) states that students with disabilities should be encouraged to make their own choices regarding their career stream they decide to choose. The majority of the participants' response agrees to the existing literature. However, one participant in this study mentions the need to look at the subjects from an accessibility perspective before making a decision. This is an important factor that should be taken into consideration as researchers like Eguavoen (2016) have indicated the importance of accessible resources in their study.

Question 5b: What courses do you recommend when the VIL has a desire to do Engineering? Why?

Table 5.14 indicates the participants' response when asked what courses they would recommend when the VIL has a desire to do Engineering. This question had varied responses from the participants. One of the participants recommended Computer Engineering, pointing out that it would be the safest choice for VILs. The responses from two participants were similar to their previous response on Question 5a. One participant indicated that they would arrange meetings with the students and course lecturers to discuss about the challenges and the accessible resources available for the course, while the other participant indicated that they do not recommend VILs to do any specific course and the students decide what they want. One participant indicated they do not limit VILs to do any specific course.

Table 5.14 Courses for VILs with desire to do Engineering – Participants' Responses

	Responses
Resp-1	Same answer as 5a
Resp-2	N/A
Resp-3	Computer Engineering – Can do this without endangering himself
Resp-4	Same answer as 5a
Resp-5	They usually do all the courses. We do not limit them

There is no literature regarding the recommended courses for VILs to do Engineering. The response from the participants indicated that they recommended courses for VILs by considering the safety issues and knowledge of VILs about the subject.

Question 6: In your opinion, do you think that VILs find Engineering challenging? If so, why?

Table 5.15 presents the participants' response regarding whether they considered Engineering challenging for VILs. The participants' overall response indicated that they consider Engineering to be a challenging stream for VILs.

Table 5.15 Is Engineering challenging for VILs? – Participants' Responses

	Responses
Resp-1	Do not know
Resp-2	VILs will find any area of study challenging
Resp-3	No experience of this
Resp-4	Engineering is very maths and physics based so is generally challenging for most students. I would say it really depends on the individual. In the past we

	Responses
	have had some VILs excel in Engineering, while others not
Resp-5	The only challenging part is when lecturers are not understanding the small changes and adaptations that are needed, such as providing enlarge print or fonts for ease of reading

Forty percent of the participants could not indicate their viewpoint on this question, as they had no prior experience regarding the challenges that VILs face in Engineering education. The rest of the participants indicated their viewpoints regarding this. One participant clearly indicated that VILs would struggle in Engineering, while another indicated that it depends on the ability of the individual to find this stream challenging or not. One participant raised his concern that lecturers do not understand the importance of providing resources that are accessible to VILs and the respondent considers this as a barrier that may affect their learning process. There is no substantial literature regarding whether VILs find Engineering challenging. It should be noted that the literature indicates that there is a low representation of VILs in Engineering (Mayat and Amosun, 2011). Therefore, the participants' response adds to the existing literature.

Question 7: What are the factors that hinder VILs in pursuing Engineering

The factors that hinder VILs in pursuing Engineering according to the participants' viewpoint are presented in Table 5.16. The concerns raised by the participants as the hindering factors for VILs in Engineering were safety issues, lack of vision, fear of not being assisted by lecturers and DU at universities, and restricted programme choice for VILs. One of the participants also mentioned that Engineering courses demand a great amount of visual content.

Table 5.16 Hindering factors for VILs in Engineering – Participants' Responses

	Responses
Resp-1	Will not know until they try..
Resp-2	Sight is important in Engineering.
Resp-3	Dangerous – Electrical Engineering!
Resp-4	Restricted programme choice because a lot of VILs come from special schools who do not offer the high level maths and physics courses to allow the students to qualify for Engineering
Resp-5	It could be material that is not readable or their fear that should they get to the post-school sector, the lecturers will not support them or there will be no DU that can advise or support.

The researchers Mayat and Amosun (2011) indicate that a negative attitude of some lecturers hinders the accommodation of VILs in Engineering. Maguvhe (2015), in his study done at some special schools in SA, indicated that only a few special schools in SA offered Science and Mathematics to VILs. This restricts the programme choice of VILs at tertiary institutions as these subjects are considered as prerequisites for Engineering. Therefore, the participants' responses verify and add to the existing literature.

Question 8: If the resources mentioned in Questions 1 and 2 were in place, would you still recommend VILs to take Engineering?

Figure 5.5 indicates the participants' viewpoint regarding their support for VILs to do Engineering, if there are adequate resources. A total of 60% (3 out of 5) of the participants indicated that they would recommend VILs to take Engineering while a total of 40% (2 out of 5) indicated that they would not recommend VILs to take Engineering even if resources were in place.

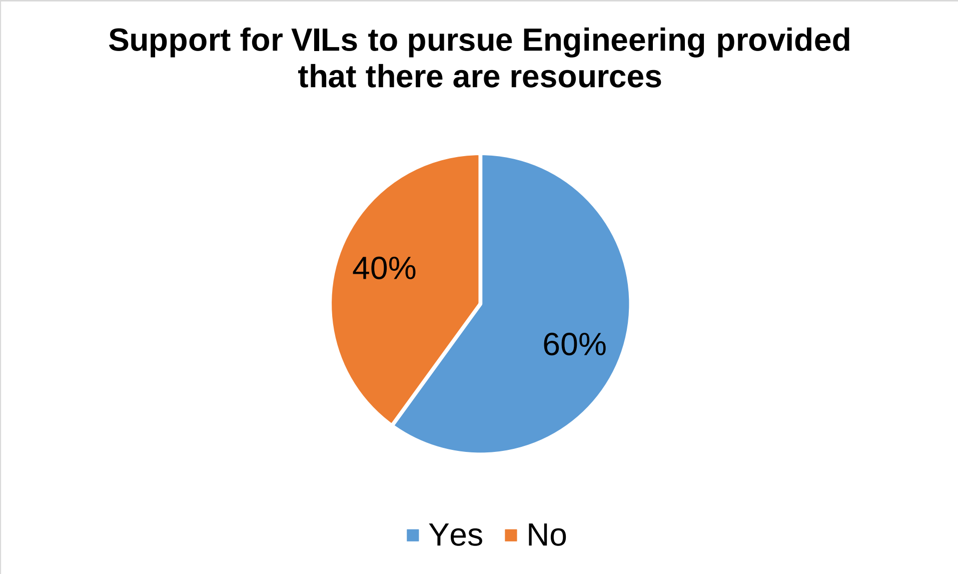

Figure 5.5 Support for VILs to pursue Engineering provided that there are resources– Participants' responses

In his study, Eguavoen (2016) asserts the importance of resources in accommodating VILs in their academic courses. Forty percent of the participants agreed to Eguavoen's study. However, 60% of the DU staff did not feel that resources are important.

Question 9: If no, explain.

This was a sub-question for the participants who indicated that they did not recommend VILs to do Engineering in the previous question. Table 5.17 indicates the participants' explanations for not recommending Engineering as a field of choice for VILs.

One participant indicated that they would not recommend VILs to take Engineering because of safety reasons while another participant indicated that it is the choice of the student to take Engineering or not. There is not much research done to find out why VILs are under-represented in Engineering even if resources were in place. Therefore, the participants' responses add to the existing literature.

Table 5.17 VILs in Engineering if resources in place? – Participants' Responses

	Responses
Resp-1	No response
Resp-2	N/A
Resp-3	I am of the opinion that they will endanger themselves and others – for example, Electrical Engineering
Resp-4	It is really up to the individual, some students will enjoy it, others will not
Resp-5	No response

PART D: FUNCTIONING OF DUs

This section of the questionnaire captured the functioning of DUs. The first question in this section asked the participants to list the challenges faced by DUs to assist VILs. The responses are presented in Table 5.18.

Question 1: What are the challenges faced by the disability unit to assist VILs?

Table 5.18 Challenges faced by DUs – Participants' responses

	Responses
Resp-1	Academic staff to apply universal design in learning and involve VILs in their lectures and taking note of their needs. Labour- intensive work to be done in the preparation of study material.
Resp-2	Accessing the student and then training the on the devices available to them. Students are not always keen to come forward.
Resp-3	Logistics and trained personnel

	Responses
Resp-4	Most challenges are centred on accessible course material and physical access. It can be difficult to acquire course material well in advance in order to make it accessible for our VILs as lecturers may not have planned their courses well in advance. Sometimes the trained mobility routes can be blocked by construction or vehicles parking illegally, etc.
Resp-5	Mostly attitude. Lecturers that want to assist are very keen to do so. Sometimes that fact that extra support means extra costs for the faculty creates a negative impression about disability and support. If we had a big budget for tutoring support we could assist faculties more with support students more

Even though the responses of the participants were different, most of their responses were interrelated. The responses of the participants were analysed, coded and organised into categories. The categories are presented in Table 5.19.

The majority of the participants were concerned about the way the curriculum and study materials were designed. The department and lecturers have to take extra effort to adapt the study materials for VILs. Lack of budget was another concern raised by another participant. Trained personnel, logistics, physical access, training VILs on assistive devices were other challenges presented by the participants. The Fotim report (2011) indicates that a lack of budget, trained staff and minimal autonomy are challenges faced by DU. This report also states that it is essential to have a physically accessible DU in all the higher educational institutions of SA. The participants' response verifies and adds to the existing literature. Training VILs on assistive devices was stated as an additional challenge by the participants.

Table 5.19 Challenges faced by DU – Categories

Categories	Frequency	Percentage
Lack of budget for tutoring support	1	20%
Accessible course material	2	40%
Logistics	1	20%
Training VILs on the accessible devices	1	20%
Trained personnel	1	20%
Requirements for extra efforts from the lecturer	1	20%
Physical access	1	20%

Question 2: What percentage of VILs approach the disability unit if they need assistance?

Table 5.20 indicates the statistics regarding the percentage of VILs that approached the DU unit if they needed assistance. Most of the participants indicated that a high percentage of VILs have approached the DU (above 75%). Two participants indicated only 20%, which is quite low.

The literature indictes that VILs tend to approach DU whenever they needed assistance (Lyner-Cleophas *et al.*, 2014). The responses of the participants validate what has been discussed in literature.

Table 5.20 Percentage of VILs approaching DU – Participants' responses

	Responses
Resp-1	75%
Resp-2	20%
Resp-3	20%
Resp-4	I don't know the percentage, but it is probably quite high
Resp-5	80% - 90% do approach us

Question 3: What could be the reasons for some VILs not approaching the disability unit?

Table 5.21 indicates the participants' responses regarding the reasons for some VILs not approaching the DU. Most of the participants (80%) indicated that stigma and fear of being excluded or not treated properly as some of the reasons.

Table 5.21 Reasons for VILs not approaching DU – Participants' responses

	Responses
Resp-1	Mostly the partially sighted students – all our totally blind students approach us
Resp-2	Fear of discrimination and not wanting to be seen as disabled
Resp-3	Stigma attached
Resp-4	Afraid that disclosing their disability might impact on how they might be seen
Resp-5	If there are no support services, assistive technologies or understanding staff, then this could be exclusionary.

In their study done in a rural university of SA, the researchers Tugli *et al.* (2013) report that VILs find it difficult to adapt to the new environment in universities due to the poor treatment by staff and management towards VILs. Therefore, they feel excluded in universities. The fear of being excluded and discriminated against may also restrict VILs to approach DUs. The participants' responses agree with what has been discussed in the literature.

Question 4: For teaching VILs, which of the following do you recommend? a) Training of current lecturers in the university; b) Recruiting special lecturers for VILs.

Figure 5.6 indicates the participants' recommendations for teaching VILs. A total of 80% (4 out of 5) of participants indicated that they preferred training current lecturers at the university to teach VILs, while only one participant recommended that special lecturers should be recruited for VILs.

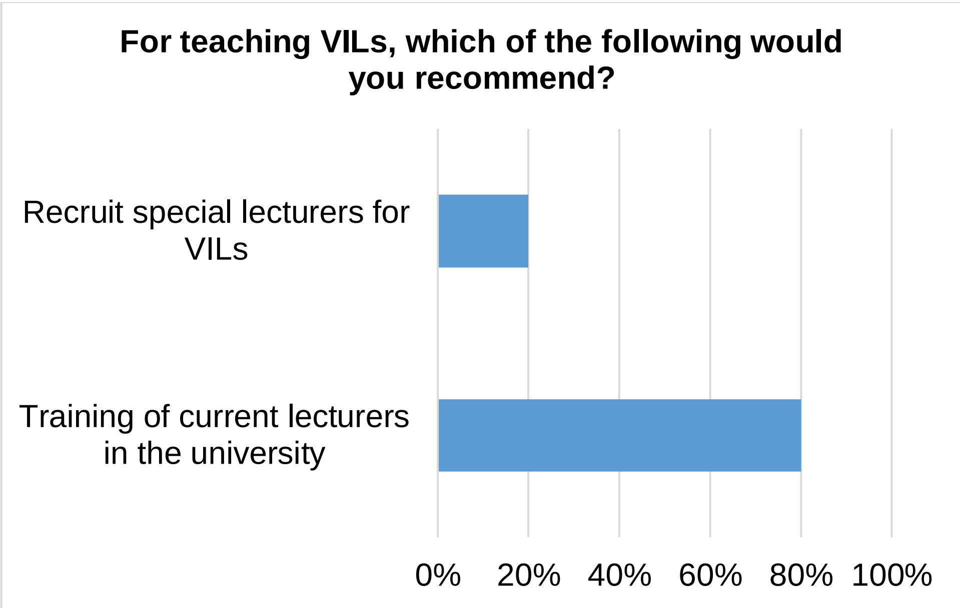

Figure 5.6 Recommendations for teaching VILs – Participants' responses

Researchers like Mushome and Monobe (2013) recommend both training the current lecturers and recruiting special lecturers for VILs. No comparison has been done regarding this by other researchers. Most of the participants (80%) in this study preferred training current lecturers at universities to assist VILs.

Question 5: What resources are used in the university to assess VILs?

VILs are presented in Table 5.22. Forty percent of the participants indicated that they used assistive software to assess VILs. One of the participants' indicated that they used limited resources to assess VILs while another one indicated that they did not use any specific resources for VILs. One of participants indicated that there is a Wellness Centre at the university to assess VILs.

Table 5.22 Resources to assess VILs – Participants' responses

	Responses
Resp-1	The same as non-VILs
Resp-2	Computer software
Resp-3	Very limited resources
Resp-4	All students are required to have a proof of disability to register with DRU but should a student not be diagnosed then the university's Campus Health and Wellness Centre will assess the student.
Resp-5	Enlarged print. Extra time. Assistive software

The literature indicates that universities should have a Wellness Centre and a resource centre to assist students with disabilities (Fotim, 2011; Mushome and Monobe, 2013). The majority of the participants agree to what has been discussed in the literature. However, one of the participants mentioned that they do not use any specific resources for VILs.

Question 6a: Are you collaborating with disability units of other universities?

All (100%) the participants indicated that they do collaborate with DUs of other universities. The participants' response contradict findings by UNESCO (1997) that states that DUs in SA are reluctant to collaborate with each other.

Question 6b: If yes, please mention the universities

The participants were asked to mention the universities that their DUs collaborated with. Table 5.23 presents the universities mentioned by the participants.

Table 5.23 Collaborating with other DUs – Participants' responses

	Responses
Resp-1	University of the Witwatersrand (Wits), Stellenbosch, University of Cape Town (UCT) mostly
Resp-2	Nelson Mandela University (NMU) / Walter Sisulu University(WSU)/and other Universities in SA
Resp-3	UFS, Cape Town, Stellenbosch
Resp-4	We collaborate with many universities in SA, but have a closer relationship with those that are close to us - University of Johannesburg, University of Pretoria, UNISA
Resp-5	Most universities are part of Higher and Further Education Disability Services Association(HEDSA). We exchange ideas and have recently started a listserve which universities still need to buy into, so that questions, ideas and good practice can be shared constructively amongst institutions. Generally, my most common go-to university includes: WITS, UCT, University of Western Cape(UWC), Cape Peninsula University of Technology(CPUT) and NMU.

The participants' response indicates that they collaborated with the DUs of other universities. Each participant had mentioned at least two universities that they interact with. As in the participants' responses, the DUs that were frequently stated were the University of Cape Town, followed by University of Witwatersrand, Nelson Mandela University and Stellenbosch University.

Question 6c: Are the other disability units cooperative?

All the participants indicated that the other DUs are cooperative. UNESCO (1997) reports that there is a lack of cooperation among DUs in SA. The participants disagree to what has been discussed in the literature.

5.4.1.4 Questionnaires for HODs and senior lecturers of Engineering faculty in South African public universities

The questionnaires were distributed electronically using Google Forms to the HODs and senior lecturers of faculties where Science, Technology, Engineering and Mathematics (STEM) education is provided at universities in SA. Even though the focus of this study was to consider only universities that had a fully-fledged Engineering faculty, institutions that had an Information Technology department were also invited to participate in the study as these streams are considered to be part of STEM education. STEM are closely interconnected and one cannot usually work in isolation from the others (Foster, 2005). The aim of this questionnaire was to collect the perceptions of HODs and senior lecturers in Engineering regarding the provision of VILs in Engineering.

The links to the Google Forms were sent to the participants via email. The email contained the description of the study, contact information of the researcher as well as the consent forms for the participants. The data was analysed using a qualitative content analysis technique. After the data analysis, the researcher verified that the results addressed the research objectives of the study. The data collected are presented below.

PART A: BACKGROUND INFORMATION

This section of the questionnaire captured the background and the biographical information of the participants, which included the participants' gender, age, place of work, department, years of experience in teaching, and teaching qualification.

Questions 1: Gender
Questions 2: Age
Questions 3: University

Table 5.24 presents the biographical information of the participants. In terms of gender, 72% of the participants (18 participants) were males and 28% (7 participants) were females. These percentages indicate that gender bias may exist since the majority of the participants were male. However, studies indicate that women are underrepresented in Science, Technology and Engineering as a few number of women graduate in this field (Hill, Corbett and St Rose, 2010). Riordan and Louw-Potgieter (2011) reports that women in SA are underrepresented in senior academic positions and they are less appreciated for their leadership skills because of the misconception that females are less productive than males in their workplaces. Nothing can be really done at this stage to mitigate this. Furthermore, the voices of these women must be heard, as the voices of minorities are equally important as the voices of the majority.

Table 5.24 Participants' biographical information (gender, age, university)

	Gender: Male /Female	**Age**	**University**
Resp-1	Female	50 yrs. and above	University of Free State
Resp-2	Male	50 yrs. and above	University of Free State
Resp-3	Male	50 yrs. and above	University of Johannesburg
Resp-4	Female	40-44 yrs.	University of Johannesburg
Resp-5	Male	40-44 yrs.	University of Stellenbosch
Resp-6	Male	50 yrs. and above	Rhodes University
Resp-7	Male	50 yrs. and above	University of Stellenbosch
Resp-8	Female	50 yrs. and above	North-West University
Resp-9	Male	45-49 yrs.	University of Stellenbosch
Resp-10	Male	30-34 yrs.	Tshwane University of Technology
Resp-11	Male	50 yrs. and above	University of the Witwatersrand
Resp-12	Male	50 yrs. and above	Central University of Technology
Resp-13	Male	40-44 yrs.	Central University of Technology
Resp-14	Female	45-49 yrs.	Central University of Technology

	Gender: Male /Female	Age	University
Resp-15	Male	50 yrs. and above	Central University of Technology
Resp-16	Male	40-44 yrs.	Central University of Technology
Resp-17	Male	40-44 yrs.	Central University of Technology
Resp-18	Male	30-34 yrs.	Central University of Technology
Resp-19	Male	45-49 yrs.	University of Free State
Resp-20	Female	35-39 yrs.	Central University of Technology
Resp-21	Male	50 yrs. and above	Rhodes University
Resp-22	Female	40-44 yrs.	University of Free State
Resp-23	Male	30-34 yrs.	Central University of Technology
Resp-24	Male	50 yrs. and above	Central University of Technology
Resp-25	Female	50 yrs. and above	University of Cape Town

The majority of the participants were in the age group 50 years and above. People from older generations are considered to have much more life lessons and experience when compared to the younger generation (Berčan, 2014). These life lessons may also provide them with the confidence to state their opinions on important aspects of life and to take a stand on societal issues (Charles and Carstensen, 2010). The viewpoints of these experienced participants would prove beneficial to this study. Some researchers also consider the viewpoints of older generation to be outdated and encourage participation of younger generation in their studies (Duncan and Schaller, 2009; Christian *et al.*, 2014).

Question 4: Department

Figure 5.7 indicates the participants' department. Twenty-five participants from 11 departments responded to the questionnaire. This included a wide range of Engineering departments like Civil Engineering, Information Technology, Electrical, Electronic and Computer Engineering. The Information Technology department had the largest representation in this study.

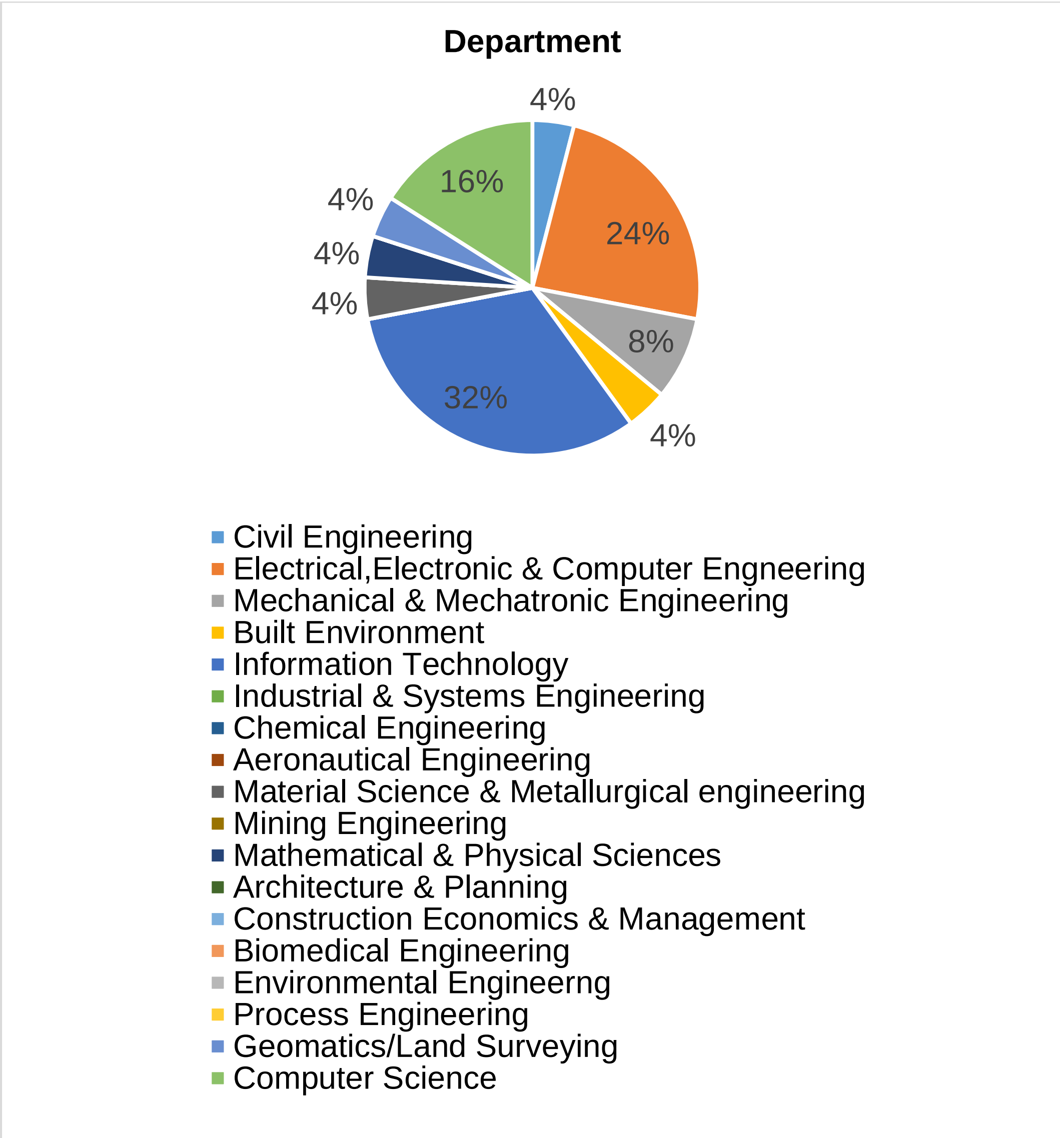

Figure 5.7 Participants' department

Question 5: Years of experience in teaching

Figure 5.8 indicates the participants' years of teaching experience. Most of the participants (18 participants) were well experienced with a working experience of 12 years and above. Only 16% of the participants (4 participants) indicated their work experience was 6-9 years; 8% of the participants (2 participants) indicated that their work experience was 3-6 years, and only 4% of the participants (1 participant) indicated their work experience was 9-12 years.

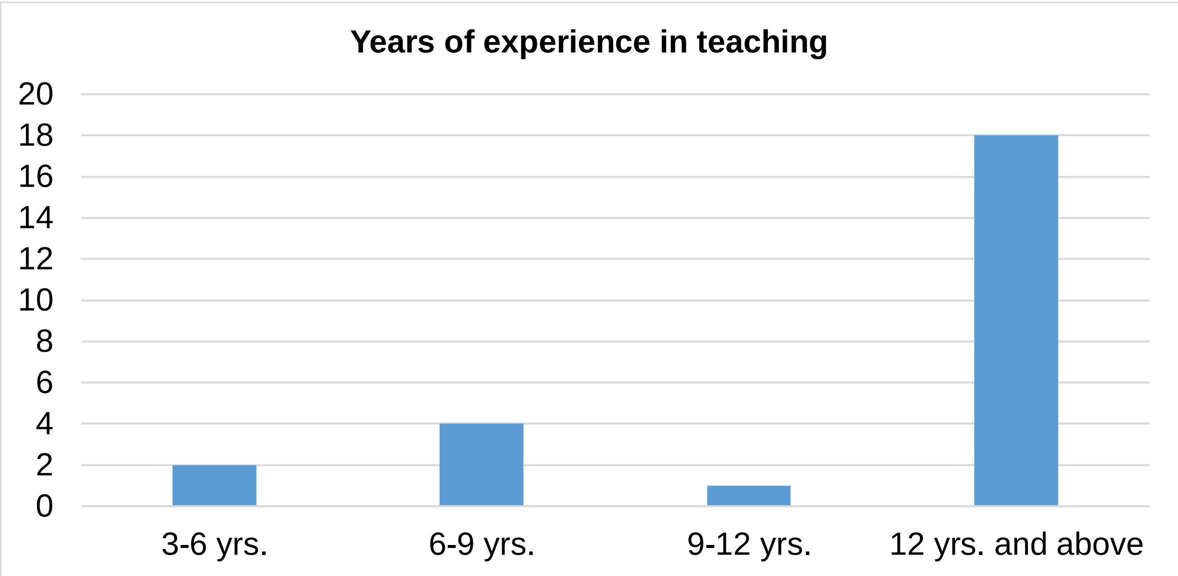

Figure 5.8 Participants' years of experience

The literature indicates that the experience of academic staff can assist in improving student performance at universities (Lyner-Cleophas *et al.*, 2014). Since the majority of the participants were well experienced, their viewpoints played a crucial role in this study. Viewpoints of younger generation can also provide meaningful insights to the researcher as they constantly have an urge to improve theirselves which exposes them to many current and relevant issues (Shah and Udgaonkar, 2018).

Question 6: Do you have a teaching qualification (for example Post-Graduate Certificate of Education (PGCE))?

The participants had to indicate whether they had completed any teaching qualification. Figure 5.9 indicates the participants' responses. Most of the participants (84%) indicated that they had a teaching qualification while the rest indicated that they did not have one.

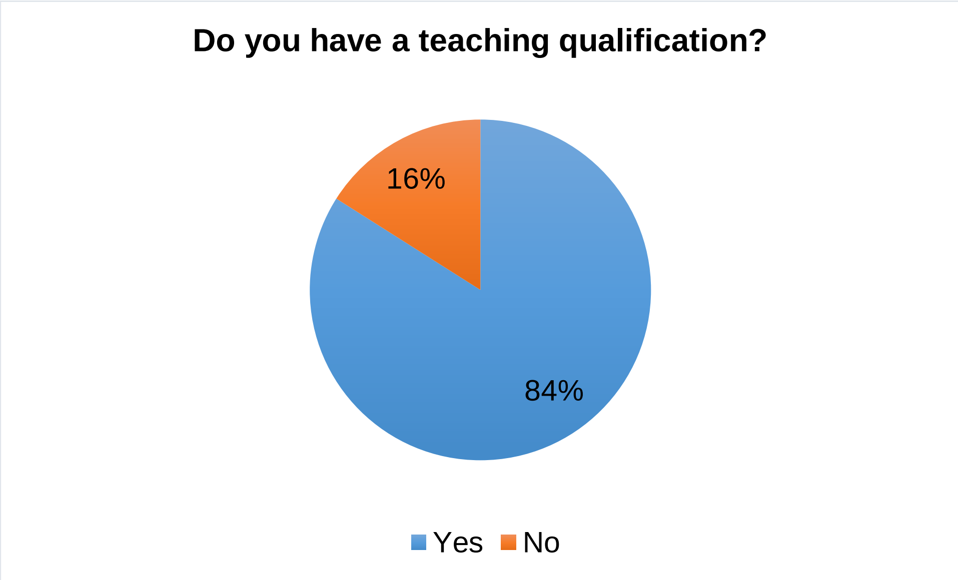

Figure 5.9 Participants' teaching qualification

According to Boudersa (2016), a teaching qualification is an essential ingredient to provide quality education for students. The majority of the participants in this study had a teaching qualification; therefore, their viewpoints are crucial for this study. It is also beneficial to investigate whether the engineering staff in universities receive specialised training to teach VILs. Specialised training may assist the lecturers to use different ICT tools effectively in teaching VILs and in understanding VILs (Negash, 2017). This data was not collected in this study. Therefore, it is recommended to be included as a part of future research of this study.

Question 7: If yes, please mention.

Only five participants (Participant 1, 2,8,15 and 16) responded to the request to specify the teaching qualification they possessed. Three out of the five participants indicated that they have completed a Diploma in Higher Education while one participant indicated that they have done a Master of Education degree. The fifth participant indicated that they have done a Module in Teaching and Facilitation which is offered as a course.

PART B: VIEWS ON ACCOMMODATING VILS IN HIGHER EDUCATION

This section of the questionnaire captured the views of participants with regards to the accommodation of VILs in higher education.

Question 1: Currently, are you accommodating any VILs in your department? Please explain
Question 2: How many VILs do you have in your department?

Table 5.25 indicates whether the participants accommodated any VILs and the number of VILs they had in their department.

Table 5.25 Accommodating VILs within university departments

	Responses
Resp-1	No. Over the past 20 years we only had one.
Resp-2	No
Resp-3	No
Resp-4	No
Resp-5	Yes – Special sized printouts
Resp-1	No. Over the past 20 years we only had one.
Resp-2	No

	Responses
Resp-3	No
Resp-4	No
Resp-5	Yes – Special sized printouts
Resp-6	No
Resp-7	I don't know of any.
Resp-8	When necessary
Resp-9	I have a blind PhD student
Resp-10	No, the field of Geomatics cannot cater for VILs due to the visual nature of content.
Resp-11	Not to my knowledge
Resp-12	No. However, I had a deaf student last year. It was challenging
Resp-13	Not that I am personally aware of.
Resp-14	No
Resp-15	There are no VILs in our department
Resp-16	None
Resp-17	I don’t know
Resp-18	NA
Resp-19	No
Resp-20	No
Resp-21	We don't have any VILs
Resp-22	No
Resp-23	No
Resp-24	No. None of my students need or require this service.
Resp-25	No, do not do anything different on their behalf

The majority of the participants indicated that they do not have VILs in their departments; only one participant indicated having a blind PhD student in their department. Another participant responded “When necessary”. The remainder of the participants (5%) indicated that they were not aware whether or not they had VILs in their departments.

The majority (76 %) of the participants (16 out of 25) therefore indicated that they did not have VILs in their departments. Eight percent of the participants (2 out of 25) indicated that they accommodate one VIL in their department; while one respondent reported that they had two VILs.

The literature indicates that there is a low participation of VILs in Engineering (Mayat and Amosun, 2011).The participants' responses verify what has been discussed in the literature.

Question 3: Please give your options and perceptions on the following statements which will be measured on a 4-point scale, from strongly agree to strongly disagree.

The participants were presented with six statements(3a-3h). The participants were asked to rate these statements on a 4-point Likert scale: "Strongly Agree", "Agree", "Disagree", "Strongly Disagree". The Likert scale is a rating scale that allows a researcher to measure the participants' perceptions (Joshi *et al.*, 2015). Studies have shown that participants do not always interpret a midpoint in a Likert scale in the right way (Kulas and Stachowski, 2009; Nadler, Weston and Voyles, 2015). Participants tend to choose a midpoint even if their response is not neutral. Studies have indicated that participants put in little effort to think of a proper response when they see a midpoint on the Likert scale (Raaijmakers *et al.*, 2000; Kulas, Stachowski and Haynes, 2008). Therefore, a 4 point Likert scale was used in this study. The participants' responses in percentage form is presented in Table 5.26. The percentages are calculated based on the number of the participants that rated the statement on a particular scale. For example, in Question 3a), 13 out of 25, i.e. 13/25=52% of the participants strongly agreed to that statement, while 12 out of 25 i.e. 12/25=48% of the participants agreed.

Table 5.26 4-point scale Participants' responses

Statement	Strongly Agree	Agree	Disagree	Strongly Disagree
a) There are few VIL engineers in South Africa	52%	48%	0%	0%
b)Universities should accommodate VILs	32%	64%	4%	0%
c) My department is equipped with proper resources to educate VILs	0%	8%	48%	44%
d)My department is prepared to accommodate VILs	8%	24%	48%	20%
e) Proper training is provided to staff in my department in order to educate VILs	4%	0%	40%	56%
f) The current curriculum is challenging for VILs	52%	40%	4%	4%
g) Computer literacy should be a prerequisite for students with visual impairments to succeed in most Engineering courses	44%	48%	0%	8%
h) VILs are prepared for tertiary education	0%	28%	60%	12%

Mayat and Amosun (2011), in their study done at the University of Cape Town, report that students with disabilities were under-represented in Engineering. The data we collected and presented in Table 5.26 clearly indicates that the participants had the same viewpoint. They have indicated that there are only a few VIL engineers in SA. It was interesting to observe that even though the majority of the participants supported accommodating VILs, a few participants were still against this idea. The same applies to question 3(f) where the majority of the participants agreed that the current curriculum was challenging while a few participants felt that the curriculum needs no change to adapt to the needs of VILs. According to Nkoane (2006), the curriculum does not adhere to the needs of VILs. The participants' response verifies the existing literature.

Table 5.28 also indicates that staff training to assist VILs was only provided to a few participants (4%). As noted in the literature, academic staff are not given enough training to educate VILs (Mushome and Monobe, 2013). According to Omede (2014), computer literacy would assist VILs to succeed in most Engineering courses. A total of 44% of the participants strongly agreed and a total of 48% of the participants in the study agreed to what has been discussed in the literature.

Lack of proper resources for VILs may affect their learning process and thus their functional independence in the society (Spencer, 2008). There was a strong agreement from the participants that there are not enough of the proper resources for VILs, but a small percentage was confident that their department was well equipped with resources to handle VILs. Interestingly, there were varied responses when participants were asked whether the VILs were prepared for tertiary education or not. Even though the majority of the participants disagreed with this idea, a fair number of participants (28%) supported that VILs were prepared for tertiary education.

PART C: CURRENT TEACHING STRATEGIES AT UNIVERSITIES

This section of the questionnaire captured the views of participants on the current teaching strategies used at universities.

Question 1: As an academic yourself, what role should an academic play in the development of VILs?

Various codes were identified based on the participants' responses. The codes were grouped into categories. The codes that were not relevant to the question were discarded during the process. Categories are features of participants' accounts characterising particular perceptions and/or experiences that the researcher sees as relevant to the research question. The responses were analysed according to the types of categories and issues that emerged.

Based on the categories that emerged out of the analysis, the role of an academic in the development of VILs is to:

- assist VILs;
- become trained VIL lecturers in order to assist VILs;
- develop a modified curriculum for VILs;
- motivate VILs;
- understand the challenges/problems of VILs;
- make courses accessible for VILs;
- identify appropriate tools and resources to assist VILs;
- adopt appropriate teaching methodologies and strategies for VILs; and
- improve the lives of VILs.

The literature indicates that the role of an academic in the development of VILs are to assist VILs by providing them with the required resources and by providing them with emotional support (Spungin and Ferrell, 2007). The participants in the study agree to the findings from the literature.

Question 2: How does visual impairment affect learning?

Qualitative data analysis method was applied based on the categories that emerged out of the analysis. The categories are as follows:

- VILs struggle in their theory and practical classes because of their visual impairment;
- Visual impairment makes it difficult for VILs to understand the concepts;
- Visual impairment hampers the learning process;
- VILs requires assistance from other students;
- The lack of accessible materials, improperly designed curriculum affects the learning process of VILs;

- VILs require separate classroom requirements.

According to Agesa (2014), visual impairment decelerates the learning process, thereby making them dependent on assistive resources. The participants agree to what has been noted in the literature.

Question 3: What subject are you offering in your department?

The participants listed the following as the subjects they offered in their department:

- Programming and Software Design;
- Design/Control theory / Measurement theory;
- Algorithm and Programming A1 (BET);
- Electrical and Electronic Engineering subjects;
- Computer Science;
- Machine Design;
- System Analysis and Design, Computer Security;
- Signal Processing;
- Project Management, Computer Applications, Surveying IV, Site Surveying;
- Welding and Fabrication Science;
- Programming and Computer Security;
- Development Software II and Technical Programming I;
- Information Systems II and Application Technology Management IV;
- Databases;
- Electronic Communication;
- Electrical Engineering;
- Construction Materials, Structural Steel Design, Concrete Technology;
- User Interface;
- Digital Literacy;
- Computer Architecture;
- Databases;

- Digital Systems 1 and Control Systems 3; and
- Software Development

Question 4: What modules do you offer that will be challenging to VILs?
Question 5: Why would these modules prove challenging?

The participants listed a number of modules that they think would be challenging to VILs, which include: Signal Processing, Core Modules, Non-math Modules, Database Modelling, Electronics, Programming, Digital Systems, Design Theory, and Control Systems. Some of the responses that the researcher received were not specific (for example: all modules).

Some of the participants also indicated the reasons why they thought these modules would be challenging to VILs. The reasons indicated by the participants were:

- These modules rely heavily on vision;
- Theory classes – note taking, as well as difficulty in conducting practical classes with VILs would be difficult;
- The lack of adequate resources;
- Difficulty of VILs to use the available resources;
- The requirement of special facilities to accommodate VILs; and
- The difficulty of VILs to understand the subject content

There is no substantial literature regarding the Engineering modules that would be challenging to VILs. Therefore, the participants'' responses add to the existing literature.

Question 6: What teaching methodologies do you think should be used to assist VILs?
Question 7: Which of these identified methodologies are you currently using, if any?
Question 8: What type of educational technologies could be used to assist VILs?
Question 9: Which of these identified technologies are you currently using, if any?

The teaching methodologies that the participants listed include: recorded lecturers, problem-based learning, computer-based learning, audio lessons, hybrid technology, and materials in digital format. By teaching methodologies, the researcher was actually trying to refer to the methods and strategies used by the participants to enhance student learning. Some of the popular teaching methodologies, as indicated in the literature, are problem-based learning, case-based learning, team-based learning, active learning etc. (Dalton, Mckenzie and Kahonde, 2012). Even though a few participants (3 participants) indicated teaching methodologies (e.g.: problem-based learning, computer based learning), majority of the participants listed the tools/resources used to assist VILs (e.g.: audio lessons, materials in digital format) instead of listing the teaching methodologies. It appears as if the participants did not understand Question 6.

It is concerning that there was a low response rate when the participants were asked to mention the methodologies they were using in their classes to assist VILs (Question 7). The majority of the participants (84%) indicated that they were not using any teaching methodologies to assist VILs. The remaining participants indicated that they used video lectures (recorded lectures), study materials in digital format and simulation software.

The participants indicated computer based assistance, audio recordings, Braille and blended technologies as the educational technologies that could be used to assist VILs. The majority of the participants indicated that they did not use any educational technologies in their department to assist VILs. Only a few participants mentioned the technologies that they used in their classes that included recordings, 3D printing, simulation software and magnifiers. From the data analyzed it is clear that the participants understood that there are a variety of tools to assist VILs. But, very few participants (4%) indicated that they were using tools to assist VILs. It was their choice to decide what tool was best for them and their students.

Some of the popular educational technologies as indicated in the literature are screen reading software, Braille translation software, magnifying devices, simulation software etc. (Dalton, Mckenzie and Kahonde, 2012; Omede, 2014). The participants' response agreed to the findings from the literature.

Question 10: What assessment strategies may be used to assist VILs?
Question 11: Which of the identified strategies do you use, if any?

Some of the responses from the participants include: Oral exams, computer simulation software, additional time for assessments, large print question papers, individual rooms for VILs during assessments and verbal assistants. The current strategies used by the participants were oral exams, simulation software, and verbal assistants. Some of the popular assessment strategies indicated in the literature are oral examinations, use of scribers and assistants, screen reading software, use of Braille and enlarged question papers, etc. (Department of Education, 2011). The participants' response agreed to what has been noted in the literature.

Question 12: How do you assess the level of visual impairment (partially sighted learners, moderately blind learners, severely blind learners, completely blind learners) in your students?
Question 13: Based on your assessment, which technologies do you use for the different levels (partially sighted learners, moderately blind learners, severely blind learners, completely blind learners)?

Visual impairment can be assessed in the following levels: partially sighted learners, moderately blind learners, severely blind learners, completely blind learners (World Health Organisation, 2018).

The majority of the participants indicated that the visual impairment assessment was done by the Student Counselling Division/professionals hired by the university. The literature supports this for VIL in SA (Dalton, Mckenzie and Kahonde, 2012). Some of the participants indicated that they get "*information from other students*" or that "*the VIL's response in class*" helps them to assess the level of visual impairment of the student. The participants' response verifies and adds to what has been discussed in the literature.

Based on the results of the visual impairment assessment, the participants were asked which technologies would they then use for the different levels of visual impairment. A large number of the participants indicated that they did not use any technology for VILs, while a few participants indicated that they used different technologies for different levels of visual impairment on a case-by-case basis in consultation. Dalton, Mckenzie and Kahonde (2012) stresses the need for a framework called Universal Design for Learning (UDL) to address the learning needs of students with varying levels of visual impairment. The responses from the participants indicated that they did not use any specific technology to deal with students with different levels of visual impairment.

Question 14: What can be done by your department in order to accommodate VILs?

This question forms a very crucial part of the study and the framework that the researcher seeks to develop. The categories that emerged out of the analysis are depicted in the Table 5.27.

Table 5.27 Department initiatives to accommodate VILs - Categories

Categories
Provide appropriate tools/equipment/ resources for VILs
Train staff to assist VILs
Offer awareness programs about VILs
Prepare a modified curriculum for VILs
Investigate the current facilities for VILs in the department
Provide required assistance

The researchers Mayat and Amosun (2011) suggested that the department should take initiatives to spread awareness about disability, while staff, students and management should treat VILs properly. Apart from this, there is no literature regarding the initiatives that could be taken by Engineering departments to accommodate VILs. Therefore, the participants' responses add to the existing literature. The participants suggested that the departments should investigate the current facilities for VILs in the department, provide VILs with required assistance and resources, train staff to assist VILs and provide a modified curriculum to VILs.

PART D: CHALLENGES VILs FACE IN UNIVERSITIES

This section of the questionnaire captured the views of participants on the challenges faced by VILs at universities.

Question 1: In your observation, what are the current challenges that the VILs are facing in the university?

The categories that emerged out of the analysis were considered to be the challenges faced by VILs in the university. They are as follows:

- VILs struggle due to the nature of Engineering content;
- Lack of resources;
- Lack of appropriate teaching and learning strategies;
- Lack of trained staff;
- Lack of infrastructure;
- Lack of information regarding the VIL needs;
- Lack of information provided to VILs regarding the course requirement;
- Lack of learning material in appropriate format;
- Theory classes, practical classes and note taking is difficult for VILs;
- Poor classroom facilities for VILs;
- Costly learning materials;
- Higher Education system not designed for VILs; and
- Lack of proper mobility facilities for VILs.

The literature indicates that a lack of student support services, inadequate infrastructure, lack of resources, lack of trained staff, inadequate mobility services and accommodation are challenges faced by VILs at a university (Matshedisho, 2007; Tugli *et al.*, 2013). The participants' responses verify and add to the existing literature.

Question 2: In your opinion, what could be the reason for minimal intake of VILs in Engineering courses at universities?

The responses were analysed according to the types of categories and issues that emerged. The categories that emerged out of the analysis are presented in Table 5.28.

Table 5.28 Reason for minimal intake of VILs in university – Categories

Categories
Practical hands-on course
Lack of proper resources
Lack of funds
Lack of facilities at special schools
Safety reasons
Lack of awareness by parents and school staff about Engineering
The nature of Engineering content
Career expectations
Poor classroom setup for VILs
Difficulty in theory and practical classes
Higher Education system not designed for VILs
Lack of infrastructure
Too much time
Lack of awareness of VILs about Engineering
Attitude of university in accommodating VILs

The literature indicates that the attitude of universities in accommodating VILs and the lack of awareness about disability issues may be possible reasons for low participation of VILs in Engineering courses at universities (Mayat and Amosun, 2011). This is one of the crucial questions in the study as this study aimed at investigating the low representation of VILs in South African universities. The participants' response adds to the existing literature by indicating a number of further reasons, such as lack of awareness about Engineering among parents and school staff, lack of infrastructure, etc.

Question 3: For my department, to accommodate VILs would require:

- **a) Too much time**
- **b) More resources (Trained lecturers, equipment, infrastructure, etc.)**
- **c) Inclusivity**
- **d) Financial expenses**

One of the major challenges faced by the teaching staff to accommodate students with disabilities in tertiary institutions was the constraints on time available to create accessible learning materials for these students. All visual impairments slow the pace in which academic activities are done and this means the academic staff needs to put in more time and effort in order to assist the VILs, so that they do not miss out on anything in class.

Academic staff often have to develop time management strategies that best suit students with special needs (Nkoane, 2006). Since the equipment used by VILs is time consuming than ordinary typing and writing, they require extra time to finish their tasks (Heller and Kennedy, 1990). During their lectures, extra time is needed to carry out some tasks, such as reading through slides, assimilate information and respond before going on to the next stage. Sometimes, they might require assistance of other students, for example the student may need an assistant to view the video with them at an alternative time. Eight percent of the participants indicated that too much time was required by the department to accommodate VILs.

By the term "*resources*" the researcher means trained lecturers, equipment, infrastructure, etc. The majority of the participants (80%) indicated that more resources (trained lecturers, equipment, infrastructure, etc.) were required by the departments in order to accommodate VILs. Sayed, Soudien and Carrim (2003) in his study mentions that less qualified and trained teachers hinder inclusive education. Lecturers play an important role in the academic lives of VILs. Therefore, it is of utmost importance that lecturers should be trained. Inadequate infrastructure further poses a major threat towards the health of VILs (Tinklin, Riddell and Wilson, 2004). Therefore, adequate infrastructure is considered to an essential factor for accommodating VILs in the universities. The participants' responses agree with the findings from the literature.

Very few participants indicated that inclusivity and financial support are required for the departments to accommodate VILs. Inclusivity is attained by providing equal quality education to all students regardless of their background or disability (Khumalo and Hodgson, 2017). Many studies indicate that lack of proper funding is one of the major barriers for the success of students with disabilities (Naidoo, 2010).

Question 4: What suggestions would you provide to universities for effective learning and teaching of VILs in Engineering courses?

The responses were analysed according to the types of categories and issues that emerged. The categories that emerged out of the analysis were:

- Train staff/personnel to assist VILs;
- Adequate resources, tools and technologies for VILs;
- Appropriate teaching and learning strategies;
- Create awareness about VILs;
- Dedicated department for VIL needs;
- Support from government;
- Identify proper courses for VILs;
- Treat VILs like other students;
- Budget allocation for VILs;
- Create separate programs for VILs;
- Devise a VIL-friendly curriculum for VILs;
- Proper infrastructure for VILs; and

- Recruit special staff to assist VILs.

Mayat and Amosun (2011) suggest that awareness about disability issues must be created among staff, management and students and that academic staff should treat VILs with the proper attitude. The participants' responses verify and add to the existing literature. The additional factors mentioned by the participants were: trained staff for VILs, proper resources dedicated department for VIL needs, support from government, identify proper courses for VILs, accessible curriculum, adequate fund and proper infrastructure.

Question 5: Is there any other comment, question or thought that you would like to raise in this regard?

Table 5.29 indicates the comments and thoughts shared by the participants regarding this study.

Table 5.29 Comment, question or thought from the participants - Participants' responses

	Responses
Resp-1	I have little experience in this field
Resp-2	No response
Resp-3	No
Resp-4	Nil
Resp-5	Some occupations require specific skills and capabilities. Any severely visually impaired person would not be able to practice as an engineer, unless the work is almost exclusively software design. Some Engineering courses would not be an option, just like surgery would not be an option for a severely visually impaired person.
Resp-1	None
Resp-2	No
Resp-3	Good luck

	Responses
Resp-4	Every year our department is squeezed more severely in terms of workload and budget. To accommodate these special needs students – and we should – would require *additional* funding and resources.
Resp-5	No
Resp-6	In the area that I teach there are two reasons why VILs would struggle: these are the need for visual interpretation (the major issue) and a safe working environment. In metallurgy heat of up to over 2000C is not uncommon. Some machines use up to 500 amps power at 380V.
Resp-7	Have you consider using eye-tracking in your study?
Resp-8	N/A
Resp-9	I would like to know if there are any online learning courses for VILs.
Resp-10	We can support the projects done by the dedicated department for blind learners by providing our resources, teachers etc.
Resp-11	Determine which fields of Engineering would be MORE suitable for VIL
Resp-12	None
Resp-13	N/A
Resp-14	Initiatives should be taken by the respective departments if VILs are enrolled.
Resp-15	I think it is expensive to teach VILs, the institutions might need a lot of support from the government
Resp-16	More responsibility should be taken by tertiary institutions to support VILs
Resp-17	A lot of planning needs to be done so that VILs can be accommodated in universities
Resp-18	Why is there very little awareness for VIL

	Responses
Resp-19	None.
Resp-20	No thanks
Resp-21	I have little experience in this field
Resp-22	No response
Resp-23	No
Resp-24	Nil
Resp-25	Some occupations require specific skills and capabilities. Any severely visually impaired person would not be able to practice as an engineer, unless the work is almost exclusively software design. Some Engineering courses would not be an option, just like surgery would not be an option for a severely visually impaired person.

Participant 5 responded that “VILs do not have the skills and capabilities to practice as an engineer unless the work is almost exclusively software design”. This indicated a negative attitude regarding accommodating VILs at universities. Mushome and Monobe (2013) in their study state that the negative attitudes from the academic staff are one of the major challenges for the provision of VILs at universities. Participants 9 and 16 mention the need of funds to accommodate VILs. Participant 11 shared her/his personal experience as to why VILs struggled in her/his area of study. This participant pointed safety as a major barrier to accommodate VILs in Engineering. Three of the participants indicated that the tertiary institutions must provide support to accommodate VILs. The comments from these participants also indicated that more open discussions need to happen at universities regarding what changes should be made to best suit their needs in the courses they have chosen and also to ensure a healthy academic environment for the VILs.

5.5 SUMMARY

This case study focused on collecting the perceptions, opinions and views of DU managers, HODs and senior lecturers of faculties where STEM education is provided at universities in SA. Even though the focus of this study was to consider only universities that had a fully-fledged Engineering faculty, institutions that had an Information Technology department were also invited to participate in the study as these streams are considered to be part of STEM education.

The data was collected using online semi-structured questionnaires. After analysing the data, the researcher identified the barriers or challenges that affected the provision of VILs in Engineering courses at universities. A qualitative content analysis technique was used to analyse the data and organise it into themes and categories. The challenges identified from the questionnaires distributed to the DUs are as follows:

- Lack of resources at universities;
- Lack of support from DUs;
- Lack of accessible learning materials;
- Fear of VILs to get into post school sector;
- Entry level subjects for Engineering not taught at special schools;
- Lack of funds/budgets for VILs;
- Lack of trained staff at universities;
- VILs finds area of study (Engineering) challenging;
- Lack of support to VILs from lecturers;
- Training VILs on the resources;
- Lack of physical access to buildings;
- Lack of safety measures; and
- Requirement of labour intensive work by lecturers for VIL course material preparation

The challenges identified from the questionnaires distributed to the HODs and senior lecturers of faculties at universities where STEM education is provided are as follows:

- Lack of resources at universities;

- Lack of appropriate teaching and learning strategies;
- Lack of funds;
- Lack of accessible curriculum for VILs;
- Lack of trained staff;
- Lack of information provided to VILs regarding the course requirement;
- Negative attitude of universities towards VILs;
- Lack of infrastructure;
- Poor classroom facilities for VILs;
- Lack of information regarding the VIL needs;
- Lack of learning material in appropriate format;
- Lack of proper mobility facilities for VILs;
- Lack of safety measures;
- Lack of government support;
- No dedicated department for VIL needs;
- Identify proper course for VILs;
- Need to create separate programs for VILs;
- Unawareness by parents and staff about Engineering; and
- Costly learning materials

The ICT tools for Engineering that were identified from the questionnaires distributed to the DUs are as follows:

- Magnifiers (software and hardware);
- Screen-reading software;
- Braille devices (for example notetakers, embossers, graphic embossers, tactile machines, etc.); and
- OCR software

The ICT tools for Engineering that were identified from the questionnaires distributed to the HODs and senior lecturers of faculties at universities where STEM education is provided, are as follows:

- Recordings;
- 3D printing;

- Simulation software; and
- Magnifiers

The data from this case study and the case study at school level (Chapter 4) were triangulated to form the framework for this study. The next chapter, Chapter 6, presents the framework for the provision of VILs in Engineering education. The different stages involved in developing the framework are also discussed along with the evaluation of the framework by field experts.

CHAPTER 6: DESIGN AND EVALUATION OF THE FRAMEWORK

6.1 INTRODUCTION

Inclusivity in higher education is crucial to the successful growth of a democratic nation. This study endeavoured to develop a framework for the provision of VILs in Engineering education in SA using ICTs. The framework presented in this chapter was developed based on the data collected from the literature review and case study. The previous chapters presented how the researcher collected and analysed the data to identify the challenges that VILs face in SA when considering entry into Engineering courses. The case study (Part B) done at university level was discussed in Chapter 5. The school level study (Part A) was discussed in Chapter 4. The literature review was discussed in Chapter 2. The proposed framework was evaluated by experts in the field to establish its validity. The refined framework after expert evaluation is presented in this chapter.

Section 6.2 provides a brief definition of a framework and the different steps in developing the framework. Section 6.3 presents the proposed framework and section 6.4 describes the framework evaluation procedure for a research study. Section 6.5 presents the evaluation of the proposed framework and section 6.6 presents the final framework after refining the proposed framework based on expert reviews. The chapter is summarised in section 6.7.

6.2 DEVELOPING A FRAMEWORK FOR THE PROVISION OF VISUALLY IMPAIRED LEARNERS IN ENGINEERING EDUCATION IN SOUTH AFRICA

The framework for the study was developed based on the data collected from the literature, focus groups and questionnaires. There are two types of frameworks in literature: conceptual and theoretical. A conceptual framework is determined based on the literature collected by the researcher (Berman, 2013). Ravitch and Carl (2016) state that a theoretical framework is a structure that assists researchers in situating and scrutinising formal theories into their studies. A theoretical framework is not applicable to this chapter.

There are still arguments as to whether ‘theoretical’ and ‘conceptual’ frameworks are conceptual synonyms, or whether they refer to different constructs. Some researchers like Maxwell (2005) suggests that these are very similar terms and as such, there is hardly any difference between them. Other researchers have different opinions about these terms (Adom, Hussein and Agyem, 2018). Adom, Hussein and Agyem(2018) suggest that theoretical framework provides a general or broader set of ideas within which a study belongs and conceptual framework refers to specific or narrower ideas a researcher utilises in their study. This study has used the term “*conceptual framework*” in this study. Jabareen (2009) defines conceptual framework as a network of interlinked concepts when put together provides a thorough understanding of a phenomenon. A conceptual framework sets out key concepts and assumes the relationships among them (Miles and Huberman, 1994).

6.2.2 Steps in the development of the proposed conceptual framework

A conceptual framework is a structure which the researcher believes can best explain the natural progression of the phenomenon to be studied (Camp, 2001). Akintoye (2015) points out that the conceptual framework is mostly used by researchers when existing theories are not applicable or sufficient in creating a firm structure for the study. Jabareen (2009) proposed eight steps in the formulation of a conceptual framework. This study has followed these steps while developing the framework for the provision of VILs in Engineering courses at universities. The steps are described below:

6.2.2.1 Step1: Mapping the selected data sources

The first step is to map a variety of literature regarding the research topic from multidisciplinary sources. This study has collected both primary and secondary data to study the research problem in detail. The data sources utilised in this study are described in detail below:

Primary data is the information collected by the researcher using techniques like surveys, interviews etc. (Ajayi, 2017) . This study used online questionnaires and focus group discussions to collect data from the participants. This study gathered primary data to investigate the research problem and to provide the researcher with a realistic view about the topic. The following sub-objectives were addressed by the primary data in this study:

- Determine the degree to which Engineering faculties in SA are accommodating VILs;
- Identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA;
- Incorporate many of the ICT tools into the framework to benefit VILs in Engineering education in SA;
- Incorporate many of these ICT tools into the framework to benefit VILs in Engineering education in SA; and
- Evaluate the framework with specific field experts so as to establish its validity and refine its suitability for higher education in SA.

Secondary data are gathered by someone else for their research study (Johnston, 2017). The researcher gathered and examined all relevant documents related to the research topic. Published journals, articles, books etc. formed the secondary data for the study.

6.2.2.2 Step 2: Extensive reading and categorizing of the selected data

During this step, the researcher read and categorised the data sources – literature review, focus group discussions and questionnaires based on the importance and relevance to the study. The barriers or challenges faced by VILs in higher education formed the categories from the data sources. The categorisation of the data sources is described below:

A **literature review** is a systematic process of examining various published works with an aim of discovering all relevant information related to the research topic (Snyder, 2000). The objective of developing a conceptual framework is to organise and describe the concepts identified during the research study and map relationships among these concepts (Jabareen, 2009). In order to achieve this objective, existing theory and empirical research has to be integrated together to confirm whether there are any contradictions or refinements required (Aspers and Corte, 2019).The literature review plays an integral role in developing a conceptual framework as it assists the researcher in understanding the research phenomenon (Maxwell, 2005). The barriers faced by VILs in higher education identified during the literature review included a lack of government support, financial constraints, and a lack of safety measures. The literature review was discussed in detail in Chapter 2. The factors that affect the provision of VILs in higher education are presented in Table 2.3 of Chapter 2.

Focus group discussions collect the perceptions of participants in a study which forms building blocks for constructing a conceptual framework (Charmaz and Belgrave, 2012). The perceptions of the participants are crucial for the study as they have more experience about the research topic under investigation and they might provide vital insights about the topic which is being discussed (Maxwell, 2005).The factors that emerged from the focus groups, which affect the provision of VILs in higher education institutions in SA, especially for Engineering courses was presented in Chapter 4.

Questionnaires were used in both parts of the study – Case Study A and B. Questionnaires were distributed to three categories of participants – special school educators (case study-part A), HODs and senior lecturers from Engineering faculty at tertiary institutions (case study-part B) and DUs at tertiary institutions (case study-part B). The challenges identified from the special school educator questionnaire is presented in Chapter 4. The factors identified from the questionnaires distributed at university level study is presented in Chapter 5.

6.2.2.3 Step 3: Identifying and naming the concepts

The researcher is expected to re-examine the data sources and identify the key concepts of the study at this step (Glaser and Strauss, 1967). The factors affecting the provision of VILs in higher education were identified and compared from all data sources (literature review, the focus groups and all questionnaires). The result was a long list of factors, with repetitions and a few contradictions. The factors after this step are as follows:

- Negative attitude at the university towards VILs;
- Fear of adapting to the new environment;
- Requirement of labour-intensive work by lecturers for VIL course material preparation;
- Lack of awareness about disability issues among the staff, students and management;
- Lack of safety measures;
- Minimal autonomy of disability units;
- Lack of supportive disability Units;
- No dedicated department for VIL needs;
- Inadequate Infrastructure;
- Lack of funds;
- Teaching VILs are time consuming;
- Lack of access support services at universities;
- Lack of accessible learning materials;
- Lack of trained staff;
- Lack of assistive resources, equipment and tools at university;
- Difficult for VILs to cope with the workload and technology used at universities;
- Curriculum not designed to the needs of VILs;
- VILs struggle to do practical courses;
- Lack of policies for VILs;
- Lack of accommodation facilities;
- Training VILs on the resources;
- Theory classes, practical classes and note taking is difficult for VILs;
- VILs struggle to meet the course requirements;
- No separate classes for disabled learners;
- Lack of management support;
- Lack of mobility services;

- Costly learning materials;
- Inadequate marketing of Engineering courses;
- Lack of resources at special schools;
- Inadequate transport facilities;
- Lack of government support;
- Need to identify proper course for VILs; and
- Need for separate programs for VILs

6.2.2.4 Step 4: Deconstructing and categorising of the concepts

The factors from the previous step were examined thoroughly to check for redundancies. Some of the factors mentioned by the participants were important and require attention, but were not relevant factors for the framework in this study. This framework can be used as a guide to higher education institutions in SA to accommodate VILs. The factors that were removed from the list at this step are presented in Table 6.1. These factors were excluded from the list as special schools need to attend to these factors. These factors are beyond the control of higher education institutions. VILs are not taught the prerequisite subjects, i.e. Mathematics and Science, at special schools. As discussed in Chapter 4, students are enrolled in higher education institutions based on a point system and individual departments have their special admission requirements (for example, Engineering department have minimum requirements for Mathematics, Science and IT).

The other factors mentioned were lack of passion for Engineering and the thought that Engineering is difficult for VILs. Higher education institutions can organise awareness campaigns about Engineering to increase the interest of the pupils in Engineering, but if the prerequisite subjects are not taught at school level, VILs would not be interested in Engineering as they are not exposed to the required subject content. Lack of resources at school and low school results need utmost attention but it is the responsibility of the special schools to attend to these issues.

Table 6.1 Factors excluded from the framework

Factors
No prerequisite subjects taught at school
Consider Engineering difficult
Lack of passion for Engineering
Lack of resources at school
Introduce Engineering to learners at school
Low school results

The remaining factors were deconstructed and categorised. At the end of this phase, the study identified 22 factors that led to the development of the framework. The factors are presented in Table 6.2.

Table 6.2 Factors for framework development

Concepts
Adequate government Support
Ample management Support
Appropriate policies for VILs
Sufficient funds
Appropriate safety measures
Adequate university facilities
Appropriate and safety sensitive accommodation facilities
Physical access to buildings
Access to easy mobility around the campus
Transport facilities
Appropriate equipment for effective teaching and learning
Appropriate teaching and learning strategies
Appropriately trained teachers
Sufficient time allocation of schedule for teaching VILs
Train VILs to cope with the workload used at universities
Appropriate curriculum design

Concepts
Supportive DUs
Supportive university environment which welcomes VILs
Assisting VILs to overcome the fear of adapting to the new environment
Awareness campaigns about disability
Training VIL on resources available to them
Organise separate classes for disabled learners
Create separate program for VILs

6.2.2.5 Step 5: Integrating concepts

Similar concepts were integrated and grouped together. This step drastically reduced the number of generated concepts to a set of principal concepts. The concepts that were linked to one principal concept were grouped together as sub-concepts under a principal concept. Table 6.3 presents the principal concepts and sub-concepts of the conceptual framework.

Table 6.3 Principal concepts and sub-concepts for the conceptual framework

Principal Concepts	Sub-concepts
Government and Management Support	Government Support
	Management Support
	Policies for VILs
Finance	Sufficient funds
Infrastructure	Safety measures
	University facilities
	Safe accommodation facilities
	Easy physical access to buildings
Mobility	Easy mobility around the campus
	Transport facilities
Teaching and learning	Equipment for effective teaching and learning
	Appropriate teaching and learning strategies

Principal Concepts	Sub-concepts
	Trained teachers
	Allocation of sufficient time for teaching VILs
	Train VILs to cope with the workload at universities
	Design curriculum for VILs
Student support services	Supportive DUs
	Supportive university environments
	Assisting VILs to overcome the fear of adapting to the new environment
	Awareness campaigns of student disabilities
	Training VILs on resources available to them

6.2.2.6 Step 6: Synthesis and making sense

The researcher followed an iterative synthesis process to identify the concepts which were used to build the conceptual framework. According to Miles and Huberman (1994), developing a conceptual framework involves a lot of phases like data collection, data reduction and verification of findings. The principal concepts of this framework are: government and management support, finance, infrastructure, mobility, teaching and learning, student support services. The conceptual framework is discussed in section 6.3

6.2.2.7 Step 7: Validating the conceptual framework

The goal of this step was to validate the framework developed by the researcher. At this step, the researcher had to verify whether the conceptual framework proposed by the researcher made sense to other researchers and scholars. There are two ways in which the framework could be evaluated: a real world evaluation of the framework and expert evaluation of the framework. Compared to real environment evaluation of the framework, expert reviews were chosen based on the fact that the implementation of all the factors in the framework was not feasible for the study. The experts consisted of researchers who had done research in Engineering education, HODs of Engineering faculties, Disability Unit managers and visually impaired engineers. The expert evaluation is discussed in section 6.4. Apart from this, the researcher presented and discussed the concepts as well as the framework in various conferences to seek feedback from other researchers (Tom, Mpekoa and Swart, 2018, 2019, 2020)

6.2.2.8 Step 8: Rethinking the conceptual framework

The goal of this step is to revise the framework based on the feedback, comments and insights received from the previous step. The insights from experts may assist the researcher to identify the flaws in the study and to enlarge the viewpoint on the phenomenon being researched. The conceptual framework, presented in Figure 6.1, was refined based upon expert reviews. The final version is discussed in section 6.6.

6.3 THE CONCEPTUAL FRAMEWORK FOR VISUALLY IMPAIRED LEARNERS IN SOUTH AFRICA

The conceptual framework for the study was based on the literature review and case studies conducted by the researcher. The literature review helped the researcher to understand that VILs were under represented in Engineering courses at universities. Some of the barriers faced by VILs in higher education institutions were also identified from the literature. The existing viewpoints from the literature as well as the findings using the research tools (focus group, questionnaires) in this study were collated to develop a conceptual framework. The steps used in developing the framework were discussed in the previous section. The proposed conceptual framework is presented in detail below (section 6.3.1 to section 6.3.7)

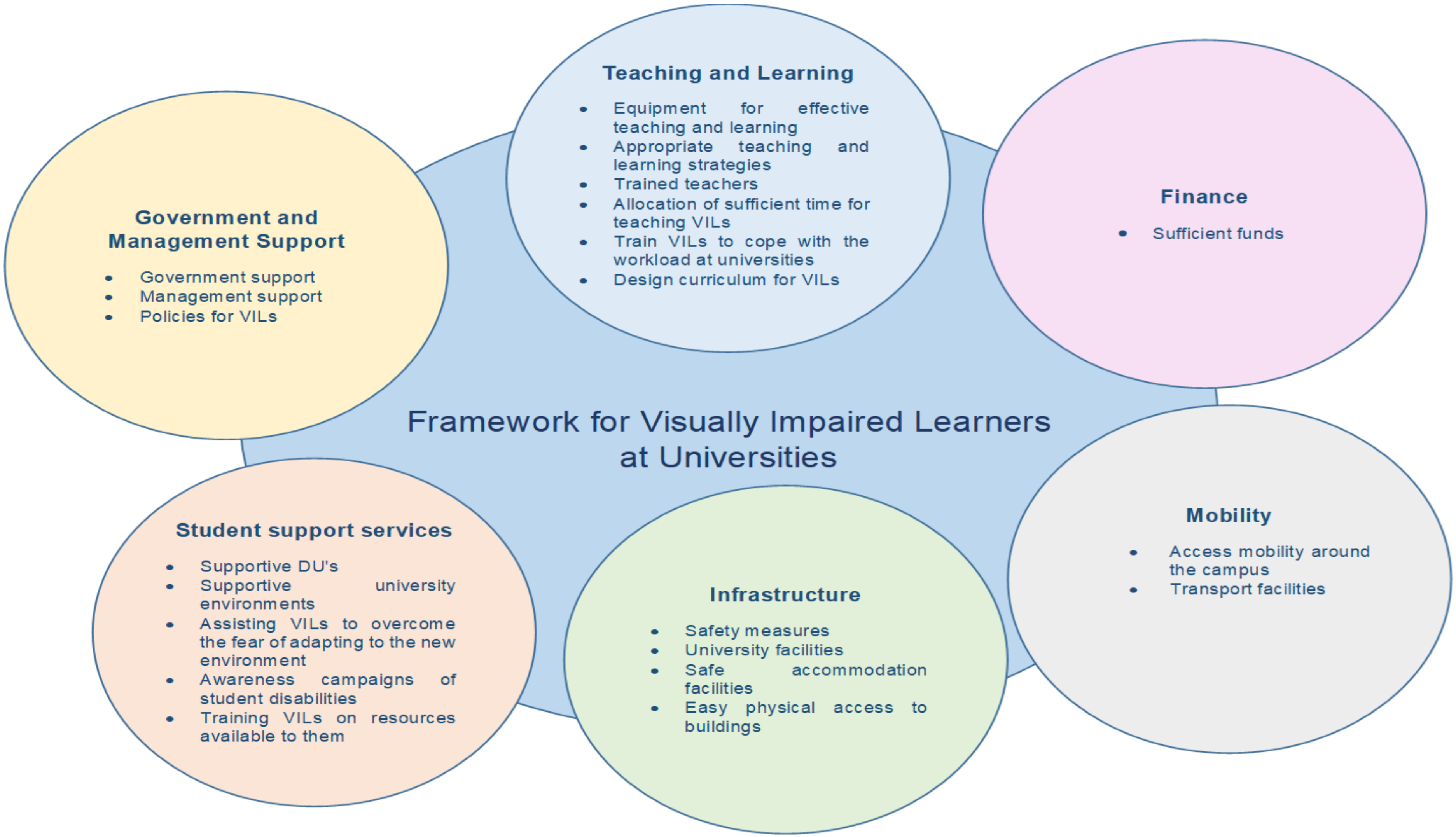

Figure 6.1 Framework for universities to assist VILs in engineering

6.3.1 Government and Management Support

The governance in higher education institutions of South Africa was discussed in Chapter 5. VILs require a good deal of support from their institutions which could only be possible with adequate government and management support (Matshedisho, 2007). The government and university management recognise the rights of VILs and profess interest in the implementation of inclusive education in higher education institutions in SA (Department of Higher Education and Training, 2014). In reality, however, studies show that VILs are not being accommodated in Engineering courses in South African higher education institutions (Mayat and Amosun, 2011). Literature and responses from the participants collected during this study indicate that there is a lack of government and management support for VILs in higher education institutions. This section discusses government support, management support and policies for VILs.

6.3.1.1 Government Support

Special school educators (see Chapter 4) and senior staff from universities (see Chapter 5) both indicated that there is a lack of government support for VILs. Literature further indicates that there is a lack of initiative from government to recruit trained staff at special schools in SA (Hodgson and Khumalo, 2016). This lack of proper training at school level leaves VILs unprepared for tertiary education. Furthermore, inadequate political commitment exists with regard to the VIL issues faced by the department of higher education in SA (Matshedisho, 2007). Higher education institutions fail to accommodate the needs of VILs due to this lack of commitment. VILs face many financial constraints as they require assistive resources, travel costs, accommodation costs, mobility practitioners etc. while studying at the tertiary institutions. If government does not take initiative in providing sufficient support to VILs, it may affect their academic performance. They may drop out from their courses since they are not catered for. Therefore, this sub factor forms a part of this framework as it promotes the inclusion of VILs in Engineering education.

6.3.1.2 Management Support

The special schools (from Chapter 4) and university (from Chapter 5) case studies indicated inadequate management support as a challenge affecting the provisioning of VILs in Engineering education. The literature (from Chapter 2) indicates that the DUs in the universities find it challenging to assist VILs due to the poor response received from the university management regarding VIL issues like allocation of resources, financial constraints, etc. (FOTIM, 2011). The lack of management support can also be a reason for some of the other challenges affecting the provision of VILs in Engineering education identified in this study for example lack of awareness about disability, lack of resources, lack of funds, lack of trained staff etc. VILs may feel neglected if they do not receive the support that they expect from the management of their institutions. If management does not make an effort in providing adequate resources and skilled staff to assist VILs, they might struggle to excel in their academic courses. This may affect their self-confidence and self-esteem, thereby affecting their academic life. Therefore, management support plays an important role in promoting the inclusion of VILs in Engineering education.

6.3.1.3 Policies for VILs

Literature (from Chapter 2) indicates that there is lack of proper policies for VILs (Nkoane, 2006). Policies are an essential element of any constitution or organisation. Disability policies are formulated to provide adequate services to the people with disabilities and to address the barriers faced by them in the society, thereby eliminating the exclusion of people with disabilities. SA has adopted many policies to protect the rights of the disabled. Some of the policies are:

- Section 29(1) –-Constitution of SA (1996),
- Section 9 – Constitution of SA (1996),
- PEPUDA – national legislation mandated by section 9(4) of the Constitution (2000), Employment Equity Act (1998),
- Article 24 –United Nations Convention on the Rights of the Persons with Disabilities (2006),

- White Paper on the Rights of Persons with Disabilities – Department of Social Development (2015).

However, higher education institutions are not given proper directions regarding how to implement these policies. If proper policies and directions regarding on how to implement these policies are not provided by the government, VILs will be deprived of their right to enjoy equal access to education. The current policy followed by the South African institutions is not specifically for VILs or deaf learners but is used generally for all people with disabilities. VILs might be having a different challenge compared to a student who is wheelchair-bound. Therefore, the disability issues of VILs may not be addressed properly, thereby making them feel socially excluded. Because of the significance of adequate policies for VILs, it is included as a sub-factor in the proposed framework.

6.3.2 Finance

Literature indicates that a lack of funding is one of the major challenges faced in the provisioning of VILs in tertiary institutions (Howell, 2006; Matshedisho, 2007; Fotim, 2011). The literature review was presented in Chapter 2. Most of the factors being discussed in this framework cannot be implemented without adequate funds. In order to implement inclusive education and accommodate the needs of all learners, there should be a transformation of higher education in SA which incurs additional costs. But it is difficult for institutions in SA to meet all the financial costs to ensure quality education for all students. The Department of Higher Education and the Ministry of Education promise financial assistance to all DUs in SA. The participants in the university case study (from Chapter 5) indicated that their institutions struggle to assist VILs due to financial constraints. Proper infrastructure and easy access to the buildings are essential for VILs who may struggle to locate their classes in a strange environment.

They may end up missing classes which in turn affects their academic performance. Due to the lack of funds, universities fail to provide proper infrastructure facilities to VILs. This negatively impacts the academic life of VILs. VILs also require all learning materials to be adapted to their needs, so that they may not be disadvantaged during assessments. This requires lot of funds as the stationery items like Braille paper, Braille typewriter, etc., are expensive. Investigations done by Fotim (2011) at South African universities (see Chapter 2) reported that the DUs of higher educational institutions in SA experience difficulties in obtaining adequate funding to assist VILs. In order to provide an inclusive learning environment for VILs, universities should provide VILs with easy mobility access around the campus, accessible buildings, good transport facilities, adequate safety measures, proper training on their assistive resources and accessible learning materials. All of these facilities cannot be made available to VILs without proper funds from government and management of tertiary institutions.

6.3.3 Infrastructure

The infrastructure plays a crucial role in effective teaching and learning in educational institutions (Teixeira, Jeremie and Gresham, 2017). It is important to create a safe, accessible and comfortable learning environment for the provision of education for VILs in tertiary institutions of SA (Mutele and Odeku, 2014). In order to accommodate the needs of VILs, universities should carefully plan and structure the infrastructure, such as eliminating the barriers in the campus that restrict the mobility of VILs, taking necessary safety measures, providing VILs with facilities that assist them learning their academic courses (Yasin *et al.*, 2010). Issues related to the infrastructure in the tertiary institutions of SA are discussed in this section, such as the safety measures, university facilities, accommodation facilities and physical access to building.

6.3.3.1 Safety measures

Participants from the special schools (Chapter 4) and university case studies (Chapter 5) have indicated safety concerns as a challenge affecting the provisioning of VILs in Engineering education. Engineering courses are technical and hands-on compared to other academic courses and the different Engineering streams like Chemical Engineering, Mechanical Engineering, Civil Engineering, etc. involve many practical sessions. Practical classes can be hazardous for VILs if adequate safety precautions are not taken. First degree chemical burns can happen if proper safety measures are not taken when students are working with chemicals. VILs may dismember a finger or hand if not familiarised with the laboratory equipment, especially in Civil and Mechanical Engineering. In Electrical Engineering, VILs may be more exposed to electrical hazards like electric shock and electrocutions due to the nature of the laboratory work that requires much visual inspection. Apart from this, other obstacles on campus may also pose a danger to VILs, for example: construction works, uneven surfaces, holes in the pavement, broken branches from the trees, etc. VILs may injure themselves if safety precautions or assistance are not provided to them on campus. It is of the utmost importance to address the safety issues to promote the inclusion of VILs in Engineering education.

6.3.3.2 University facilities

Participants from the special schools (Chapter 4) and university case studies (Chapter 5) indicated a lack of appropriate university facilities as one of the major barriers that affect the provision of VILs in higher education in SA. Studies have indicated that VILs are not happy with the library services offered at universities (Phukubje and Ngoepe, 2017). VILs may require more time to reach the library and by the time they reach it, they are often denied access by the security staff stating as the library may be full. This becomes more challenging to VILs when they have to submit assignments and study for examinations. Even if VILs manage to enter the library, they do not always receive accessible study materials. This affects the academic performance of VILs. Apart from the issues mentioned above, the university must also ensure that VILs receive adequate transport facilities, supportive DUs, adequate funds, reasonable accommodation facilities and adequate resources (assistive tools, trained staff, etc.). Researchers like Chiwandire and Vincent (2017) have reported that many universities in SA deny admissions to students with disabilities as those universities do not have enough facilities to assist these students in their academic courses. It is important to address these issues to promote the inclusion of VILs in Engineering education.

6.3.3.3 Safe accommodation facilities

Participants from the special school case study (Chapter 4) indicated that there is a lack of adequate and safe accommodation facilities for VILs. Literature indicates that VILs at tertiary institutions also face the same challenge as special schools do (Lourens and Swartz, 2016). The Fotim report (2011) states that DUs require more funding from the government and management to build accessible and safe accommodation facilities to VILs. VILs find the distance of accommodation to the campus as one of the learning challenges they face in the universities. Sometimes, VILs are shifted to a further residence stating that the nearby residences do not have the facilities to accommodate them. In such cases, students have to leave early from their residences to reach their campus in time for their classes.

At times, students have to wait for transport facilities to reach campus. If the transport services are not on time, VILs might miss classes or even exams. At tertiary institutions, VILs become part of a wider social group and they might often feel reluctant to ask for assistance to travel between the residence and campus. Dedicated and safe accommodation facilities might be useful for students with disabilities. The residences might require facilities like elevators, sign boards, etc., to assist the students. If the accommodation facilities are accessible to VILs, it promotes their participation in the social activities in the campus. Therefore, safe accommodation facilities will assist to promote the participation of VILs in Engineering education.

6.3.3.4 Easy physical access to buildings

Many tertiary institutions in SA are reported to be physically inaccessible to students (Nkoane, 2006; Tugli *et al.*, 2013; Mutanga, 2017).Participants from the special schools (Chapter 4) and university (Chapter 5) case studies have indicated a lack of accessible buidings as one of the major barriers that affect the provision of VILs in higher education in SA. The library, toilets, lecture halls, practical labs, parking spaces, DUs etc. should be accessible to the students. VILs require a lot of assistance in manoeuvring around the campus to locate the lecture venues and student support centres. VILs could be late to a class or an assessment if the buildings are situated in inaccessible locations. Therefore, the neglect of providing physical access to buildings to VILs can affect the academic learning process of VILs, thereby restricting their equal participation in the society. VILs find it difficult to enter certain buildings due to the lack of ramps, automatic doors, heavy entrance doors, etc. It is unfair to expect VILs to academically perform well without even providing them with the basic facilities like accessible buildings. Easy access to buildings is necessary to promote the inclusion of VILs in Engineering education and is therefore included in the framework.

6.3.4 Mobility

Navigating around the tertiary institution campus may prove challenging to VILs (Pitt and Tracey, 2014). Even though universities in SA have taken sufficient measures to ensure safe navigation for VILs, studies do indicate that VILs still struggle to navigate the campus (Wolanin and Steele, 2004). This section discusses various mobility factors (mobility in the campus and transport services) that might assist the accommodation of VILs in tertiary institutions.

6.3.4.1 Easy mobility around the campus

The special schools (from Chapter 4) and university (from Chapter 5) case studies reported that VILs struggle in manoeuvring around a campus. Walking to the library, lecture venue, DU, accommodation, etc., should not be a challenge for VILs. If not assisted in case of construction works, there are possibilities of VILs getting injured while walking around the campus. Sometimes, VILs require mobility services so that they will not be late for classes. Lack of proper mobility services may affect their participation in the academic courses at educational institutions. The sign maps in educational institutions are not useful for VILs; they require a mobility practitioner to assist them with the mobility around the campus. The special schools in SA struggle to appoint a mobility practitioner due to lack of funds (Simalalo, 2017). Not all universities in SA offer this facility to VILs as it is costly and time-consuming. A mobility practitioner may not be a feasible solution. VILs may need to be trained on a new route every time when their lecture venue changes. But, VILs find it difficult to understand and follow tactile maps. It is necessary to have a good navigation system that assists VILs to navigate independently and confidently around the campus, thereby improving their participation in academic courses.

6.3.4.2 Transport facilities

It is a fundamental requirement that all the barriers that restrict access to academic services for VILs should be eliminated as far as possible. Literature (Chapter 2) indicates that transport services are at times inaccessible for VILs in South African universities (Chiwandire and Vincent, 2017). Therefore, VILs struggle to reach their classes on time and sometimes they miss their classes. The situation becomes worse on days when they have examinations or have to submit assignments. This might leave VILs excluded from participating in academic activities regularly thereby affecting their academic performance. Parking vehicles in the university campus is also difficult as there is not enough accessible parking space allocated for the students and the spaces allocated are very far from their lecture halls (Engelbrecht and De Beer, 2014). Arranging appropriate transport facilities for VILs is considered to be as one of the key responsibilities of DUs, but studies indicate that DUs have minimal autonomy; therefore, all the initiatives taken by the DUs may not be implemented (Fotim, 2011). It is challenging for VILs to participate in the social events of the university because of the lack of flexible transport facilities.

The transport facilities are usually not available to the students during the evenings. This restricts VILs from participating in entertainment activities, university events, social clubs, etc., thereby leaving them socially excluded. They will have to depend on others if they want to attend such events. In order to maintain the social network VILs have created, they have to constantly interact with their friends. With inadequate transport facilities, the only way for VILs to socialise is during their break time. Access to transport facilities may enhance VILs access to academic and social activities of the university and promotes the successful participation of VILs in higher education courses.

6.3.5 Teaching and learning

The quality of teaching and learning determines the success of an educational system (Bidabadi *et al.*, 2016).The teachers have to ensure that adequate accommodations or arrangements are made in the classrooms to meet the learning needs of all students. The teachers should adopt proper teaching strategies that are aligned to the learning strategies of the VIL. VILs prefer enrolling in universities that have skilled staff that are capable of addressing their educational needs. VILs do require assistive devices in their courses. Therefore, VILs expect their teachers to be trained on those devices so that they could assist them further. Factors related to teaching and learning in the tertiary institutions of SA are discussed in this section, such as equipment for effective teaching and learning, trained teachers, allocation of sufficient time for teaching VILs, training VILs to cope with the workload at universities and to design curriculum for VILs.

6.3.5.1 Equipment for effective teaching and learning

The special schools (from Chapter 4) and university (from Chapter 5) case studies indicated that a lack of equipment for effective teaching and learning hinders the provision of VILs in Engineering education in SA. Assistive tools and equipment play a key role in improving the academic performance of VILs (Nkoane, 2006). A lack of adequate equipment or resources can hinder VILs from accessing the prescribed curriculum in universities. This may affect the learning process of VILs thereby affecting their self-esteem and functional independence. VILs encounter a lot of difficulty in their academics like reading the study materials, following the presentations given by the lecturers in class and completing written assignments. The study materials have to be in Braille for totally blind learners or should be in large print for partially sighted learners. Not only the study materials, but also the examination papers should be adapted to the needs of VILs.

VILs use assistive resources like screen readers to read the study materials in electronic format (Molina, Ordóñez and Gustavo García Zerda, 2016). Assistive equipment assists VILs to perform a task and actively participate in all the learning activities which otherwise would have been difficult. Due to the technicality of Engineering courses, using only screen readers might not be sufficient to assist VILs in their courses. VILs require a variety of ICT tools, resources and equipment that can assist them in Engineering courses. Therefore, appropriate equipment for teaching and learning may facilitate the inclusion of VILs in Engineering education.

6.3.5.2 Appropriate teaching and learning strategies

While some universities have given importance to assistive devices, the process of adopting appropriate teaching strategies to integrate these devices are often neglected in the South African higher education system (Fotim, 2011). The researcher received poor responses from the HODs and senior lecturers (from Chapter 5) who participated in this study when asked about the teaching strategies that they use to assist VILs in their classes. The special school educators (from Chapter 4) reported using a number of specialised teaching strategies for VILs. However, all the participants were not trained to teach VILs who require assistive resources to be successful. VILs also require specialised and appropriate teaching and learning strategies that would assist them to use these resources effectively. Implementing an effective teaching strategy also involves understanding the learning strategies of students and motivating them to enhance their learning process. The literature and case study findings indicate that much attention is not given to identifying and implementing appropriate teaching and learning strategies for VILs. This may hinder the participation of VILs in their academics. Addressing these issues may promote the inclusion of VILs in Engineering education.

6.3.5.3 Trained teachers

This framework is developed with the intention to guide the Engineering faculty in the provisions for VILs in Engineering courses in tertiary institutions of SA. The special schools (from Chapter 4) and university (from Chapter 5) case studies indicated a lack of trained lecturers as a barrier that can affect the provisioning of VILs in Engineering education. The role of a teacher in an inclusive classroom is challenging as he/she should be capable enough to deal with a diverse group of students. These teachers should be competent to handle the difficulty encountered by VILs while learning concepts in class. The responsibilities of a teacher include adopting different teaching strategies that can assist VILs, planning the curriculum and lesson plans carefully by considering the needs of VILs and handling the assistive tools assigned to VILs. Studies indicate that VILs struggle in excelling in their academic courses in tertiary institutions due to lack of trained teachers (Howell, 2006; Mushome and Monobe, 2013).

The teachers do not receive adequate training in tertiary institutions to address the needs of VILs in their academic courses. The lack of knowledge of disability issues may affect the learning process of VILs (Ngubane-Mokiwa and Khoza, 2016). Some teachers also tend to avoid getting involved in dealing with disability issues as they feel that it should be handled by DUs (Van Jaarsveldt and Ndeya-Ndereya, 2015). But teachers should understand that VILs expect a lot of emotional and academic support from their teachers. VILs should not be always directed to DU offices with their issues. They may feel excluded and unwelcomed by their department. This will affect their academic life adversely. The academic journey of VILs can only be successful if they receive adequate support from their teachers in their academic courses.

6.3.5.4 Allocation of sufficient time for teaching VILs

The special school educators (from Chapter 4) reported that teaching VILs is a time consuming process and may hinder the provisioning of these students in Engineering education. Inclusive education can be successfully implemented in SA only with the effective participation of all the stakeholders in the academic planning of the tertiary institutions of SA. The teachers in tertiary institutions are expected to play a vital role in implementing inclusivity in the classrooms. Research indicates that teachers in SA find lecturing VILs a stressful process due to lack of support from the higher authorities and lack of training to teach VILs (Walton *et al.*, 2014). Inclusive teaching can be challenging as the teachers have to deal with a diverse group of students under a single educational setting. If sufficient time is not allocated for the teachers to prepare and plan well for their classes, VILs may not benefit from the instruction offered at the educational institutions. Because of their disability, VILs require a great deal of assistance from their teachers to learn the academic courses. This support is required especially during the first year when they transition from school education to tertiary education. If adequate time is not provided for teachers to train and plan to teach VILs, VILs may struggle to complete their studies. When the academic and social needs of VILs are not met, they may feel excluded in their classrooms. In order to address the barriers faced by VILs in learning, a realistic amount of time should be allotted to the teachers so that they can be well prepared to teach VILs.

6.3.5.5 Train VILs to cope with the workload at universities

The special school educators (from Chapter 4) mentioned that training VILs to cope with the workload at universities maybe a factor that might affect the provision of VILs in Engineering education. Transition of VILs from special schools to tertiary institutions may be challenging. They become part of a larger group in universities, i.e. the number of students in university classrooms might be twice or three times as compared to the number of students in special school classrooms. VILs tend to receive less attention from their teacher when they become part of a large group. In the universities, VILs have to access a vast amount of information – and that, independently (Meyer *et al.*, 2008). VILs have to access the library and internet for accessing textbooks and exam papers. They have to keep themselves motivated and organise their time efficiently to manage their workload. The teachers in universities provide knowledge on different concepts and the students have to expand the knowledge by independently accessing various resources like books, internet etc.

Studies indicate that VILs find the workload in the universities overwhelming (Macupe, 2017). VILs further require assistive devices to access the academic content effectively. Depending on the subject content, the technology used in different subjects may vary (Arrigo, 2005). VILs may struggle during their first year of their academic life as they have to adapt themselves to this new environment. VILs require a great deal of support from teachers, management and other students to master the technology and workload offered at the universities. Without adequate support, VILs may drop out from university as they might struggle coping with the technology and workload at universities. Therefore, in order to promote the inclusion of VILs in tertiary institutions, they have to be trained in how to cope with the workload and technology used at institutions offering Engineering.

6.3.5.6 Design curriculum for VILs

The university case study (from Chapter 5) reported that a curriculum should be designed for VILs to promote their inclusivity in higher education. Curriculum design has been always a crucial topic discussed in education as it reflects the ongoing changes in the society, practice and knowledge. When SA initiated inclusivity in education, there was a growing demand and need of adapting the curricula to meet the educational needs of all learners. But the curricula followed in the tertiary institutions of SA are not flexible enough to address the needs of all students (McLean, Heagney and Gardner, 2003). The curriculum does not adhere to the needs of VILs. The curriculum used in South African universities should be designed in such a way that it is useful to all students regardless of their disabilities. An accessible curriculum is one that should be flexible and easy to use but still demanding for all students (Jonker, 2020). Designing an accessible curriculum may assist VILs to accomplish the academic goal of each course, thereby promoting their inclusion in tertiary institutions that offer Engineering.

6.3.6 Student Support Services

The success of an educational institution depends on the quality of services provided to the students. Student Support Services assist students with disabilities to overcome the hurdles they face while pursuing the academic skills needed to attain the educational goal. They also enable academic guidance and motivation to all students, including disadvantaged groups. This section discusses on different student support services that assist in the provision of education to VILs in Engineering courses-disability units, university environments, assisting VILs in adapting to new environment, training VILs on resources and organising awareness campaigns about disability.

6.3.6.1 Supportive Disability units

The university (from Chapter 5) case study reported that a lack of supportive DUs might affect the provision of VILs in Engineering education. DUs are considered to be the primary point of contact for many students with special needs at educational institutions. DUs support disabled students by ensuring the provision of assistive devices and services, as well as assisting them with administrative procedures. Assistance with transportation facilities, accommodation facilities, administration tasks, psychological issues, funds, health issues, security, navigation in the campus are some of the services rendered by DU. The understaffing and office locations of DUs in many institutions does affect the functioning of these units as they cannot attend to all the needs of the students (Ntombela and Soobrayen, 2013). While DUs should exist in every tertiary institution, the Fotim Report (2011) states that many of these units have little authority. This restricted their decision making capacity to assist students with disabilities. It is important to address the issues faced by student support services in order to promote the inclusion of VILs in tertiary institutions offering Engineering.

6.3.6.2 Supportive university environments

The special schools (from Chapter 4) and university (from Chapter 5) case studies reported that there is a negative attitude towards VILs at universities. Tolerance, integrity, respect and understanding are the fundamental factors to create a unified, diverse society. The educational institution plays a vital role in establishing a diverse society by ensuring that these fundamental values are delivered to all students. But, researchers like Ramakuela and Maluleke (2011) assert that tertiary institutions in SA often fail to serve these fundamental values to VILs. VILs are being ignored in their campus by the staff, students and management. This poor treatment indicates the negative attitude that the staff, students and management have towards VILs. Some of the academic staff even consider that accommodating VILs in tertiary institutions might cause a discomfort for the non-disabled students (Mayat and Amosun, 2011). Students with disabilities may also face social stigma and marginalisation in their institutions, resulting in social injustice (Tinklin, Riddell and

Wilson, 2004). This affects the self-respect and dignity of VILs and they may end up feeling that they are a misfit and misfortune to society. VILs may refrain from approaching the academic staff for support to avoid being labelled and being excluded from the rest of the students in the campus. An inclusive learning environment can only be created if students, staff and university treat all students equally with respect and dignity. Supportive learning environments are therefore required for encouraging the provision of assistance to VILs in tertiary institutions.

6.3.6.3 Assisting VILs to overcome the fear of adapting to the new environment

The special schools (from Chapter 4) and university (from Chapter 5) case studies indicated that VILs find it difficult to adapt to the new environment at university. VILs have to face a lot of challenges at higher education instiutions, especially during the first year in their campus. The transition from special schools to higher education instiution might not be smooth. At higher educaton institutions,VILs have to adjust to a lot of new experiences as part of a wider social group. VILs have to adapt to the new environment in the campus in many ways – navigating the campus and adapting to the social, academic and administrative activities of the university. Lourens and Swartz (2016) mention the emotional stress that many of these students experience during their first academic year at university. VILs struggle navigating on campus independently and finding their lecture venues. They might get lost in the campus making them feel scared and uncertain.

At the universities, VILs have to adapt new skills to benefit from the instruction offered (Zeidner, 1992). Adapting to the academic curriculum, understanding the subjects and learning materials, adapting new learning mechanisms and submitting assignments may prove challenging to VILs. Unlike the non-disabled peers, VILs require a good support system (lecturers, other students, DUs, etc.) to assist them to master the academic skills (Hoz and Alon, 2001). In tertiary institutions, VILs have to take part in the social activities where they have to interact with other students. It is a tedious task to maintain the network of friends as VILs might struggle recognising and identifying people. Social integration and acceptance plays a major role in adapting to the new environment. VILs might feel excluded if they cannot socially adjust with the university environment; hence affecting their inclusion in higher education institutions that offer Engineering.

6.3.6.4 Awareness campaigns of student disabilities

The special schools (from Chapter 4) and university (from Chapter 5) case studies indicated that there is a lack of awareness regarding the disability issues among staff, students and management. Some of the challenges relate to poor treatment of university staff towards VILs and a lack of commitment from management. This is often due to a lack of awareness by the staff, students and university regarding the disabilities faced by these students. Lack of awareness campaigns for disability may lead to discrimination, social injustice and stigmas. Some studies have also reported that some may consider students with disabilities as an embarrassment or shame to the institution (Mayat and Amosun, 2011; Lourens and Swartz, 2016). Apart from this, academic staff are also concerned whether these students can fulfil the academic requirements for the university courses. This lack of awareness among the academic staff may affect the academic life of VILs. It is important to organise awareness campaigns to assist the entry of VILs into tertiary institutions offering Engineering.

6.3.6.5 Training VILs on resources available to them

The university (from Chapter 5) case study reported that a lack of training programmes relating to assistive resources for VILs might hinder their inclusion in Engineering education. Engineering is considered to be challenging as the students are trained to use the skills they have acquired during the course to plan and create applications, products or outcomes (Farrell, 2006). Students are expected to acquire a great deal of knowledge and skills (problem solving skills, programming skills, analytical skills etc.) from the Engineering courses (Brunhaver *et al.*, 2017). For example, in computer science Engineering, students have to learn how to design, create and test software solutions to meet the needs of organisations or institutions. VILs would require much more assistance from the university (staff, DU etc.) to acquire these skills. Assistive resources have proved to be helpful in enhancing the learning experiences of VILs.

Based on the course requirements and the ICT tools identified by the university for each Engineering subject, DU staff and Engineering staff should collaborate to train VILs on those resources so that they are prepared before their classes. Otherwise, learning how to use the resources while also acquiring the vast amount of different subject knowledge might prove challenging to VILs. It may also be time-consuming to find accessible resources in the library or study material to complete an assignment. The situation is different from school, where all the students accessed the same study material. Training VILs on the assistive resources can be beneficial to them as it helps them in building their self-confidence and improving their time management skills. This may enable them to successfully participate in Engineering courses.

The next section discusses the evaluation procedure of the research. The factors that should be taken into consideration while evaluating a study are also discussed in section 6.4. The conceptual framework for this study was evaluated based on the procedure discussed in the next section.

6.4 EVALUATING THE RESEARCH

The aim of a research study is to create new knowledge and to utilise that knowledge to find solutions for problems (Clark and Dickson, 2003). Research evaluation is a process carried out to assess the quality of the research study (Mårtensson *et al.*, 2016). Mathison (2005) defines evaluation as a method used for gathering and analysing evidence to make judgements about the merit or significance of a product, program or activity. There are many studies (descriptive studies, formative evaluations) that cannot be assessed based on worth or value (Trochim, 2006). Therefore, researchers like Trochim (2006) define evaluation as a systematic process of assessing research to gain useful feedback about the performance of an object. The term ‘object’ refers to programme, policy or technology. The focus is on improving the performance of an object based on expert reviewer feedback and not on the merit of the study. This feedback plays a crucial role in finalizing the decision making process of a study.

According to Ghent (2019), there are eight factors that should be taken into consideration while evaluating a study. They are as follows:

1. The evaluation procedure chosen for the study should be in conformation with the evaluation goals.
2. The evaluation should take into consideration the possible impact the study would create in the society.
3. The diverseness between different disciplines should also be considered while evaluating the study.
4. For each chosen evaluation method, the simplicity of the procedure is weighed up against the complexity of the research.
5. The criteria used for evaluating the study should be informed well in advance to all stakeholders.
6. Adequate number of experts in the field should be appointed to evaluate the study.
7. These principles should be executed by using evaluation indicators.
8. An evaluation committee should take responsibility to implement all the above mentioned principles.

Pace and Friedlander (1978) assert that good evaluation uses accurate and reliable observations, systematically collects the evidence and performs an objective analysis on the findings. Research evaluations are conducted to assess an object based on its merit, to measure the performance of a system or to determine the impact of a study (Rossi, Lipsey and Freeman, 2003; Pammett and Goodman, 2013).

In this study, evaluation was done to determine the comprehensiveness of the framework. The main objective of this study was to develop a framework for the provision of VILs in Engineering education using ICTs in SA. Therefore, the aim of the evaluation process in this study was to determine the necessity and relevance of a framework for VILs, to determine whether the developed framework meets the needs of VILs and to refine the framework based on the feedback received from the experts.

The evaluation process involves five steps, namely (Trochim, 2006):

1. Formulation of evaluation goal and objectives.
2. Conceptualisation of the main components of evaluation.
3. Design of the evaluation.
4. Analysis of the information.
5. Utilisation of the evaluation results.

The evaluation process for this study was implemented using the above-mentioned steps. The main goal of this evaluation was to determine the importance and relevance of the proposed framework and to refine it based on the feedback received from the experts. The experts consisted of researchers who have done research in Engineering education, HODs of Engineering faculties, disability unit managers and visually impaired people working in the Engineering/IT field. The evaluation tool was piloted by DU managers, HODs and senior lecturers at the CUT. Following the pilot, the modified questionnaire was converted to a Google Form and sent electronically to the experts. Both quantitative and quantitative analysis was performed on the collected information. Based on the evaluation results, the conceptual framework was refined and the framework was finalised.

6.5 EXPERT EVALUATION OF THE CONCEPTUAL FRAMEWORK

Evaluation by researchers who are experts in the field is the principal method used for research evaluation (Langfeldt, 2002). Expert evaluation can be considered as a research tool that focuses on the judgements and decisions of the experts. The decision-making process of the experts are crucial to a study and should be purely focused on improving the research quality and not be influenced by organisational interests. The effectiveness of expert evaluation lies in choosing experts who are knowledgeable about the research topic and are willing to share their experience and knowledge (Frey, 2018). An expert evaluator judges a study based on his experience in the field and based on his knowledge and insights about the research topic

(Stufflebeam, 2000). A good evaluation involves multiple reviewers working on the study separately. Gathering multiple reviews assists in gathering multiple feedbacks, identifying more issues and minimising biased opinions (Tessmer, 1995).

A study should have at least 1 reviewer, but 3-5 is considered as an ideal number (Sauro, 2016). The conceptual framework was evaluated by six experts. The framework was presented using an evaluation questionnaire which was sent electronically to the experts. Experts had to rate all factors in the framework based on its importance and relevance. The experts were also asked to provide recommendations on the factors that could be added or removed from the framework. The experts were:

1. A researcher in Engineering education

   The reviewer is a senior researcher and project leader in the Engineering faculty of Stellenbosch University. She is a specialist in multidisciplinary Engineering education research and curriculum design for Engineering. She has 10 years' industrial experience and 20 years teaching experience.

2. A HOD of an Engineering department

   The reviewer is the chair of the Department of Electrical and Mining Engineering, College of Science, Engineering and Technology, School of Engineering at University of South Africa, Pretoria. He is a specialist in Engineering education research, developing education frameworks, curriculum development for Engineering and work-integrated learning in the School of Engineering. He has 10 years' industrial experience and 20 years teaching experience.

3. A DU manager

   The reviewer is an adaptive technologist in the DU at University of the Witwatersrand, Johannesburg. His research interest is in investigating the latest assistive technologies and ICT tools for VILs. He also takes initiatives in training the VILs at WITS. He has always been keen on finding innovating ways of assisting VILs in campus and has 10 years of experience working for the DU.

4. A DU manager

   The reviewer is an officer in the DU at the University of Free State. She is responsible for the administration and coordination of accessible study material, implementation of the accessible study material, student management and implementation of the disability support procedure and policies. Her main responsibility is to assist VILs to succeed in their studies and help them obtain a tertiary degree. She has 15 years of experience working for the DU.

5. A DU manager

   The reviewer is an officer in the DU at the University of Free State. This reviewer is visually impaired. He is responsible for Braille production and proof-reading and training VILs to use computers and ICT tools at UFS. He has four years of experience working for the DU.

6. A visually impaired person working in the Engineering/IT field

   The reviewer is a visually impaired person and is working as a computer facilitator at the Cape Town Society for the Blind (CTSB). This reviewer was chosen as the Mentor of the Year for 2016 at CTSB. He is the first blind person in Africa to obtain the International Computer Driving License, a well-known certification in computing. He has four years of experience at CTSB.

6.5.1 Data Collection and Analysis-Expert Evaluation questionnaire

The questionnaire is divided into three sections: Part A (Background Information), Part B (Framework Evaluation) and Part C (Overall Framework Evaluation). The questionnaire is presented in Appendix I.

6.5.1.1 Part A: Background Information

This section of the questionnaire captured the background and the biographical information, which included the expert's age, gender, race, position and years of service.

Four out of the six experts were males, suggesting a level of gender bias. Studies do indicate that women are underrepresented in science, technology and Engineering as fewer women graduate in these field (Hill, Corbett and St Rose, 2010). The experts consisted of researchers who have done research in Engineering education, HODs of Engineering faculties, disability unit managers and visually impaired people working in Engineering/IT field. A total of 50% of the experts (three experts) were in the age group 35-39 years, while one expert fell into the 40-44 years' age group and two experts fell into the age group of 50 years and above. The statistics indicates that 50% of the participants were from an older generation (above 40 years of age). As noted in the literature, the life experiences of the older generation have helped them to analyse and handle issues in social environments effectively (Charles and Carstensen, 2010). Therefore, the viewpoints of these participants would prove beneficial to this study.

The experts in this study come from African, White, Asian and Coloured culture backgrounds of SA. These make up the dominant populations groups of SA (Puukka, 2012).This indicates a good representation of the races in SA that would help the researcher to obtain perceptions from different viewpoints that would further benefit this study. The experts were from the following fields of interest: Electrical Engineering, Adaptive Technologist, Officer in a DU, Head of Engineering, disability officer and a visually impaired person working in the Engineering/IT field. The majority of the experts (66.7%) were well experienced with more than 10 years of working experience while only 33.3% of the participants had less than four years. This validates that the participants were experts in their field of study. Two of the experts were visually impaired. The viewpoints of experts who are visually impaired proved very crucial to the study as these participants had personally experienced higher education in SA. They would have personal perceptions of the challenges that VILs face in Engineering education in SA. Their viewpoints would prove crucial in evaluating the framework.

6.5.1.2 Part B: Framework Evaluation

This section captures the expert's response regarding how they rated the factors of the framework for VILs. The rating was done in order of importance and relevance of the factors. Measuring the importance and relevance of the factors would help the researcher to determine the comprehensiveness of the framework. Table 6.4 presents a percentage measure of the responses made by the experts regarding the importance (from VERY IMPORTANT to LEAST IMPORTANT) of the factors.

Table 6.4 Expert evaluation based on importance of framework factors

Framework factors	**Very Important**	**Important**	**Not Important**	**Least Important**
1. Government and Management Support				
Government Support	50%	50%	0%	0%
Management Support	100%	0%	0%	0%
Policies for VILs	67%	33%	0%	0%
2. Finance				
Sufficient funds	100%	0%	0%	0%
3. Infrastructure				
Safety measures	100%	0%	0%	0%
University facilities	50%	50%	0%	0%
Safe accommodation facilities	67%	33%	0%	0%
Easy physical access to buildings	67%	33%	0%	0%
4. Mobility				
Easy mobility around the campus	67%	33%	0%	0%
Transport facilities	67%	33%	0%	0%
5. Teaching and learning				
Equipment for effective teaching and learning	33%	50%	0%	17%
Appropriate teaching and learning strategies	33%	50%	0%	17%
Trained teachers	67%	33%	0%	0%

Framework factors	Very Important	Important	Not Important	Least Important
Allocation of sufficient time for teaching VILs	50%	50%	0%	0%
Train VILs to cope with the workload at universities	33%	67%	0%	0%
Design curriculum for VILs	83%	17%	0%	0%
6. Student support services				
Supportive disability units	67%	33%	0%	0%
Supportive university environment	33%	67%	0%	0%
Assisting VILs to overcome the fear of adapting to the new environment	67%	33%	0%	0%
Awareness campaigns of student disabilities	67%	33%	0%	0%
Training VILs on resources available to them	50%	50%	0%	0%

All the experts rated management support (under "government and management support"), sufficient funds (under "finance") and safety measures (under "infrastructure") as the most important factors that should contribute to the provision of VILs in Engineering education. The least important factors, as per the expert evaluation, was equipment for effective teaching and learning of VILs (under "teaching and learning") and appropriate teaching and learning strategies (under "teaching and learning"). The results indicate that most of the experts agreed that the proposed factors in the framework were very important or important.

According to Gallien, Graves, and Scheller-Wolf (2015), the practical relevance of research depends on the contribution the study can provide to society and in how useful the final recommendations will be. The proposed framework in this study was developed for the provision of VILs in Engineering education in SA. Table 6.5 presents the percentage measure of the responses made by the experts based on the order of relevance (from VERY RELEVANT to LEAST RELEVANT) of the framework components.

Table 6.5 Expert evaluation based on relevance of framework factors

Framework factors	**Very Relevant**	**Relevant**	**Not Relevant**	**Least Relevant**
1. Government and Management Support				
Government Support	83%	17%	0%	0%
Management Support	100%	0%	0%	0%
Policies for VILs	66%	17%	0%	17%
2. Finance				
Sufficient funds	100%	0%	0%	0%
3. Infrastructure				
Safety measures	83%	17%	0%	0%
University facilities	100%	0%	0%	0%
Safe accommodation facilities	67%	33%	0%	0%
Easy physical access to buildings	67%	33%	0%	0%
4. Mobility				
Easy mobility around the campus	83%	17%	0%	0%
Transport facilities	33%	50%	17%	0%
5. Teaching and learning				
Equipment for effective teaching and learning	83%	17%	0%	0%

Framework factors	Very Relevant	Relevant	Not Relevant	Least Relevant
Appropriate teaching and learning strategies	83%	17%	0%	0%
Trained teachers	100%	0%	0%	0%
Allocation of sufficient time for teaching VILs	50%	33%	17%	0%
Train VILs to cope with the workload at universities	83%	17%	0%	0%
Design curriculum for VILs	50%	50%	0%	0%
6. Student support services				
Supportive disability units	83%	17%	0%	0%
Supportive university environment	67%	33%	0%	0%
Assisting VILs to overcome the fear of adapting to the new environment	67%	33%	0%	0%
Awareness campaigns of student disabilities	50%	50%	0%	0%
Training VILs on resources available to them	67%	33%	0%	0%

All the experts rated management support (under "government and management support"), university facilities (under "infrastructure"), trained teachers (under "teaching and learning") and sufficient funds (under "finance") as the most relevant factors in the framework. The factors that seemed to be less relevant as per expert evaluation were policies for VILs (under "government and management support"), transport facilities (under “mobility”), allocation of sufficient time for teaching VILs (under “teaching and learning”).

The experts also had to indicate the factors that they would recommend to be removed or added to the framework. No such recommendations were made and only a few minor suggestions were offered in terms of moving certain sub-factors to another main factor. However, this did not impact on the importance or relevance of the factors or the framework.

6.5.1.3 Part C: Overall Framework Evaluation

This section captures the experts’ overall perception about the framework. The expert’s statements are crucial in validating this framework. A 4-point (strongly agree to strongly disagree) scale was used to measure the research variables. Studies have indicated that participants tend to misinterpret the purpose of a midpoint in a Likert scale (Kulas and Stachowski, 2009; Nadler, Weston and Voyles, 2015). There is an overwhelming tendency to opt for the neutral opinion and not think of a proper response while asked to indicate the opinion (Raaijmakers *et al.*, 2000). Therefore, a 4 point Likert scale was used in this study. Table 6.6 presents a percentage measure of the expert response of the evaluation statements to validate the framework. The evaluation statements were adopted from the Evaluation Framework for Learning Analytics (EFLA). The EFLA statements offers a standardised method in evaluating an educational tool/framework in a quick and reliable way (Scheffel, 2017). It has been analysed and validated by experts in educational field. Since this framework was developed for the provision of VILs in Engineering education, the EFLA evaluation statements were included in the evaluation tool. The evaluation statements were modified to be specific to this study (for example: Step towards the successful provision of VILs in Engineering).

Table 6.6 Overall Framework Evaluation – Expert's response

Evaluation Statements	Strongly Agree	Agree	Disagree	Strongly Disagree
Efficient	17%	66%	0%	17%
Operational	0%	83%	0%	17%
Well designed and relevant	0%	83%	0%	17%
Applicable	0%	83%	0%	17%
Meets the needs of VILs	17%	50%	33%	0%
Step towards the successful provision of VILs in Engineering	17%	50%	17%	16%
Useful and valuable	17%	66%	17%	0%
Adaptable and customisable	0%	83%	17%	0%
Requires a lot of improvement	33%	17%	50%	0%

A total of 66% of the experts agreed and a total of 17% of the experts strongly agreed that the framework was efficient. A total of 83% agreed that the framework was well designed, operational, relevant and applicable while a total of 17% of the experts strongly agreed and a total of 50% of the experts agreed that the framework meets the needs of VILs and is a step towards the successful provision of VILs in Engineering. A total of 83% of the participants agreed that the framework was useful, valuable, adaptable and customisable. Only one expert strongly disagreed with this. However, the participant did not mention any reasons as to why they disagreed, also they did not indicate which of the factors needs to be removed.

A total of 50% of the experts agreed that the framework did not require improvement. A total of 33% of the experts strongly agreed and a total of 17% of the experts agreed that the framework required improvement. But when the participants were asked to give details regarding what improvement needs to be done, they did not provide any suggestions. In fact, they gave positive reviews in that section. For example, one expert said that the framework presented valuable ways and ideas on how to improve support to VILs studying engineering while another said that this framework would be useful for higher education institutions. The third expert indicated that this is a good project and provided a minor suggestion. The feedback and suggestions from the experts were carefully taken into consideration while refining the framework (explained in Section 6.6). Overall, the perceptions of the experts were positive. All the experts indicated that they feel that this framework could make a real difference to those institutions who do not know how to support VILs who study Engineering.

6.6 THE REFINED FRAMEWORK AFTER EVALUATION

No major objections were made by the experts and no factors were to be removed from the proposed framework. All the experts had rated sufficient funds and safety measures as very important factors. 83% of the experts rated “Design curriculum for VILs” as a very important factor and 17% of the experts rated this factor as an important factor of the framework. Therefore, these factors were not removed from the framework.

The experts were also asked whether they liked to recommend any new factors that needs to be added to the framework. One expert suggested that peer assisted learning or student mentorship should be added to the framework. Peer assisted learning is a teaching and learning strategy. Since teaching and learning strategies are already a part of the framework, nothing needed to be added. The feedback and suggestions from the experts were carefully taken into consideration and no significant changes were made. Therefore, the proposed conceptual framework shown in Figure 6.1 is now adopted.

6.7 SUMMARY

Currently, there exists a massive exclusion of VILs in Engineering in the higher education institutions of SA. The main aim of this study was to develop a framework for the provision of VILs in Engineering education in SA. This study followed Jabareen’s (2009) steps in building a framework. The steps are the following:

mapping the selected data sources, extensive reading and categorising of the selected data, identifying and naming the concepts, deconstructing and categorising of the concepts, integrating concepts, synthesis and making sense, validating the conceptual framework, rethinking the conceptual framework. The challenges faced in the provision of VILs in Engineering education collected from different data sources have been presented in the previous chapters (Chapters 2, 4 and 5). The challenges identified from different data sources were integrated to form the factors of the framework. The main six factors are government and management support, finance, mobility, infrastructure, teaching and learning and student support services.

The expert evaluation of the framework was also presented in this chapter. Management support (under “government and management support”), sufficient funds (under “finance”) and safety measures (under “infrastructure”) were the factors that received 100% support in terms of importance. Management support (under “government and management support”), university facilities (under “infrastructure”), trained teachers (under “teaching and learning”) and sufficient funds (under “finance”) received 100% support in terms of relevance. The majority of the experts (83%) agreed that the framework was efficient, well designed, operational, relevant and applicable, useful, valuable, adaptable and customisable.

Minor suggestions were made by the experts, such as moving a sub-factor to another main factor. However, this did not impact on the importance and relevance of these factors and therefore the proposed conceptual framework is adopted. The following chapter presents the conclusions of the study.

CHAPTER 7: CONCLUSION

6.1 INTRODUCTION

This study was undertaken to develop a framework for the provision of VILs in Engineering education in SA using ICTs. The proposed framework was presented in the previous chapter. This framework was evaluated by field experts to establish its validity and the refined version was presented in Chapter 6. This concluding chapter reviews the research findings to determine whether the objectives set out in Chapter 1 have been accomplished.

Section 7.2 gives an overview of the thesis; while section 7.3 reviews the study questions. Section 7.4 reviews the objectives while section 7.5 discusses the contributions made by this study. Section 7.6 presents the limitations of the study while section 7.7 discusses the future research.

7.2 OVERVIEW OF THE THESIS

The dissertation is ordered into seven chapters. The synopsis of the thesis is presented below:

Chapter 1: This chapter presented the background study. This included the assessment of the research area, contemporary information regarding the problem and the relevant literature on the issue. The problem statement of the study was formulated based on the background information. The background study indicated that institutions of higher learning in SA do not have proper guidelines for teaching Engineering to VILs using ICTs. This motivated the researcher to develop a framework that could assist VILs in Engineering education using ICTs. The research objectives and questions that guided the study were also discussed in this chapter. Further to this, an outline of the research methodology and design for the study was provided. The research tools used for the study were both quantitative and qualitative in nature. Therefore, a mixed method research approach was used. This chapter also presented a brief description of the data collection instruments (literature review, focus groups, and questionnaires) used in this study. The scope and significance of the study were also discussed along with ethical considerations. This chapter concluded with a brief overview of the dissertation.

Chapter 2: This chapter discussed the literature used in the study. This study sought to investigate the different ICT tools that could be adopted to better facilitate the entry of VILs into Engineering courses (sub-objective 3 of this study). Therefore, a literature review of the ICT tools or assistive tools that could be used for VILs in Engineering courses was conducted. The tools identified in this study included iNetSim, PRISCA, AudioMath, i-Math, MathPlayer, Math Genie, MoodleVox, Audio visual tool for Java, Haptic devices for robotics, Logger Pro and VB scripts for GUI forms. Apart from these Engineering ICT tools, a few popular ICT tools were also presented in this chapter. These tools were: Video Magnifier, Perkins Brailler, Electronic Braille Note, Braille Embosser, Slate and Stylus, JAWS, Talking Calculator, Haptic Device with Computer Applications and Tactile Graphics. Sub-objective 2 of this study was to identify the challenges that VILs in SA face when contemplating entry into Engineering courses.

A detailed literature was conducted on studies regarding the challenges and barriers faced by VILs while contemplating entry into higher education. Some of the challenges that was identified from the literature were negative attitude of fellow non-disabled learners, educators and institutions; lack of awareness about disability issues among the staff, students and management, and minimal autonomy of DUs. Other challenges included a lack of the following aspects: Infrastructure; financial support/funding; access support services; trained staff; and assistive resources, equipment and tools. Additionally, literature also pointed to the following challenges: curriculum was not designed to the needs of VILs; lack of policies; and VILs struggled to meet the course requirements. The literature review that was presented in this chapter was the initial data collection done for the study.

Chapter 3: This chapter presented the research methodology and design for the study. The researcher investigated different technologies that could allow VILs to access their academic content using computers more efficiently (discussed in

Chapter 2). Therefore, this study falls under the Human Computer Interaction (HCI) domain. The different paradigms within the HCI discipline were discussed in this chapter. A design science research paradigm was used in this study because this paradigm is suitable for education research studies that address complex research problems where there are no pre-set guidelines for the available artefacts. The different stages involved in the research process were explained in detail. The stages include: research philosophies, approaches, choices, strategies, time horizons, techniques and procedures. An inductive approach was used in this research. The study utilised data from multiple sources such as focus groups, questionnaires, literature review and expert review.

Views and perceptions of VILs, DUs, special school educators and HODs and senior lecturers of Engineering faculty were obtained via focus group discussions and qualitative questionnaires. The research tools used for the case study gathered both quantitative and qualitative data. Therefore, a mixed method research approach was used. Since the study was not confined to a single philosophy, the research paradigm used in this study was pragmatic. The researcher had to complete the study within a certain time frame; therefore, this is a cross sectional study. Piloting and sampling techniques were explained in detail. The study used both probability and non-probability sampling techniques to determine the study population. Content analysis and descriptive statistics methods were used to analyse the collected data.

Triangulation techniques were used to validate and strengthen the findings obtained from analysing multiple data sources used in the study. The ethical considerations used in this study was also discussed in this chapter. Ethical clearance was obtained from the Faculty Research and Innovation Committee at CUT.

Chapter 4: This chapter presented the case study done at school level. This chapter started with emphasising the importance of schooling and school governance. The researcher chose the special schools in the Free State province in order to investigate the challenges faced by VILs while trying to enrol into Engineering courses. The demographics of the special schools in the Free State Province (Bartimea School for the Blind and Deaf and Thiboloha School for the Blind and

Deaf) were presented in this chapter. The literature review that was presented in the previous chapter assisted the researcher to develop the data collection tools in this study. The questions were also linked to the research questions and objectives. The aim of the school level research tools was to identify the challenges and barriers faced by VILs while contemplating entry into higher education.

Focus group discussions were conducted with VILs at special schools of Free State province. The participants were VILs attending Grade 10, 11 and 12. There were five (5) focus groups; with each group having 6-7 members each. VILs from CUT were recruited for the pilot-testing of focus group questions. Questionnaires were developed using Google Forms and were distributed electronically to the special school educators. Senior lecturers from the Engineering faculty at the CUT piloted this questionnaire. Of the educators, 52% (14 educators) from two special schools responded to the study. The data collection process continued until no new perspectives and insights emerged out of the collected data. Qualitative content analysis techniques and quantitative techniques were used to analyse data and organise them into themes and categories. 19 challenges that affected the provision of VILs in Engineering courses were identified from the focus groups and 17 challenges were identified from the questionnaires.

Chapter 5: This chapter presented the case study done at university level. The importance of tertiary education and the governing bodies at tertiary institutions is discussed in this chapter. The case study at university level targeted the DUs of the universities as well as the HODs and senior lecturers of Engineering faculties. Questionnaires were used as the main data collection instrument. The questionnaires were sent electronically through Google Forms to the participants. The questionnaires aimed to achieve the following sub-objectives: to determine the degree to which Engineering faculties in SA are accommodating VILs, to identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA, to incorporate many of the ICT tools into the framework to benefit VILs in Engineering education in SA. The DU questionnaire was piloted by DU staff at CUT. Following the pilot, the modified questionnaire was distributed electronically to 20 universities, of which five responded.

The questionnaire for HOD and senior lecturers at Engineering faculties in South African universities was piloted by the HOD and senior lecturers in the Engineering faculty at CUT. Twenty-five participants (HODs and senior lecturers) from nine universities participated in the main study. A qualitative content analysis technique was used to analyse the collected data. The findings from the DU questionnaires revealed that there are fewer VILs enrolled in the field of Engineering as compared to other disciplines. The ICT tools for Engineering that were identified from the questionnaires were: magnifiers (software and hardware), screen-reading software, Braille devices, OCR software, recordings, 3D printing, simulation software.Thirteen challenges that affected the provision of VILs in Engineering courses were identified from DU questionnaire and 18 challenges was identified from HODs and senior lecturers' questionnaires.

Chapter 6: This chapter discusses the design, development and evaluation of a framework for the provision of VILs in Engineering education in SA using ICTs. The framework presented in this chapter was developed based on the data collected from the literature review (Chapter 2) and case studies (Chapters 4 and 5). This study followed Jabareen's (2009) eight steps in the formulation of the framework for the provision of VILs in Engineering courses at universities. The challenges identified from different data sources were integrated to form the factors of the framework with irrelevant elements being removed. The factors are government and management support, finance, mobility, infrastructure, teaching and learning and student support services.

The developed framework was evaluated by experts in the field of study. The experts consisted of researchers who have done research in Engineering education, HODs of Engineering faculties, DU managers and visually impaired people working in the Engineering/IT field. The evaluation tool was prepared using Google Forms and was sent electronically to the experts. Before distributing the tool to the experts, it was piloted by the DUs, HODs and senior lecturers in the Engineering faculty at CUT. Both quantitative and quantitative analyses were performed on the collected information. The findings indicated that the majority of the experts (83%) agreed that the framework was efficient, well designed, operational, relevant and applicable, useful, valuable, adaptable and customisable. The overall opinion of the experts was positive and they indicated that the framework could make a real difference to those institutions who do not know how to support VILs studying Engineering. Minor suggestions were made by the experts, such as: moving a sub-factor to another main factor. However, this did not impact on the importance and relevance of these factors and therefore the proposed conceptual framework was adopted.

Chapter 7: This concluding chapter presents a synopsis of the research study. The research objectives, findings and recommendations are laid out together. This chapter summarises the discussions in each chapter thereby providing an overview of the research. The researcher also provides a brief description of the key findings from the study which was developed to resolve the research problem. The scientific and social contributions of this study have also been discussed in this chapter. The scientific contributions discuss how this study contributes to the body of knowledge while social contributions discuss how this study improves the societal conditions of VILs. This study has a few limitations which have been listed in this chapter. Future research areas are identified by the researcher and have been discussed in this chapter.

7.3 REVIEWING THE RESEARCH QUESTIONS

The research study was guided with this main research question:

What guidelines should exist in South African universities to facilitate the inclusion of VILs in Engineering using ICTs?

Five sub-questions exist as follows (listed below with appropriate discussions):

To what degree are the Engineering faculties in SA accommodating VILs?

Literature (section 2.5 of Chapter 2) revealed that there are only a few studies that have analysed the situation of VILs in Engineering faculties at South African universities. In fact, there is only one study that discussed VILs in an Engineering faculty at one of the South African university (Mayat and Amosun, 2011). Their research indicated that that there is low representation of VILs in Engineering. Thus, as indicated earlier, the researcher saw a need to investigate this status quo of VILs in Engineering faculties. Further investigation of this research question was done using a case study (Chapter 4 and 5).

The second research sub-question is discussed below:

What are the challenges that VILs in SA face while contemplating entry into Engineering courses?

The literature revealed a number of challenges faced by VILs in higher education (Chapter 2). Some of the challenges identified from the literature were lack of policies, minimal autonomy of DUs, inadequate infrastructure, negative attitude of fellow non-disabled learners, educators and institutions towards VILs, lack of funds etc. The case study (Chapter 4 and 5) assisted the researcher to verify, and add to, the identified challenges. Lack of safety measures, inadequate training for VILs on the ICT resources available for them, difficulty of VILs to cope with the workload at the universities, etc., were some of the additional challenges identified from the case study.

The third research sub-question is discussed below:

What are the current ICT tools that could be effective for VILs in Engineering?

This study conducted a literature review to identify ICT tools that could assist VILs in Engineering (Chapter 2). These tools include iNetSim, PRISCA, AudioMath, i-Math, MathPlayer, Math Genie, MoodleVox, Audio visual tool for Java, Haptic devices for robotics, Logger Pro and VB scripts for GUI forms. Apart from these tools, a few popular ICT tools were also presented in this chapter. These tools include video Magnifier, Perkins Brailler, Electronic Braille Note, Braille Embosser, Slate and

Stylus, JAWS, Talking Calculator, Haptic Device with Computer Applications and Tactile Graphics.

The fourth research sub-question is discussed below:

What guidelines should exist for the effective use of these ICT tools by VILs in Engineering?

This study puts forward six guidelines for the effective use of ICT tools by VILs in Engineering (Chapter 6). The guidelines were formulated with the help of literature review and a case study (Chapters 2, 4 and 5). The guidelines are the following: government and management support, finance, mobility, infrastructure, teaching and learning and student support services.

The fifth research sub-question is discussed below:

Why should this framework be evaluated by field experts?

The proposed framework was evaluated by experts in the field of study to establish its validity and to refine its suitability for Engineering education in SA. Compared to real environment evaluation of the framework, expert reviews were chosen based on the fact that the implementation of all the factors in the framework was not feasible for the study.

7.4 REVIEWING THE RESEARCH OBJECTIVES

The main objective of this study is:

Develop a framework for the provision of VILs in Engineering education in SA using ICTs

Achieving this main objective required that five sub-objectives be accomplished. The researcher now discusses in detail how this was achieved.

SUB-OBJECTIVE 1:

Determine the degree to which Engineering faculties in SA are accommodating VILs.

The research objective was determined with the help of a literature review. The case study also assisted the researcher in this regard. The case study had two parts: part A and Part B, as indicated in Chapter 4 and Chapter 5. Part B of the case study findings revealed that 68% of the senior Engineering staff were not prepared to accommodate VILs in their departments. Additionally, the majority (76%) of the participants (16 out of 25) indicated that they do not have VILs in their departments. The case study also revealed that the minority (5%) of the participants (5 out of 25) were not aware of the number of VILs in their department. The university case study also included DUs at the universities.

In Chapter 5, the DUs revealed that there was a good number of VILs accepted at university level, the number of students vary between 5 and 203. However, within this range, only a maximum of 29 students were accepted in the Engineering stream. The large discrepancy between university and Engineering VIL intake indicates that the Engineering faculty does not, to a large extent, accommodate VILs. This lack of accommodation by university Engineering faculties can be explained to some degree by Part A of the case study that was done at school level. The special school educators (school level study) reported that their alumni VIL students indicated that universities did not accommodate the needs of VILs. This might also explain the high degree of drop-outs of VILs from universities.
These drop-outs are an indication of lack of preparedness by universities to accommodate VILs which was also indicated by the university case study participants (senior Engineering staff).

SUB-OBJECTIVE 2:

Identify the challenges that VILs in SA face when contemplating entry into Engineering courses in SA.

Previous studies indicated that VILs in SA faced a lot of challenges when contemplating entry into Engineering courses. The case study done at school and university level further investigated the challenges VILs faced at higher education institutions, and especially for Engineering courses. The challenges identified from the literature review and case study are:

- Lack of appropriate policies for VILs;
- Insufficient funds;
- Lack of appropriate safety measures;
- Lack of university facilities;
- Lack of safe accommodation facilities;
- Lack of physical access to buildings;
- Lack of proper mobility services around the campus;
- Inadequate transport facilities;
- Lack of proper equipment for effective teaching and learning;
- Lack of proper teaching and learning strategies;
- Necessity for appropriately trained teachers;
- Sufficient time allocation of schedule for teaching VILs;
- Difficult for VILs to cope with the workload and technology used at universities;
- Need for curriculum to be designed to accommodate the needs of VILs;
- Lack of supportive DUs;
- Assisting VILs to overcome the fear of adapting to the new environment;
- Lack of training of VILs on resources available to them;
- Need to organise separate classes for disabled learners;
- Need to create separate program for VILs;
- Necessity for awareness campaigns about disability;
- Assisting VILs to overcome the fear of adapting to the new environment;

- Inadequate government support; and
- Ample management support

SUB-OBJECTIVE 3:

Examine the ICT tools that could be adopted to better facilitate the entry of VIL into Engineering courses.

In Part B of the case study, the DU participants (Chapter 5) indicated that they did not use any Engineering specific tools in their universities and they were not aware of any tools. A lack of appropriate resources was listed as one of the challenges (from literature and case studies) faced in the provision of VILs in Engineering. Studies have indicated the impact of ICT tools in stimulating the learning process of VILs and improving their academic performance (Chapter 2). ICT is considered to be an effective tool to implement inclusive education. Therefore, it was essential for the researcher to examine the various ICT tools that could be adopted to assist the teaching and learning of VILs in Engineering courses. The Engineering-specific ICT tools were discussed in detail under section 2.3 and the generic ICT tools were discussed in detail under section 2.4. The Engineering-specific ICT tools and generic ICT tools identified from the literature are presented in Table 7.1.

Table 7.1 ICT tools that can be used in higher education courses

Engineering-specific ICT tools	**Generic ICT tools**
iNetSim	Video Maginifier
PRISCA	Perkins brailler
AudioMath	Electronic Braille Note / Note Taker
Math Genie	Braille Embosser
i-Math	Slate and Stylus
MathPlayer	JAWS
MoodleVox	Talking Calculator
Audio visual tool for Java	Haptic Device with Computer Applications

Engineering-specific ICT tools	Generic ICT tools
Haptic devices for robotics	Tactile Graphics
Logger Pro	
VB scripts for GUI forms	

If VILs are provided with appropriate ICT tools, it could assist them in succeeding in the Engineering field.

SUB-OBJECTIVE 4:

Incorporate many of these ICT tools into the framework to benefit VILs in Engineering education in SA.

The conceptual framework was developed following Jabareen's (2009) eight steps of framework formulation which included:

1. Mapping the primary (focus group and questionnaire) and secondary data sources (literature review)
2. Categorizing the concepts
3. Labelling the concepts
4. Deconstructing the concepts
5. Integrating the concepts
6. Synthesis and making sense
7. Validating the framework
8. Rethinking the framework

The results from the literature review, focus group discussions and questionnaires were collated to determine whether the research questions were addressed. The principal concepts and sub-concepts of the conceptual framework proposed by the researcher were:

1. Government and Management Support
    - Government Support
    - Management Support

- Policies for VILs

2. Finance
    - Sufficient funds
3. Infrastructure
    - Safety measures
    - University facilities
    - Safe accommodation facilities
    - Easy physical access to buildings
4. Mobility
    - Access mobility around the campus
    - Transport facilities
5. Teaching and learning
    - Equipment for effective teaching and learning
    - Appropriate teaching and learning strategies
    - Trained teachers
    - Allocation of sufficient time for teaching VILs
    - Train VILs to cope with the workload at universities
    - Design curriculum for VILs
6. Student Support Services
    - Supportive DUs
    - Supportive university environments
    - Assisting VILs to overcome the fear of adapting to the new environment
    - Awareness campaigns of student disabilities
    - Training VILs on resources available to them

SUB-OBJECTIVE 5:

Evaluate the framework with specific field experts so as to establish its validity and refine its suitability for higher education in SA.

The framework evaluation is described in detail in Chapter 6 (Section 6.5). The conceptual framework proposed by the researcher was evaluated by six experts. Experts consisted of a group of researchers who had done research in Engineering education, HODs of Engineering faculty, managers of disability centres (of which one was a visually impaired person) and a visually impaired person working in an Engineering/IT field. Most of the expert reviewers (66.7%) were well experienced with a working experience of 10 years. The results in Chapter 6 indicate that most of the experts agreed that the factors in the framework for VILs at university were important. The very important factors were as follows: ample management support, appropriate safety measures and sufficient funds. These very important factors can contribute to the provision of VILs in Engineering courses at universities.

The findings in Chapter 6 also indicated that most experts agreed that the factors in the framework for VILs in universities were very relevant. Ample management support, adequate university facilities, appropriately trained teachers and sufficient funds were viewed as the very relevant factors that contribute to the provision of VILs in Engineering courses at universities.

The majority of the experts (83%) agreed that the framework was efficient. A total of 83% of the participants agreed that the framework was well designed, operational, relevant and applicable while a total of 67% of the participants agreed that the framework meets the needs of VILs and is a step towards the successful provision of VILs in Engineering. A total of 83% of the participants agreed that the framework was useful, valuable, adaptable and customisable. A total of 50% of the experts agreed that the framework did not require improvement.

One expert suggested that "*peer-assisted learning or student mentorship*" should be added as a component in order to improve the framework. However, peer assisted learning was already part of the teaching and learning component of the proposed framework. The feedback and suggestions from the experts were carefully taken into consideration and no changes were made to the framework. The framework after evaluation was presented in Chapter 6.

The sub-objectives were attained by utilising more than one research tool. Research assistants were also used during the data collection phase of the case study. The case study research tools were piloted before the actual study. The research tools were only distributed after receiving ethical clearance from the Faculty Research and Innovation Committee at the Central University of Technology. The research study collected data from different populations such as high school VILs, special school educators, DUs at public universities and senior Engineering staff from public universities. The data collected from different sources were triangulated using data triangulation, investigator triangulation, theory triangulation and methodological triangulation and the final framework was developed based on the feedback from the experts.

This section described in detail how the researcher has achieved the sub-objectives of the study. Attaining the sub-objectives of the study helped the researcher to achieve the main research objective. The next section discusses the contribution of this study in detail.

7.5 CONTRIBUTION OF THE STUDY

The main aim of this study was to develop a framework for the provision of VILs in Engineering education in SA using ICTs. Limited research has been done in the past about the challenges that VILs face in Engineering in SA. Therefore, this study has contributed by identifying six main factors and 21 sub-factors that would assist the provision of VILs in Engineering. The contributions can be considered in two perspectives: scientific and social contributions.

7.5.1 Scientific contribution

The objective of this study has been fulfilled by developing a set of guidelines to assist Engineering faculties in universities to accommodate VILs and by contributing significantly to the existing body of knowledge in Engineering education, ICTs in Engineering education and disability. It is also anticipated that the proposed framework will serve as an initiative for improving inclusivity in Engineering education in South African institutions.

The initial part of the study examined the degree at which the South African universities were accommodating VILs. The literature review and case study confirmed the low representation of VILs in Engineering faculties. This motivated the researcher to investigate the reason behind this low representation. This study has identified the challenges that VILs faced in higher education institutions, especially for Engineering. The findings confirmed the need for creating a framework to accommodate the needs of VILs in Engineering. This study also verified and added to the already identified challenges of VILs in higher education institutions (for example: safety measures) thereby adding to the body of knowledge in disability challenges at higher education institutions. Although, the framework in this study was developed for assisting Engineering faculties in the provision of VILs in Engineering, it could also be used by other faculties as a guideline for assisting VILs in their departments. The key factors will now be discussed with relevant recommendations:

Key Factor 1: Government and Management Support

This key factor was identified from the literature review and case study. The government and management of educational institutions should extend support towards assisting VILs by providing adequate funds; organising awareness campaigns about disability; training the lecturers; and providing adequate resources for VILs. The Department of Basic Education and Department of Higher Education and Training should make sure that there are sufficient trained staff including mobility practitioners, Braille instructors et al. to assist VILs at special schools and higher education institutions. The current disability policy in SA is not specifically for VILs or deaf learners but is used generally for all people with disabilities. It is recommended that there should be a variety of policies which cater for different types of disabilities as well as the degrees thereof. The Department of Higher Education (DHET) should ensure that tertiary institutions are committed to implementing existing VIL policies. Furthermore, the government should create a dialogue around the responsibilities which will ensure the full cooperation and participation of all stakeholders involved in and affected by VIL policies.

Key Factor 2: Finance

The findings of this study indicated that a lack of funding affected the provision of VILs in Engineering education. The DHET should ensure that the Ministry of

Education allocate adequate budgets in the National Education Budget to financially support the DUs in SA. This will assist the DUs to provide VILs with resources (specialised assistive tools) that promote their inclusion in Engineering courses. This study recommends that government and management of tertiary institutions should allocate sufficient funds to train academic staff to handle VILs or recruit skilled staff to teach VILs. Educational institutions in SA should also ensure that there are adequate funds for basic facilities on campus (such as easy mobility access around the campus, good infrastructure, adequate safety measures, etc.) that could assist in accommodating VILs in Engineering.

Key Factor 3: Infrastructure

The results from this study indicated that infrastructure is a key factor in promoting the inclusion of VILs in Engineering education in SA. The sub-factor, safety measures, was rated the most important by experts who reviewed the framework. This study therefore recommends that safety policies be developed for VILs in Engineering. Additionally, it would be beneficial to appoint a security officer to monitor the safety of VILs at their residences. The sub-factor, university facilities, received 100% agreement by the experts for being one of the most relevant factors in the framework. Thus, in order to promote equal participation of VILs in Engineering, it is suggested that VILs should be guaranteed basic infrastructural facilities (for example: ramps, automatic doors, even floors, etc.) and easy access to buildings (lecture halls, toilets, libraries, residences etc.).

Key Factor 4: Mobility

The study findings revealed easy mobility around the campus and transport facilities plays a vital role in accommodating VILs in Engineering. Subsequently, universities should provide mobility practitioners to train VILs to learn routes to buildings (lecture halls, libraries, DUs). Appointing a mobility practitioner is not always a feasible solution as VILs may need to be trained on a new route every time when their lecture venue changes. Therefore, using assistive technologies (wireless, mobile etc.) like Drishti, Eye substitution, Mobile Geo, etc., may be a better solution to assist VILs in navigating around the campus. It is also recommended that adequate transport facilities be provided for VILs so that they can participate in the academic and social activities of the university thereby providing them a sense of independence and autonomy.

Key Factor 5: Teaching and learning

This key factor was identified from literature reviewed and a case study. Based on outcomes of the study, it is recommended that VILs use specialised ICT tools to master the technical skills and to conceive the concepts within their Engineering course. Some of the identified ICT tools that could be used in Engineering (Chapter 2) are PRISCA, MoodleVox, iNetSim, audio- visual tool for Java, etc. This study suggests integrated educational approach as an effective methodology which can be used in the educational institutions as it assists integration of VILs with the rest of the classroom. To implement this approach, certain prerequisites like allocation of appropriate ICT tools; designing a curriculum based on VIL needs; skilled lecturers, etc., are required. Some of the teaching methods that can be used to implement integrated approach are: team-based learning, peer-assisted learning, inquiry-based learning, etc. Experts in this study rated trained teacher as one of the most relevant factors of this framework. The teachers should be given specialised training on the assistive devices and different teaching methodologies that should be adopted in class to accommodate the needs of VILs. A realist amount of time should also be allotted to the teachers so that they can be well prepared to teach VILs.

Key Factor 6: Student Support Services

The primary and secondary data collected for this study identified student support services as an essential factor in the provision of VILs in Engineering education. It is suggested that DUs be given more authority so that they can address the needs of students with disabilities better. The university management team should make sure that there are enough staff in DU to assist VILs and provide them with adequate office space and supplies. The tertiary institutions in SA should also emphasis in ensuring a supportive university environment to all the students. The management of universities should take initiatives in organising awareness campaigns for disability. Such campaigns should be organised to spread the knowledge about disability issues; to correct the misconceptions about disability issues; and to publicise the disability services offered by the institution.

The management of tertiary institutions must also take initiatives to organise campaigns at special schools to advertise about the courses and the facilities offered at the institutions. This will assist the learners to choose the appropriate institution to pursue their career. A supportive university environment will also assist VILs to overcome the fear of adapting to the new environment. To excel in the academics, VILs should be given orientation courses to train them on the different assistive resources that they would be using throughout their courses. This could be beneficial to them as it will help them in building their self-confidence and improving their time management skills.

7.5.2 Social contribution

This framework was developed with the intention of improving the lives of VILs in SA and worldwide. Education plays a vital role in the social and economic development of every individual. Higher education offers personal benefits, like better employment opportunities and a better quality of life. Benefits to the society include lower crime rates, increased civic engagement and increased productivity. Higher education institutions in SA offer courses that can assist students to progress in the labour sector. Therefore, students who have attained a higher educational qualification are attractive employees in the labour market as employers believe that these students are prepared to work in the labour sector. Even though the education system in SA supports inclusive practices, VILs continue to be marginalised from attaining higher education. This situation is worse in certain courses like Engineering. The reason for many universities for not encouraging the enrolment of VILs in these causes might be due to the misconception that VILs may not perform well like other students or because the universities are not prepared or equipped to offer the courses to VILs.

This study has put forward a framework that can assist universities to plan and accommodate VILs in Engineering education. VILs should not be discouraged from attending higher education institutions and completing their studies successfully. Studies indicate that VILs who desire to do Engineering, drop their passion as the universities do not have a proper framework to assist VILs in Engineering courses. This study therefore assists the empowerment of VILs in SA. Pursuing higher education improves the chances of getting employment, thereby improving their quality of life and improving the country's economic prosperity.

7.6 LIMITATIONS OF THE STUDY

The limitations of the study are as follows:

- This study was based on a case study that was done in two parts - Part A at school level and Part B at university level. The school level case study was limited to the special schools in Free State Province (Bartimea School for the Blind and Deaf and Thiboloha School for the Blind and Deaf) and these schools served as a representation of the special school education system within the South African context. This case study targeted the high school VILs and educators at special schools. The researcher collected the data until data saturation was reached. The university level case study was limited to the public universities in SA. Even though the researcher targeted all public universities of SA, 45% of the institutions (9 out of 20 institutions) responded to the senior Engineering staff questionnaire and 25% of the institutions (5 out of 20 institutions) responded to the disability unit questionnaire. The geographic limitations may potentially limit the conclusions drawn from the study.
- Public opinion or government views have not yet been sought on the framework due to time constraints.
- The real-world environment evaluation of the framework was not conducted in this study. Implementation of all the factors in the framework was not feasible for the study. Including the real-world implementation might turn this study into a very large study. This was not possible for the researcher due to resource and time constraints. This can be considered as another study or future work

to this study. Therefore, expert reviews were done to evaluate the proposed framework by the researcher.

- The researcher has identified a few ICT tools that may assist VILs in Engineering. But Engineering education is not limited to these tools. Engineering is a broad field with many branches like Mechanical Engineering, Civil Engineering, Electrical Engineering, IT, Computer Science etc. For the framework to be completely applicable in all Engineering courses, the ICT tools for each specific Engineering discipline needs to be identified.

7.7 FUTURE RESEARCH

The following may be considered as future research areas:

- A similar study could be done using different research tools and methodologies to develop a framework for schools to assist in the provision of VILs for Engineering. This provision will help adequately prepare VILs for Engineering courses because the researcher noticed that a lot more needs to be done at school level for tertiary preparations. In this regard, participants in the current study pointed out various factors that needed attention at school level to help VILs cope with demands of school subjects. For example, learners indicated lack of resources for teaching and learning of maths and science; lack of awareness of Engineering as a university offering. These factors indicate that the school system itself is flawed as it does not help prepare these students for studies towards an Engineering qualification. Therefore, further investigation needs to be done to develop a framework focusing at high school level in order to assist the provision of VILs in Engineering.
- A study on identifying the different ICT tools for all Engineering subjects based on their curriculum. There are many branches in Engineering and the ICT tools may vary depending on the nature of the subject. Identifying the appropriate ICT tools for each subject might prove very useful for VILs and will extend the usability of the framework in this study.
- A study that would assess the degree of acceptance and adoption of ICTs in Engineering education. This study only identified the ICT tools. The degree of

acceptance of these tools was not tested in South African conditions. Since ICT plays a major role in assisting VILs in their academics, this might prove to be a very useful study.

- A study that will evaluate the implementation of the framework for the provision of VILs in Engineering education in SA using ICTs should be undertaken. This study's framework can be considered as a guideline for the researcher implementing it. This study has six principal factors and twenty-one sub-factors. Implementing each and every principal factor can be considered as a separate study since implementing each factor requires adequate amount of time and resources.
- A study to investigate whether engineering staff in the universities receive specialised education to teach VILs.

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APPENDICES

APPENDIX A: Ethics Approval Letter CUT

FACULTY RESEARCH AND INNOVATION COMMITTEE

RESEARCH ETHICS APPROVAL LETTER

Date: 01 September 2017

This is to confirm that:

Applicant's Name	Mrs S.L Tom
Supervisor Name for Student Project (where applicable)	Dr N Mpekoa
Level of Qualification for Student Project (where applicable)	PhD in IT
Tittle of research project	"A framework for the adoption and effective use of ICT's for visually impaired learner's in higher education"

Ethical clearance has been provided by the Faculty Research and Innovation Committee on 31 August 2017 in view of the CUT Research Ethics and Integrity Framework, 2016 with reference number FEIT 8/17

The following special conditions were set:

[X] None

[ ] Specific conditions

We wish you success with your research project.

(FRIC Chairperson)

APPENDIX B: Research Process

Research Step	Research options	Option chosen for the study
Research paradigms	Positivist Interpretivist Pragmatism	Pragmatism
Research paradigms (HCI)	Design science Adaptive Management Paradigm Economic Paradigm Engineering Approach Traditional science Paradigm	Design science
Research approach	Deductive Inductive	Inductive
Research method/choice	Qualitative Quantitative Mixed Method	Mixed Method
Research strategy	Experiment Survey Case study Grounded theory Ethnography Archival research Action Research	Case study
Time Horizon	Longitudinal Cross sectional	Cross sectional

APPENDIX C: Research Tools and Techniques

Research Tools and Techniques		
Data collection Tools	Questionnaires Interview Observations Literature review Focus groups Expert reviews	Questionnaires Literature review Focus groups Expert reviews
Sampling	Convenience sampling Snowball sampling Purposeful sampling Quota sampling Simple random sampling Systematic random sampling Stratified sampling Systematic Sampling Cluster sampling	Convenience sampling Purposeful sampling Stratified sampling
Data analysis	Descriptive statistics Inferential statistics Content analysis Hermeneutic analysis Discourse analysis Narrative analysis Framework analysis Thematic analysis	Descriptive statistics Content analysis

APPENDIX D: Data Collection Tools

Research Objective	Data Collection Tool
To determine the degree to which Engineering faculties in SA are accommodating VILs.	• Focus groups of VILs • Questionnaires • Literature review
To identify the challenges that VILs in SA face when contemplating entry into Engineering courses.	• Focus groups of VILs • Questionnaires • Literature review
To identify which current ICT tools can be adopted to better facilitate the entry of VIL into Engineering courses.	• Literature review
To develop a framework to effectively use these ICT tools to benefit VILs in Engineering education in SA.	• Focus groups • Questionnaires • Literature review
To evaluate this framework by field experts so as to establish its validity and refine its suitability.	• Expert reviews

APPENDIX E: Focus Group Questions

Introduction by facilitator

Good morning and welcome to our session. Thanks for taking the time to join us to talk about your opinions and feelings about Engineering courses in South African universities. My name is Sheethal Liz Tom. I am currently enrolled for a PhD in IT at Central University of Technology, Free State. My study is to develop a framework for the provision of Visually Impaired learners (VILs) in Engineering Education using ICTs in South Africa. I would like to know about your perceptions of tertiary education, your feelings and opinions on taking Engineering courses at university level. Engineering courses can include civil Engineering, mechanical Engineering, electrical Engineering, computer systems Engineering and IT. Your views will be very valuable in formulating guidelines to improve the teaching learning process at the university. We are having discussions like this with several groups in your school.

There are no wrong answers but rather differing points of view. Please feel free to share your point of view even if it differs from what others have said. Keep in mind that we're just as interested in negative comments as positive comments, and at times the negative comments are the most helpful. This session is completely voluntary; you may withdraw from this session at any point when you decide so. I hope you will be comfortable speaking honestly and sharing your ideas with us. This session will take approximately an hour and half and please note that this session will be recorded to ensure that we adequately capture your ideas during the conversation. The session will be recorded manually using a digital recorder. My research assistant will be assisting me in recording the data (Introduce the research assistant). You may be assured of complete confidentiality. We will not use any names in our reports. Do you have any questions before we begin?

1. Can you please tell me what grade are you in?
2. Do you think that every high school student in South Africa should aspire to a college degree? Why or why not? Why is it important for a VIL to go to college?
3. What are your current career goals?

4. What factors may influence your decision to choose a particular tertiary institution?
5. a) Do you have career guidance from school?
   b) If yes, is it the teacher or career guidance advisor?
   c) What kind of career advice have you received?
6. Is anyone of your peers interested in choosing Engineering at university level?
7. What may help to interest you in an Engineering course?

To obtain the perceptions of Visually Impaired Learners regarding the provision of entry into tertiary institutions, especially to Engineering courses We just want to emphasize again that we refer to Engineering as including civil Engineering, mechanical Engineering, electrical Engineering, computer systems Engineering and IT. So the following questions will be about Engineering courses.

8. Do you feel that you might struggle to complete an Engineering course? Explain.
9. What are the factors that might hinder you from choosing Engineering?
10. What do you think should be in place at a university to offer Engineering to VIL?
11. a) Are you frightened by the thought of going to a university?
    b) If yes, why?
12. What are your suggestions that could help alleviate these obstacles and make you feel more comfortable on campus?
13. Have you given thought to attending any university in South Africa? If yes, which one and why?
14. Have we missed anything? Any other issues that I have missed?

APPENDIX F: Questionnaire-Special school educators

Questionnaire for educators at special schools

My name is Sheethal Liz Tom. I am currently doing my PhD at Central University of Technology.The title of my thesis is:"A framework for the adoption and effective use of ICTs for visually impaired learners in higher education ". The main aim of this study is to develop a framework for the provision of visually impaired learners (VILs) in engineering education in South Africa using ICTs . Engineering courses can include civil engineering, mechanical engineering, electrical engineering, computer systems engineering and IT. The main aim of this questionnaire is to collect perceptions and opinions of educators regarding the provision of VILs in tertiary institutions, especially engineering courses. Your views will be very valuable in formulating guidelines for the provision of VILs in the university.

This questionnaire will take approximately 30 minutes to complete. This questionnaire is completely voluntary; you may withdraw from answering this questionnaire at any point if you decide to do so. You may be assured of complete confidentiality. Your responses will be anonymous. Thank you so much for taking the time to answer this questionnaire and your cooperation is highly appreciated.

PART A: BACKGROUND INFORMATION

1. **Gender**

   Mark only one oval.

   - Male
   - Female

2. **Age Group**

   Mark only one oval.

   - 20-24 yrs.
   - 25-29 yrs.
   - 30-34 yrs.
   - 35-39 yrs.
   - 40-44 yrs.
   - 45-49 yrs.
   - 50 yrs. and above

3. **Race**

   Mark only one oval.

   - African
   - White
   - Coloured
   - Indian
   - Asian

4. **Home Language**
Mark only one oval.

- Afrikaans
- English
- Ndebele
- Northern Sotho
- Southern Sotho
- Swati
- Tsonga
- Tswana
- Venda
- Xhosa
- Zulu

5. **Years of experience in teaching**
Mark only one oval.

- 0-2 yrs.
- 2-4 yrs.
- 4-6 yrs.
- 6 yrs. and above

6. **How long have you been involved in educating VILs?**
Mark only one oval.

- 0-2 yrs.
- 2-4 yrs.
- 4-6 yrs.
- 6 yrs. and above

PART B: CURRENT TEACHING STRATEGIES USED IN SPECIAL SCHOOLS

7. **As a teacher yourself, what role should a teacher play in the development of VILs?**

8. **How does visual impairment affect learning?**

9. **Have you received any training in teaching VILs?**
Mark only one oval.
- Yes
- No

10. **How long was the training?**
Mark only one oval.
- 1-2 months
- 2-4 months
- 4-6 months
- 6 months-1 yr.
- 1 yr. and above

11. **Do think the training you received was effective?**
Mark only one oval.
- Yes
- No

12. **If no,please explain**

13. **Which subject(s) are you offering?**
Check all that apply.

- [ ] Afrikaans
- [ ] English
- [ ] Business Studies
- [ ] Consumer Studies
- [ ] CAT
- [ ] Mathematics
- [ ] Mathematical Literacy
- [ ] Economics
- [ ] Accounting
- [ ] Physical Science
- [ ] Life Science
- [ ] History
- [ ] Life Orientation
- [ ] Sotho
- [ ] Tswana

14. **Rate the following subjects in terms of the levels of difficulty for VILs?(1-most difficult,15-least difficult)?**
Mark only one oval per row.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Afrikaans															
English															
Business Studies															
Consumer Studies															
CAT															
Mathematics															
Mathematical Literacy															
Economics															
Accounting															
Physical Science															
Life Science															
History															
Life Orientation															
Sotho															
Tswana															

15. **Do VILs take the same examination as mainstream schools?**
Mark only one oval.

- ( ) Yes
- ( ) No

16. **If no,please explain.**

17. **Do VILs in special schools follow the same curriculum as mainstream schools?**
Mark only one oval.

- Yes
- No

18. **If no,please explain.**

19. **Do you think that the standard of education of VILs at school assists them in entering tertiary education?**
Mark only one oval.

- Yes
- No

20. **If no,please explain.**

21. **What teaching methodologies (speech delivery, arrangement of classroom, preparation of handouts...etc.) do you follow to assist VILs?**

22. **What technologies (Audio Books, Braille, Slate and Stylus ...etc.) do you use to assist VILs?**

23. **How do you assess the level of visual impairment in your students?**

24. **Based on your assessment, which technologies do you use for the different levels?**

25. **How are assessments and evaluations for VILs done at special schools?**

26. **Do you think that the assessment method can be improved?**
Mark only one oval.

- Yes
- No

27. **If yes,please explain.**

28. **Are there initiatives taken to improve your skills to teach VILs?**
Mark only one oval.

- Yes
- No

29. **If yes,please explain.**

____
____
____
____
____

PART C: OPINIONS AND CONCERNS OF EDUCATORS REGARDING THE PROVISION OF VILs IN TERTIARY INSTITUTIONS ESPECIALLY ENGINEERING COURSES

30. **Are you concerned about the preparedness of your students for tertiary education?**
Mark only one oval.

- Yes
- No

31. **If yes,why?**

____
____
____
____
____

32. **Do you know the criteria for the students to be able to enter university?**
Mark only one oval.

- Yes
- No

33. **If yes,please indicate the criteria followed.**

____
____
____
____
____

34. **In your opinion, how many of your students pursue tertiary education after completing high school education?**
Mark only one oval.

- ◯ Less than 5% of VILs
- ◯ 5-10% of VILs
- ◯ 10-20% of VILs
- ◯ 20-30% of VILs
- ◯ 30-40% of VILs
- ◯ 40-50% of VILs
- ◯ More than 50% of VILs

35. **In your opinion, what could be the cause for this low number?**

36. **Have your alumni students ever complained about the struggles they face at university?**
Mark only one oval.

- ◯ Yes
- ◯ No

37. **If yes,please indicate the complaints they have shared.**

The questions that follow are questions on engineering courses at a university. Engineering courses can include civil engineering, mechanical engineering, electrical engineering, computer systems engineering and IT.

38. **Do you think that VILs should consider engineering course? Please explain.**

39. **Do you know of any universities that specifically provide for the needs of VILs in an Engineering course?**

Mark only one oval.

- ( ) Yes
- ( ) No

40. **If yes,please explain.**

41. **In your opinion, what should the university do in order to accommodate VILs in engineering?**

42. **What suggestions would you like to provide to the universities for effective learning and teaching of VILs in Engineering /IT courses?**

43. **Is there any other comment, question or thought that you would like to raise in this regard?**

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APPENDIX G: Questionnaire-Disability Units at South African universities

Questionnaire for disability units at South African universities

My name is Sheethal Liz Tom. I am currently doing my PhD at Central University of Technology.The title of my thesis is:"A framework for the adoption and effective use of ICTs for visually impaired learners in higher education ". The main aim of this questionnaire is to identify the challenges that VILs in South Africa face when contemplating entry into higher education , especially in engineering courses.Your views will be very valuable in formulating guidelines for the provision of VILs in the university.

This questionnaire will take approximately 30 minutes to complete. This questionnaire is completely voluntary; you may withdraw from answering this questionnaire at any point if you decide to do so. You may be assured of complete confidentiality. Your responses will be anonymous. Thank you so much for taking the time to answer this questionnaire and your cooperation is highly appreciated.

* Required

PART A: BACKGROUND INFORMATION

1. **Gender** *

Mark only one oval.

- Male
- Female

2. **Age Group** *

Mark only one oval.

- 20-24 yrs.
- 25-29 yrs.
- 30-34 yrs.
- 35-39 yrs.
- 40-44 yrs.
- 45-49 yrs.
- 50 yrs. and above

3. **Race** *

Mark only one oval.

- African
- White
- Colored
- Indian
- Asian

4. **Home language** *

Mark only one oval.

- English
- Sotho
- Afrikaans
- Tswana
- Swati
- Zulu
- Ndebele
- Xhosa
- Venda

5. **University** *

Mark only one oval.

- University of Cape Town
- University of Fort Hare
- University of the Free State
- University of KwaZulu-Natal
- University of Limpopo
- North-West University
- University of Pretoria
- Rhodes University
- University of Stellenbosch
- University of the Western Cape
- University of the Witwatersrand
- Cape Peninsula University of Technology
- Central University Of Technology
- Durban University of Technology
- Tshwane University of Technology
- Vaal University of Technology
- University of Johannesburg
- University of South Africa
- Nelson Mandela University
- Walter Sisulu University

6. **How long have you been involved in working for the disability unit?** *

Mark only one oval.

- 0-2 yrs.
- 2-4 yrs.
- 4-6 yrs.
- 6 yrs. and above

PART B: BACKGROUND INFORMATION-DISABILITY UNITS

7. Give us a brief background on what the disability unit does *

8. How many students with special needs do you cater for per year in your university? *

9. How many VILs do you cater for per year in your university? *

10. How many VILs do you cater for per year in your university for engineering? *

11. From the number indicated in (a) how many VILs were interested in doing engineering? *

PART C: CHALLENGES VILs FACE IN HIGHER EDUCATION

12. Which resources do you have in place for the provision of VILs? *

13. Which resources do you have in place for the provision of VILs in engineering? *

14. **Do you support VILs to do engineering?** *

Mark only one oval.

- Yes
- No

15. **If no,please explain.**

16. **What courses do you usually recommend to VILs? Why?** *

17. **What courses do you recommend when the VIL has a desire to do engineering? Why?** *

18. **In your opinion, do you think that VILs find engineering challenging? If so, why?** *

19. **What are the factors that hinder VILs in pursuing engineering?** *

20. **If the above mentioned resources were in place, would you still recommend VILs to take engineering?** *

Mark only one oval.

- Yes
- No

21. **If no,please explain.**

PART D: FUNCTIONING OF DISABILITY UNITS

22. **What are the challenges faced by the disability unit to assist VILs?** *

23. **What percentage of VILs approach the disability unit if they need assistance?** *

24. **What could be the reasons for some VILs not approaching the disability unit?** *

25. **For teaching VILs, which of the following do you recommend?** *

Check all that apply.

- [ ] Training of current lecturers in the university
- [ ] Recruit special lecturers for VILs

26. **What resources are used in the university to assess VILs?** *

27. **Are you collaborating with disability units of other universities?** *
Mark only one oval.

- Yes
- No

28. **If yes,please mention the universities**

29. **Are the other disability units cooperative?** *
Mark only one oval.

- Yes
- No

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APPENDIX H: Questionnaire-HODs and senior lecturers at Engineering faculties of South African universities

Questionnaire for head of departments and senior lecturers in the Faculty of Engineering at South African universities

My name is Sheethal Liz Tom. I am currently doing my PhD at Central University of Technology, Free State. The title of my study is "A framework for the adoption and effective use of ICT's for visually impaired learners in higher education". The main aim of this questionnaire is to determine the degree to which engineering faculties in South Africa are accommodating visually impaired learners and to identify the challenges that visually impaired learners in South Africa face when contemplating entry into engineering courses in South Africa. Your views will be very valuable in formulating guidelines for the provision of visually impaired learners in the university.

This questionnaire will take approximately 30 minutes to complete. This questionnaire is completely voluntary; you may withdraw from answering this questionnaire at any point if you decide to do so. You may be assured of complete confidentiality. Your responses will be anonymous. Thank you so much for taking the time to answer this questionnaire and your cooperation is highly appreciated.

* Required

PART A:BACKGROUND INFORMATION

1. **Gender** *

Mark only one oval.

- ◯ Male
- ◯ Female

2. **Age Group** *

Mark only one oval.

- ◯ 25-29 yrs.
- ◯ 30-34 yrs.
- ◯ 35-39 yrs.
- ◯ 40-44 yrs.
- ◯ 45-49 yrs.
- ◯ 50 yrs. and above

3. **University** *

Mark only one oval.

- University of Cape Town
- University of Fort Hare
- University of Free State
- University of KwaZulu-Natal
- University of Limpopo
- North-West University
- University of Pretoria
- Rhodes University
- University of Stellenbosch
- University of the Western Cape
- University of the Witwatersrand
- Cape Peninsula University of Technology
- Central University of Technology
- Durban University of Technology
- Tshwane University of Technology
- Vaal University of Technology
- University of Johannesburg
- University of South Africa
- Nelson Mandela University
- Walter Sisulu University

4. **Department** *

Mark only one oval.

- Civil Engineering
- Electrical, Electronic & Computer Engineering
- Mechanical & Mechatronic Engineering
- Built Environment
- Information Technology
- Industrial & Systems Engineering
- Chemical Engineering
- Aeronautical engineering
- Material Science & Metallurgical Engineering
- Mining engineering
- Mathematical & Physical Sciences
- Architecture and Planning
- Construction Economics and Management
- Biomedical Engineering
- Environmental Engineering
- Process Engineering
- Geomatics/Land Surveying
- Other: ______________________

5. **Years of experience in teaching** *

Mark only one oval.

- 3-6 yrs.
- 6-9 yrs.
- 9-12 yrs.
- 12 yrs. and above

6. **Do you have a teaching qualification (e.g. PGCE)?** *

Mark only one oval.

- Yes
- No

7. **If yes,please mention.**

Start this form over.

PART B: VIEWS ON ACCOMMODATING VILs IN HIGHER EDUCATION

According to the 2016 statistics, about 6% of VILs are in the age group of 5-17 yrs. (school goers). In South Africa these school goers are accommodated in special schools which are present in each province. Current research indicates that these VILs are not being accommodated in universities, and especially son in engineering courses. Please give your opinions and perceptions on the following questions.

8. **Currently, are you accommodating any VILs in your department? Please explain** *

9. **How many VILs do you have in your department?** *

10. **Please give your options and perceptions on the following statements which will be measured on 4-point scale, from strongly agree to strongly disagree:** *

Mark only one oval per row.

	Strongly agree	Agree	Disagree	Strongly disagree
There are few VIL engineers in South Africa.	◯	◯	◯	◯
Universities should accommodate VILs.	◯	◯	◯	◯
My department is equipped with proper resources to educate VILs.	◯	◯	◯	◯
My department is prepared to accommodate VILs.	◯	◯	◯	◯
Proper training is provided to staff in my department in order to educate VILs.	◯	◯	◯	◯
The current curriculum is challenging for VILs.	◯	◯	◯	◯
Computer literacy should be a prerequisite for students with visual impairments to succeed in most engineering courses.	◯	◯	◯	◯
VILs are prepared for tertiary education.	◯	◯	◯	◯

PART C: CURRENT TEACHING STRATEGIES IN UNIVERSITIES

11. **As an academic yourself, what role should an academic play in the development of VILs?** *

12. **How does visual impairment affect learning?** *

13. **What subject are you offering in your department?** *

14. **What modules do you offer that will be challenging to VILs?** *

15. **Why would these modules prove challenging?** *

16. **What teaching methodologies do you think should be used to assist VILs?** *

17. **Which of these identified methodologies are you currently using, if any?** *

18. **What type of educational technologies could be used to assist VILs?** *

19. **Which of these identified technologies are you currently using, if any?** *

20. **What assessment strategies may be used to assist VILs?** *

21. **Which of the identified strategies do you use, if any?** *

22. **How do you assess the level of visual impairment (partially sighted learners, moderately blind learners, severely blind learners, completely blind learners) in your students?** *

23. **Based on your assessment, which technologies do you use for the different levels(partially sighted learners, moderately blind learners, severely blind learners, completely blind learners)?** *

24. **What can be done by your department in order to accommodate VILs?** *

PART D: CHALLENGES VILs FACE IN UNIVERSITIES

25. **In your observation, what are the current challenges that the VILs are facing in the university?** *

26. **In your opinion, what could be the reason for minimal intake of VILs in engineering courses at universities?** *

27. **For my department, to accommodate VILs would require:** *
Mark only one oval.
- Too much time
- More resources (Trained lecturers, equipment, infrastructure etc.)
- Inclusivity
- Financial expenses

28. **What suggestions would you provide to universities for effective learning and teaching of VILs in Engineering courses?** *

29. **Is there any other comment, question or thought that you would like to raise in this regard?** *

APPENDIX I: Questionnaire-Framework Evaluation by Experts

FRAMEWORK EVALUATION TOOL FOR EXPERTS

This tool has been designed for experts to validate the proposed framework for the provision of visually impaired learners (VILs) in engineering education. The main purpose of this evaluation tool is to assess the proposed framework. Additionally, it aims to gather the factors that might influence the effective teaching and learning of VILs in South African universities. Your views will be very valuable in formulating guidelines for the provision of VILs in engineering.

This questionnaire will take approximately 30 minutes to complete. This questionnaire is completely voluntary; you may withdraw from answering this questionnaire at any point if you decide to do so. You may be assured of complete confidentiality. Your responses will be anonymous. Thank you so much for taking the time to answer this questionnaire and your cooperation is highly appreciated. If there are any questions, please contact the research candidate by email at sheethalliztom@gmail.com

* Required

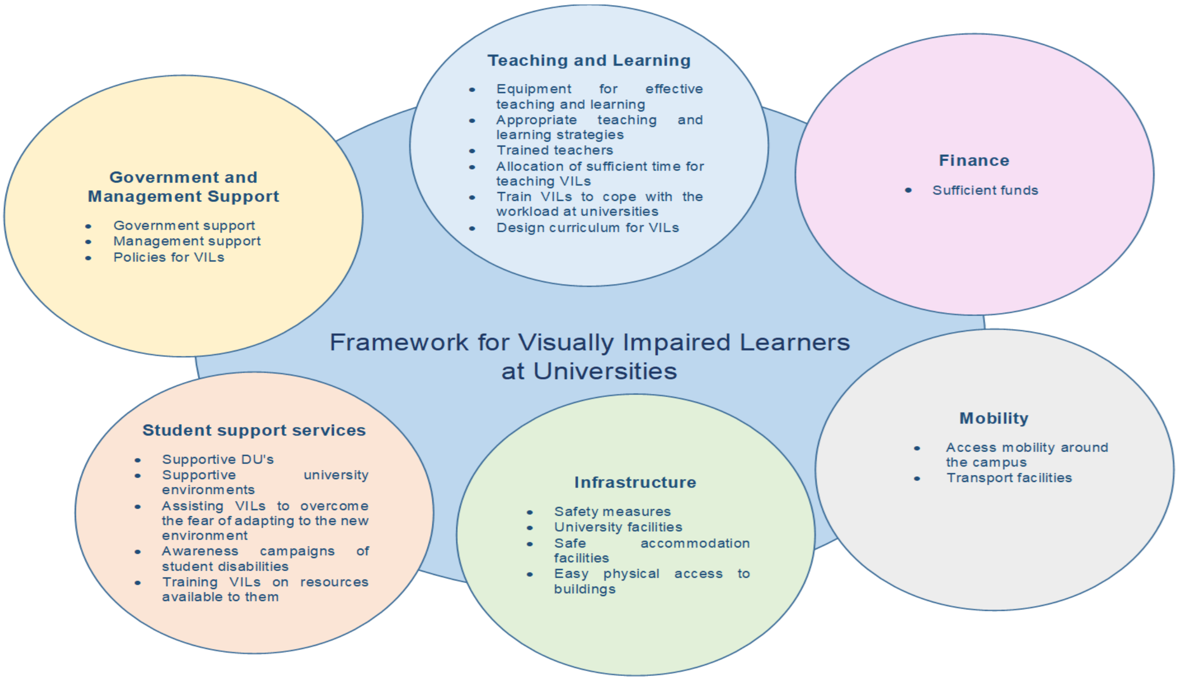
INSTRUCTIONS

There are 5 parts to this tool (Part A-C). Part A is designed to collect your biographical information and the aim of Part B is to assess and evaluate the identified factors influencing the successful implementation of the proposed framework along with your valuable inputs and comments. Part C seeks to validate the proposed framework as a whole.

PROPOSED FRAMEWORK

It is a matter of significant concern that learners with disabilities on the African continent face barriers in the education system. In the South African context there is a massive exclusion of disabled children from education (Department of Education, 2001). Despite the development of an inclusive education policy to address this exclusion, there are certain barriers in implementing this policy. There are special schools in South Africa to meet the needs of these disabled students. But it is seen that in South Africa, the number of VILs that pursue tertiary education after schooling is very low. This number dramatically drops if engineering faculty is considered. This study seeks to identify the barriers that VILs face in higher education especially in the engineering stream. Figure 1 presents the proposed framework for the provision of VILs in engineering education.

Figure 1: Proposed framework for the provision of VILs in engineering education



PART A: BACKGROUND INFORMATION

This section of the evaluation refers to background and biological information.

1. Gender *

Mark only one oval.

- Male
- Female

2. Age Group *

Mark only one oval.

- 25-29 yrs.
- 30-34 yrs.
- 35-39 yrs.
- 40-44 yrs.
- 45-49 yrs.
- 50 yrs. and above

3. Race *

Mark only one oval.

- African
- White
- Colored
- Indian
- Asian

4. Field/Position *

5. Years of service *

Mark only one oval.

- 0-2 yrs.
- 2-4 yrs.
- 4-6 yrs.
- 6-8 yrs.
- 8-10 yrs.
- 10 yrs. and above

6. Are you visually impaired? *

Mark only one oval.

- Yes
- No

PART B: FRAMEWORK EVALUATION

Despite the development of an inclusive education policy in South Africa, there still exists a massive exclusion of visually impaired learners in higher education especially in engineering courses. To address these shortcomings, this study puts forward a framework for the provision of visually impaired learners in universities, especially for engineering courses in SA.

Question 1: Which of the following do you perceive as the most important factors to consider in the framework for visually impaired learners in universities? Please rank the following factors in the order of importance (from VERY IMPORTANT to LEAST IMPORTANT)

7. Government and Management Support *

Mark only one oval per row.

	Very Important	Important	Not Important	Least Important
Government Support(eg: ensuring recruitments of staff for VILs, training staff, political commitment to disability issues)	◯	◯	◯	◯
Management Support(create awareness among staff and students to ensure inclusive education, support DUs to assist VILs)	◯	◯	◯	◯
Policies for Visually Impaired learners(eg: disability policies, ICT policies for disabled)	◯	◯	◯	◯

8. Finance *

Mark only one oval per row.

	Very Important	Important	Not Important	Least Important
Sufficient funds(more financial aid to VILs for assistive resources)	◯	◯	◯	◯

9. Infrastructure *

Mark only one oval per row.

	Very Important	Important	Not Important	Least Important
Safety measures(eg: appropriate safety measures in campus especially laboratories)				
University facilities(eg: library services, providing VILs with accessible study materials)				
Safe accommodation facilities				
Easy physical access to buildings (eg: access to buildings should not be inconvenient due to physical barriers like elevators, ramps etc.)				

10. Mobility *

Mark only one oval per row.

	Very Important	Important	Not Important	Least Important
Easy mobility around the campus (eg: proper assistance to manoeuvre in the campus, provide tactile maps to VILs)				
Transport facilities(eg: appropriate transport facilities to the campus so that VILs do not miss their classes)				

11. Teaching and learning *

Mark only one oval per row.

	Very Important	Important	Not Important	Least Important
Equipment for effective teaching and learning(eg: identify and provide VILs with the appropriate assistive tools to assist them in their academic courses)	⬭	⬭	⬭	⬭
Appropriate teaching and learning strategies	⬭	⬭	⬭	⬭
Trained teachers(eg: Provide proper training to the staff so that they are aware about the teaching methodologies that could be used to assist VILs)	⬭	⬭	⬭	⬭
Allocation of sufficient time for teaching VILs(eg: Staff should be allocated sufficient time in their workload so that they can prepare efficiently to teach VILs)	⬭	⬭	⬭	⬭
Train VILs to cope with the workload at universities(eg: Staff should assist Visually Impaired learners to manage their time and effort efficiently as the university curriculum and teaching methodologies are different from what they had in special schools)	⬭	⬭	⬭	⬭
Design curriculum for VILs(eg: Curriculum should be easy to use by everyone regardless of their disabilities and yet be challenging for all students)	⬭	⬭	⬭	⬭

12. Student Support Services *

Mark only one oval per row.

	Very Important	Important	Not Important	Least Important
Supportive Disability units				
Supportive University environment (eg: emotional support from staff, students and management)				
Assisting Visually Impaired learners to overcome the fear of adapting to the new environment(eg: provide assistance and support to Visually Impaired Learners especially first years till they get used with the university environment)				
Awareness campaigns of student disabilities				
Training Visually Impaired learners on resources available to them				

Question 2: Which of the following do you perceive as the most relevant factors to consider in the framework for visually impaired learners in universities? Please rank the following factors in the order of importance (from VERY RELEVANT to LEAST RELEVANT).

13. Government and Management Support *

Mark only one oval per row.

	Very Relevant	Relevant	Not Relevant	Least Relevant
Government Support(eg: ensuring recruitments of staff for VILs, training staff, political commitment to disability issues)	⬭	⬭	⬭	⬭
Management Support(create awareness among staff and students to ensure inclusive education, support DUs to assist VILs)	⬭	⬭	⬭	⬭
Policies for Visually Impaired learners(eg: disability policies, ICT policies for disabled)	⬭	⬭	⬭	⬭

14. Finance *

Mark only one oval per row.

	Very Relevant	Relevant	Not Relevant	Least Relevant
Sufficient funds(more financial aid to VILs for assistive resources)	⬭	⬭	⬭	⬭

15. Infrastructure *

Mark only one oval per row.

	Very Relevant	Relevant	Not Relevant	Least Relevant
Safety measures(eg: appropriate safety measures in campus especially laboratories)	⬭	⬭	⬭	⬭
University facilities(eg: library services, providing VILs with accessible study materials)	⬭	⬭	⬭	⬭
Safe accommodation facilities	⬭	⬭	⬭	⬭
Easy physical access to buildings (eg: access to buildings should not be inconvenient due to physical barriers like elevators, ramps etc.)	⬭	⬭	⬭	⬭

16. Mobility *

Mark only one oval per row.

	Very Relevant	Relevant	Not Relevant	Least Relevant
Easy mobility around the campus (eg: proper assistance to manoeuvre in the campus, provide tactile maps to VILs)	⬭	⬭	⬭	⬭
Transport facilities(eg: appropriate transport facilities to the campus so that VILs do not miss their classes)	⬭	⬭	⬭	⬭

17. Teaching and learning *

Mark only one oval per row.

	Very Relevant	Relevant	Not Relevant	Least Relevant
Equipment for effective teaching and learning(eg: identify and provide VILs with the appropriate assistive tools to assist them in their academic courses)	⬭	⬭	⬭	⬭
Appropriate teaching and learning strategies	⬭	⬭	⬭	⬭
Trained teachers(eg: Provide proper training to the staff so that they are aware about the teaching methodologies that could be used to assist VILs)	⬭	⬭	⬭	⬭
Allocation of sufficient time for teaching VILs(eg: Staff should be allocated sufficient time in their workload so that they can prepare efficiently to teach VILs)	⬭	⬭	⬭	⬭
Train Visually Impaired learners to cope with the workload at universities(eg: Staff should assist VILs to manage their time and effort efficiently as the university curriculum and teaching methodologies are different from what they had in special schools)	⬭	⬭	⬭	⬭
Design curriculum for VILs(eg: Curriculum should be easy to use by everyone regardless of their disabilities and yet be challenging for all students)	⬭	⬭	⬭	⬭

18. Student Support Services *

Mark only one oval per row.

	Very Relevant	Relevant	Not Relevant	Least Relevant
Supportive Disability units	◯	◯	◯	◯
Supportive University environment (eg: emotional support from staff, students and management)	◯	◯	◯	◯
Assisting Visually Impaired Learners to overcome the fear of adapting to the new environment(eg: provide assistance and support to VILs especially first years till they get used with the university environment)	◯	◯	◯	◯
Awareness campaigns of student disabilities	◯	◯	◯	◯
Training Visually Impaired learners on resources available to them	◯	◯	◯	◯

Question 3: From the proposed factors, which factors would you recommend to be removed (not important at all)

19. Government and Management Support *

Mark only one oval.

- ◯ Government Support
- ◯ Management Support
- ◯ Policies for Visually Impaired learners
- ◯ None

20. Which factors would you like to add to Factor 1 and why?

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21. Finance *

Mark only one oval.

- ( ) Sufficient Funds
- ( ) None

22. Which factors would you like to add to Factor 2 and why?

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23. Infrastructure *

Mark only one oval.

- ( ) Safety measures
- ( ) University facilities
- ( ) Safe accommodation facilities
- ( ) Easy physical access to buildings
- ( ) None

24. Which factors would you like to add to Factor 3 and why?

25. Mobility *

Mark only one oval.

- Easy mobility around campus
- Transport facilities
- None

26. Which factors would you like to add to Factor 4 and why?

27. Teaching and learning *

Mark only one oval.

- Equipment for effective teaching and learning
- Appropriate teaching and learning strategies
- Trained teachers
- Allocation of sufficient time for teaching VILs
- Train Visually Impaired learners to cope with the workload at universities
- Design curriculum for Visually Impaired learners
- None

28. Which factors would you like to add to Factor 5 and why?

29. Student Support Services *

Mark only one oval.

- Supportive Disability units
- Supportive university environments
- Assisting Visually Impaired learners to overcome the fear of adapting to the new environment
- Awareness campaign of student disabilities
- Training Visually Impaired learners on resources available to them
- None

30. Which factors would you like to add to Factor 6 and why?

PART C: OVERALL FRAMEWORK EVALUATION

This section of the evaluation presents statements to validate the framework as a whole.

31. a) The framework is: *

Mark only one oval per row.

	Strongly Agree	Agree	Disagree	Strongly Disagree
Efficient	⬭	⬭	⬭	⬭
Operational	⬭	⬭	⬭	⬭
Well designed and relevant	⬭	⬭	⬭	⬭
Applicable	⬭	⬭	⬭	⬭
Would meet the needs of visually impaired learners	⬭	⬭	⬭	⬭
Is a step towards the successful provision of visually impaired learners in engineering	⬭	⬭	⬭	⬭
Useful and valuable	⬭	⬭	⬭	⬭
Adaptable and customisable	⬭	⬭	⬭	⬭
Requires a lot of improvement	⬭	⬭	⬭	⬭

32. b) What are your overall perceptions of the framework? *