LEARNING OF MECHANICAL SYSTEMS IN GRADE 9 TECHNOLOGY CLASSROOM BY DEAF LEARNERS IN KWAZULU-NATAL: AN EXPLORATION OF A LEARNING OF TECHNOLOGY IN A NON-HEARING ENVIRONMENT

By

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ABSTRACT

The purpose of this study was to explore the learning of Mechanical Systems in a Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal. The study focused on how Technology is learned in a non-hearing environment, considering the nature of Technology and the interdisciplinarity between Technology and Mathematics. This is a case study set within an interpretive paradigm. Since there were five Deaf learners constituting the Grade 9 Technology class, all were considered to be participants in this study. A blended learning model (BLM) was identified as the theoretical framework for this study. BLM is foregrounded on cognitive and social constructivism, with an intention to explore the learning of Mechanical Systems in a non-hearing environment.

The data collection schedule included the following methods:

- Classroom observation;
- Document analysis; and
- Semi-structured interviews.

The results of this research were analysed qualitatively in order to adhere to the principles of the interpretive paradigm.

The research findings of this study highlighted that Deaf learners' previous experience limited their exposure to daily practices, resulting in misunderstanding of concepts in Mechanical Systems. Furthermore, the results showed effectiveness of demonstrations and simulations in enhancing the comprehension of concepts in Mechanical Systems.

The findings of my study concur with Piaget's view that the comprehension of a child is enhanced when learning is made concrete to them. Deaf learners' participation in Technology activities assisted them to develop an understanding of concepts in Mechanical Systems, and facilitated effectiveness of interdisciplinarity in scientific subjects.

DECLARATION

I, Bhekisisa Maxwell Thabethe, declare that **"Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal: An exploration of a learning of Technology in a non-hearing environment"** is my own work and that all of the sources I have consulted, have been indicated. Sources are acknowledged by means of complete references.

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DEDICATION

This thesis is dedicated to my family and my Bishop SE and DB Cele, my loving wife Lethubuhle Evidence Thabethe and my children Melinda, Mxolisi, Sbusiso, Sthembiso, Phumelele, Lungelo and Sphephelo.

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ABBREVIATIONS

ANA	Annual National Assessment
BLM	Blended Learning Model
CAPS	Curriculum and Assessment Policy Statement
C2005	Curriculum 2005
DoBE	Department of Basic Education
DoE	Department of Education
ECD	Early childhood development
FET	Further Education and Training
GET	General Education and Training
HET	Higher Education and Training
KZN	KwaZulu-Natal
MA	Mechanical Advantage
NCS	National Curriculum Statement
OBE	Outcomes-Based Education
PhD	Doctor of Philosophy
RNCS	Revised National Curriculum Statement
SASL	South African Sign Language
TT	Teaching Team
UK	United Kingdom

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS

CHAPTER 2: Literature review

CHAPTER 3: Theoretical Framework

CHAPTER 4: Research design and methodology

CHAPTER 5: Presentation and discussion of data

CHAPTER 6: Data analysis

CHAPTER 7: Findings

CHAPTER 8: Conclusion and recommendations

APPENDICES

CHAPTER 1

Introduction

1.1 Contextual information9

Technology was recognized in 1997 as an official subject in the school curriculum in South Africa (Chapman, 2002) It was made compulsory and packaged with Mathematics and Science as gateway subjects (DoBE, 2011). While Technology was implemented, the Technology curriculum identified 10 unique features aimed at awarding learners an opportunity to obtain and apply knowledge and skills in a reasonable way. One of them is the ability 'to deal with inclusivity, human rights, social and environmental issues in their tasks' (DoBE, 2011, p. 9). Both inclusivity and human rights cater for the participation of female learners and learners with different disabilities in Technology. This endeavor is entrenched in Section 29(1)a and 29(2)a and b of the Constitution of South Africa in Act 108 of 1996 (Right to basic Education).. The foreground of this was on exploring the "Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal".

Deaf learners in a Grade 9 Technology classroom were selected because 1) their learning has been mediated through Sign Language for about 8 years or more and 2) they are at the exit point to their career choices in the FET band. With Deaf learner's education, learning is not different from the way in which verbal language is used. For effective learning purposes:

> 'The language programme is integrated into all other learning areas and Sign Language is used across curriculum. Many of the Observing and Signing Language Skills will be developed within Mathematics and Life Skills, which is made up of many subjects such as, Creative Art and Beginning Knowledge including Personal and Social Well-being, Natural Science and Technology and Social Sciences'. (DoBE, 2014, p, 8).

For that matter, Deaf learners are expected to participate in the Technology curriculum inclusively. But Deaf learners are using visual-spatial language to decode and encode information for cognitive functioning as opposed to verbal language that is commonly used in the mainstream curriculum. The focus of this study is on exploring "Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal".

More research that influence proper implementation of Technology has been conducted but not much research has been done to address issues of Deaf learners pertaining to their teaching and learning. Commonly, the school curriculum is designed by hearing stakeholders who did not consult Deaf learners who depend on a mono encoding mode of learning. Deaf learners are using vision to encode information and hands to communicate their ideas in the process of learning.

1.2 Problem statement

The Annual National Assessments (ANA) results in 2013 indicated an underperformance among Grade 9 learners throughout the country, with an average pass rate of 11% in Mathematics (DoBE, 2014). Deaf learners are compeled to write the same examination in all common assements, and their results were even lower. In the light of Mathematics being the creative part of human activities, Mathematics is aimed at enhancing logical and critical thinking, accuracy and problem-solving used in the design process of Technology (DoBE, 2011). Hence this study sought to explore the learning of Mechanical Systems in a non-hearing environment with the purpose of exploring the learning of Technology in a non-hearing environment. Grade 9 was purposely chosen for this research because learners were at the verge of choosing Further Education and Training (FET) streams targeted at their world of work

1.3 Purpose of the study

The school curriculum was crafted by stakeholders who did not put into place the acknowledgement of challenges faced by Deaf learners which differs from learners who are able to see and hear information simultaneously. As part of the inclusion process, Technology teacher as well as the Sign Language interpreter had the responsibility for the teaching of the content in Technology. Deaf learners depend only on Sign Language to discus and communicate their Technology ideas. Hence the mediation of the conception and/or misconception entailed two steps:

- The explanation of the Technology content by the subject teacher using verbal language, and
- The interpretation of this mediation by the Sign Language interpreter who is not a specialist in Technology.

For that matter, the project wants to explore the experiences of Deaf learners in the Technology mainstream curriculum. Moreover this study is aimed at understanding the experiences of Deaf learners that influence their participation in Mechanical Systems and investigate how the use of Sign Language inform and influence their understanding.

1.4 Significance of the study

The projection of this study is to contribute to the debates and research on challenges facing the inclusion of diverse disabilities in the mainstreaming Technology curriculum. In particular, this study will provide insights of the challenges faced by Deaf learners who are learning Technology. Teachers have a role to embrace all necessary aspects of Technology in their teaching practice. It will assist them in understanding the needs of Deaf learners' experiences in relation to curriculum expectations. The understanding of learning experience in the Deaf classroom can enhance effective classroom practice in the Technology classroom by Deaf learners. Furthermore, this study will benefit teachers in Deaf schools, curriculum developers and researchers involved in Technology curriculum development.

1.5 Thesis, delineation and research question

This study took place at the Deaf School. This is a special school located in Newlands in Durban, KwaZulu-Natal (KZN) province. The school is an endeavour to provide disabled people with reasonable education that would address the challenges of Deaf learners. The original vision of education planners at the time was to develop learners that live a life of service and contribution to the quality of life that all South Africans could enjoy; provide them with a school that is safe, challenging and exciting; and ensure well-rounded scholars who could take their place with confidence and dignity in any institution of their choice.

The school has 90 staff members with 38 full-time teachers, 7 - 15 learners per teacher, and 320 Deaf and hard-of-hearing learners. The school participates in inclusive education within the mainstreaming curriculum programmes and they are required to write the same national assessments as all other learners in the system. In the light of the participation I witnessed, I intended to address the research topic "**Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal. An exploration of a learning of Technology in a non-hearing environment".** The investigation of this study is influenced by the two critical questions:

1. **What are the experiences of Deaf learners in learning Mechanical Systems?**
2. **What is the role of Sign Language in learning Mechanical Systems?**

1.6 Motivation for the study

In the process of developing Technology curriculum, one of the critical outcomes in Technology encourages learners to "communicate effectively using visual, symbolic and/or language skills in various mode" (DoBE, 2011, p. 5). Learning of Technology requires symbolic representation of concepts used in mechanisms of different machines. Whilst visual tools are used to demonstrate mechanisms and supplement the theory therein, not much is known about experiences that Deaf learners bring to Technology classroom. Apart from knowing experiences that Deaf learners bring to class, not much is known about the values of using Sign Language to mediate Technology concepts in a Technology classroom.

A motivation to conduct this study is that Mechanical Systems adheres to the interdisciplinarity of scientific subjects with a foreground in Mathematics and language competency (National Research Council, 1999). Considering that the standard of Mathematics among learners in South Africa is generally poor, problems may be exacerbated by the encoding deficiency that necessitates the dependency on Sign Language as a language of instruction. This study will be conducted at a school where hearing-impaired learners from various regions in KZN receive their schooling. This study will provide a platform for identifying Deaf learners' needs inclusively with a high consideration of adequate Technology curriculum (critical outcomes and unique features).

Findings of the study may influence the crafting of resolution that will encourage and motivate Deaf learners to participate in Technology with purpose and consciouseness;

1.7 Rationale

My teaching experience is above twelve years, teaching Technology, Mathematics and Science in the senior phase and FET phase. Since Technology curriculum was in developmental stages in 2002, I needed a rounded knowledge in Technology that was not influenced by any biasness from other sciences. I developed myself by acquiring Advanced Certificate in Education (ACE). I am partially sighted with a condition of Albinism. This condition provides an experience of limitation in learning. In my learning experience, most of my learning was through listening and imaginations since my teachers/lecturers were used to teaching learners/students with normal vision. In my Technology teaching experience, I observed that Technology required an enhanced understanding of concepts of Mathematics and Science. Moreover the theoretical aspect of Technology compelled learner participation to complement a practical side of the learning area (Technology) in the form of capability task. A lot of communication, accommodation and participation in a Technology classroom is required to enhance technology literacy in learners. Technology literacy engages learners in technology design by developing capacities and skills needed to create solutions in response to real life challenges. However not much research has been done to explore the inclusion of learners with different disabilities in Technology. My visual challenge led me to think about challenges faced by learners who are struggling to hear clearly and/or at all. Thus my experiences in learning and teaching Technology led me to the quest of wanting to explore the "Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners".

1.8 Definition of key concepts

The following concepts will be used consistently in the study. A researcher will explore the topic "An exploration of the learning of Mechanical Systems in a non-hearing environment" with reference to the meaning and understanding of these concepts.

1.8.1 Inclusive education

Inclusive education refers to a common curriculum approach aimed at teaching diverse learners within the same vicinity, without compromising the standard of education (Engelbrecht, 2006; Landorf & Nevin, 2007). Inclusive education focuses on the quality of education that produces competent learners without separating learners with special needs from learners without special needs. This approach rejects the notion of special schools/classrooms and advocate for accommodation of all learners reasonably.

1.8.2 Mainstreaming

Mainstreaming in education refers to an idea of providing a common curriculum to learners of diverse populations in an ordinary classroom (Squires, 2005). It is the development of an inclusive approach to education targeted at increased participation in learning though the process of addressing and responding to the diverse needs of all learners that reduces exclusion (Engelbrecht, 2006).

1.8.3 Disability

Disability means a multidimensional concept that identifies a health condition of a person beyond a medical condition (Connor, 2008). It is a physical or a mental condition that suggests that somebody cannot use part of his/her body completely or easily. It provides a limitation to the functionality and activities of a person based on physical, communication, intellectual, or sensory impairment experienced in daily life (Connor 2008).

1.8.4 Language

Language is an instrument of communication used to express the inner thoughts and emotions of an individual to other people. Language is a method of interaction between human beings, either in written or spoken words (Jakobson, 2007). Language consists of a vocabulary that depicts the literacy level of a particular community through the systematic use of symbols, and is a way of expressing emotions in a comprehensive manner.

1.8.5 Sign Language

Sign Language is a silent instrument of communication that uses gestures to express ideas (Reagan, 2008). Communication in Sign Language is visual. Sign Language is used to accommodate visual communities to all human activities in their society reasonably (Ogilvy-Foreman, Penn, & Reagan, 1994; Penn & Reagan, 1994; Reagan, 2008). Our country adopted SASL to be used as an official language for visual communities. Furthermore it is effectively used to teach the content and literacy skills in spoken languages (DoBE, 2014).

1.8.6 Technology

Technology is defined as the "use of knowledge, skills, values and resources to meet peoples' needs and wants by developing practical solutions to problems, taking social and environmental factors into consideration" (DoBE, 2011). Technology utilises scientific knowledge about the natural world to produce new knowledge from the perspective of design (McCade, 2006; Parkin et al., 2010; Thabethe, 2012). Effective participation to Technology ensures technological literacy to learners that provides opportunities for solve real life problems.

1.8.7 Mathematics

Mathematics is the study of handling numbers, quantities and/or shapes that involves calculations. It is a field of study that is purely driven by knowledge of the subject matter. Learning of Mathematics should expose learners to the world of work by applying the mathematical concepts they learn in class, and make them perceive themselves as citizens of a country with certain obligations to the world of work into which they need to fit after school and be aware of themselves in relation to other people (Ernest, 1989). Mathematics pedagogy allows students to develop personal roles in active learning strategies and in their own assessment procedures, where solutions are not conceived as perfectly true but in terms of viability, depending on the constraints of a problem. The socio-cultural perspective of Mathematics instruction encourages the teacher to link history, culture and community activities to concepts and skills in an integrated whole.

1.8.8 Design

Engelbrecht (2006) considered design to be a detailed plan of an object which is verified by a drawing from which it can be built. An object is planned and prepared with all details decided upon. Design entails simulation of an object produced with full details of operation and mechanisms as a typology model of intention (Cowan, 1991). Design is the aspect of Technology through which people produce systems, products, methods and processes by which scientific knowledge is used to depict the existence of the natural world (McCade, 2006).

1.8.9 Simulation

Simulation refers to a situation in which a particular set of conditions is created artificially or on a small, accommodative scale in order to experience something that could exist in reality (Scalese, Obeso, & Issenberg, 2008). In Mechanical Systems, a manageable situation is created to emulate mechanisms of big projects. This situation demonstrates a relationship between the input and output mechanisms, and allows the representation of this mechanism as a ratio.

1.8.10 Modelling

Modelling means to display the real-world objects in a form of graphical communication, mathematically and animation (Gila, 2007). Modelling provide an observable representation of a system that enhance the understanding in complex situations.

1.9 Organisation of the thesis

Chapter 1

This chapter provides an overview to this study, drawing from the rationale of the study, objectives, problem statement, significance of the study and the definitions of key concepts pertaining to this study. It also provides a brief review of chapters.

Chapter 2

Related literature is reviewed in the light of policy issues that influence curriculum delivery. This literature highlights the rationale for considering Technology as a tool for economic emancipation. This section also foregrounds the essence of Technology literacy envisaged by the curriculum in mainstream education, with a great emphasis on the interrelationship between Technology and Mathematics concepts. Numeration development, Mathematics language, interdisciplinary and advanced learning for competent thinking is made fundamental to the learning of Technology and Mathematics subjects. Contribution of language to education and a reduced learning opportunity for Deaf children in South Africa is contested. This chapter looks at related studies conducted with Deaf children in developed countries. Ultimately, it looks at morphisms.

Chapter 3

The researcher introduces the theoretical framework that underpins this study. A blended learning model (BLM) is used to guide data collection and data analysis. BLM is highly influenced by cognitive and social constructivism encapsulated in constructivism as a theory of learning. Types of learning are provided to benchmark a learning of Mechanical Systems in a non-hearing environment and a model is provided with its components.

Chapter 4

This chapter underlines the research design and methodology chosen to guide this study. It highlights the research paradigm, research instruments, participants and ethical issues suitable for this study.

Chapter 5

In this chapter the researcher presents data gathered in a Technology Grade 9 Deaf classroom. Different methods of data collection employed in this study are: 1) participant observation, 2) document analysis and 3) semi-structured interviews. A large number of figures are also used to present the data, since these are 'silent' data from the Deaf community. In document analysis Deaf learners' responses are provided in a written form to explore the cognitive aspects of their participation in Mechanical Systems. Different forms of lessons are used for data collection, e.g. theoretical, demonstration, simulation, and so on. Furthermore different exercises are presented to explore better ways in which Deaf learners comprehend the concepts of Mechanical Systems.

Chapter 6

Here the researcher will present data analyses for the data collected during classroom activities and interviews. Analyses will be categorised into themes, leading to identification of the effective learning styles observed in the Deaf classroom.

Chapter 7

This chapter will endeavour to answer critical questions through themes formulated in chapter 6.

Chapter 8

In this chapter, the researcher will present categories of findings against the unique features of the Technology Curriculum Assessment Policy Statement (CAPS) document in order to conclude the study. It will indicate the usefulness of the BLM in guiding data collection and data analysis of the study. Moreover, it will highlight challenges together with recommendations, and conclude by indicating further research opportunities.

1.10 Conclusion

Chapter 1 provided the research objectives, research objectives, problem statement and the reason for conducting this study. A brief description of pertinent concepts was discussed. The chapter concludes by giving an outline of all of the chapters in this study. Chapter 2 will discuss the literature used in the study.

CHAPTER 2

Literature review

2.1 Introduction

A literature survey was done in this chapter to add more insight to the study and its findings. I first discuss various relevant education policies, particularly those which pertain to the needs of deaf learners, before presenting an overview of the subject technology. I then focused on some interdependency between Technology and Mathematics, and further gave discussion on the role of language in the cognitive development of a child. The final section focuses on challenges experienced by Deaf learners in education, and surveys current studies relating to the effective participation of Deaf learners in education.

2.2 Education policy in the post-apartheid era

After the adoption of Technology as a school subject, a number of curriculum policies were provided to address the damages of the apartheid segregation that existed upon racial and ethnic lines. It encouraged a more learner-centred approach, group work, local curriculum construction and local choice of content, driven by the philosophy of Outcomes-Based Education (OBE) for integrated knowledge systems. A new curriculum framework known as C 2005 was introduced to guide eight compulsory learning areas. C 2005 brought along a lot of new terms and ambiguous language that demanded teachers to interpret new curriculum for implementable classroom practice. No intensive training was given to teachers to address demands embedded on terms and language. A lot of challenges were experienced in the process of implementation. Due to experiences in C 2005, the National Curriculum Statement (NCS) was introduced in 2002 to replace C 2005. In the process of implementing NCS, four challenges were identified as indicated in (Lelliott et al., 2009):

- A ‘gap’ between policy and practice
- Access to schooling that would address individual needs
- No link between the academic and the practical value of learning in the assessment policy

The curriculum was then revised and termed the (RNCS) in 2009 and the new (NCS) for Grades R-12 was produced in 2012, which encapsulates two different documents, namely an NCS for Grades R–9 and an NCS for Grades 10–12. In the RNCS (DoE, 2003) Grade 9 teachers were tasked to focus on how Mechanical Systems work to gain advantage, while in the NCS of 2004 teachers were expected to focus on the comprehension of the interaction in Mechanical Systems and sub-systems through analysis of practical involvement using systems diagrams. As defined in the RNCS, a systems diagram is a "set of connected units which operates together or interact to fulfil a need or achieve a goal" (DoE, 2003, p. 4). Because of the development needed to ensure practicability of Technology curriculum, RNCS was replaced by (CAPS) in 2011. CAPS extended endeavours of implementable classroom practice from general aims to specific aims. For example, general aims ensured that learners implement acquired knowledge and skills in meaningful ways in their lives while specific aims dictate the use of design process (DoBE, 2011). Technology embraced two major aspects to ensure a right to education 1) inclusivity and 2) mainstreaming in education.

2.2.1 Inclusive education and main streaming

Inclusive education means a common curriculum approach to teaching as discussed in 1.8.1. Inclusive education was adopted in South Africa to address the mischievous apartheid provision of specialised education and support based on racial lines. It was aimed at providing support to learners with special needs so that they too can access education beyond their barriers. Inclusive education was found on the following principle (DoE, 2003):

- All children and youth can learn and need support
- Education system should maintain similarities in the process of meeting the needs of all learners with a full respect of their differences.
- The classroom should maximise learning participation in educational culture and curriculum while uncovering and minimising barriers to learning.
- Education system should foster attitudes, behaviours teaching methods curricula and learning environments that meet the need of all learners.

Typically, mainstreaming means a common curriculum to learners by diverse learners in an ordinary classroom as explained in 1.8.2. Activities are shared by most learners in a particular subject and grade in different schools and provinces in the same country. For example Mechanical Systems in grade 9 curriculum is done by all learners registered in South African schools. Mainstreaming is what South African education advocates for. Hence CAPS prescribes activities to be included in each strand of Technology and predict a threshold for assessment and grading in each grade inclusively. Effective learning is the main purpose of participation beyond physical conditions of learners.

Policy discourse in inclusive education and main streaming is regulated by the White Paper 6 on special education (Kumar, & Singh, 2014). Disabilities are not segregated and categorised for particular interventions but White Paper 6 suggested that intervention should be aimed at removing barriers that are hindering children with diverse disabilities to learning. However Deaf people see their barriers to education as a language and do not regard it as a severe disability. The hypotheses is that a full inclusion of Deaf learner means a total supportive Sign Language environment that will permit learners to develop to his/her full educational , social and emotional potential, including full literacy in at least one written language such as English. There is no evidence of an in-depth research directed to issues of mediation of learning through Sign language in South Africa (DoBE, 2014).

2.2.2 Provision for Deaf learners

Incidental learning is part of a formal learning that provides opportunities for everyone to pick up lessons on every activity around them. Deaf children have less opportunities to partake in this inborn opportunity to use maximum senses for learning. According to Bull, Blatto-Vallee, and Fabich (2006), they lack access to everyday form of information that stimulate their attention, e.g. different sounds, radio, cell phone ringtones, alarms, etc. They experience difficulty in activities that involve hearing (Reagan, 2008). It is indisputable that most learning activities are selfishly designed by hearing communities, thus minimising opportunities for effective participation of Deaf learners in education (Luckner, Sebald, Cooney, Young, & Muir, 2005; Odom et al., 2005). Human senses are interdependent in complementing an envisaged human being; e.g. learning to cross the road requires both hearing and vision; timing an event requires a stimulus from the alarm / timer and a visual confirmation on a timing watch, etc. For that matter, the education system needs to address factors that provide gaps between hearing learners and Deaf learners when ensuring equal access to education (Batten et al., 2014). The identified factors will address a teaching and learning style that motivates Deaf learners to participate in effective learning. These factors will include:

- Classroom participation that ensures accommodative communications;
- A linguistic approach that encapsulate reading, writing and comprehension that enhances cognitive development; and
- A specialised education that provides an equitable opportunity for Deaf learners to perform maximally in problem-solving exercises.

Deaf learners differ in the way they process information, but they have an advantage of visual processing that is influenced by shifting of visual attention, visual scanning, and definition of motion and manipulation of mental images in their spatial processing (Knoors & Marschark, 2012). However, Deaf learners have a weakness in associating concepts, but rather focus on individual items in isolation in relations that exist (Blatto-Vallee, Kelly, Gaustad, Porter, & Fonzi, 2007). This challenge highlights their difficulty in recognising mathematical relationships and connections between elements used in normal teaching in both written and verbal mathematical instruction.

2.3 Overview of Technology

2.3.1 Place of Technology in the school curriculum

Technology is divided into four strands namely Processing, Structures, Mechanical Systems and Electrical Systems. Each strand delves into the core of Knowledge and skills needed to produce a technology literate learner in a relevant grade. Teachers have a specific role to play while learners have tasks to perform too. All tasks are guided by CAPS to ensure effective participation in Technology. In relation to Mechanical Systems, CAPS document is more specific about the content, concepts and skills that teachers need to focus on as well as time required to complete each section. For example, teachers are expected to revise syringe mechanics using two equal-sized syringes linked by a tube. Teachers should also teach about force transferred between the syringes filled with compressed air for a pneumatic system and water for a hydraulic system. Furthermore, teachers have to facilitate when learners are doing action research, where they are expected to develop investigating skills whereby they will experiment with two different syringes linked by a tube filled with hydraulic fluid (water). Learners will experience force transfer with either force multiplication or force division (depending on which syringe is used); in other words, learners will observe force being transferred between syringes in both pneumatic and hydraulic systems. In the lesson teachers should teach learners that gasses like air are compressible and that liquids like water are not compressible (DoBE, 2011).

The CAPS document provides action research where learners observe specific phenomena, e.g. different sizes of syringe, utilisation of liquids and / gasses in tubes, and quantifying those phenomena numerically. Pascal's principle is used to provide relationships between input and output syringes, thereby providing Mechanical Advantage (MA) in relation to syringe size and diameters. The CAPS document separates the theoretical aspects of a Mechanical System from a practical implementation of the principles in the form of simulation. All investigations around the simulation are made to be 'fit for purpose'.

CAPS document advocates for a capability task where learners are expected to combine knowledge and skills into a working project. The CAPS document encourages a representation of an ultimate project in the form of a system diagram and systems approach that describes how the project works and its fitness of purpose (De Jager, 2012). All sections in Mechanical Systems, e.g. hydraulics and pneumatics, gears, pulleys and linkages, are dealt with in a similar manner, and the sequence of the work within the term (MA, Load, Effort etc.) must be adhered to and ensure essential skills for the design process in Technology, e.g. investigating, drawing, designing, making and communicating. Ultimately an overall understanding of a Mechanical System enables a learner to interpret a scenario that simulates a real-life problem and to implement acquired skills in a practical task. Creativity, skills, critical thinking and problem-solving abilities are the major aspects of technological literacy aimed at providing learners with authentic real-life context (Middleton, 2005). Moreover technological literacy possesses a vocabulary from Technology and Mathematics that describes tasks articulately as evidence of the potentials required for conscious choices to be made by individual learners in design. Eight levels of technological literacy are represented in Figure 2.1; these are inter-related to produce a competent learner.

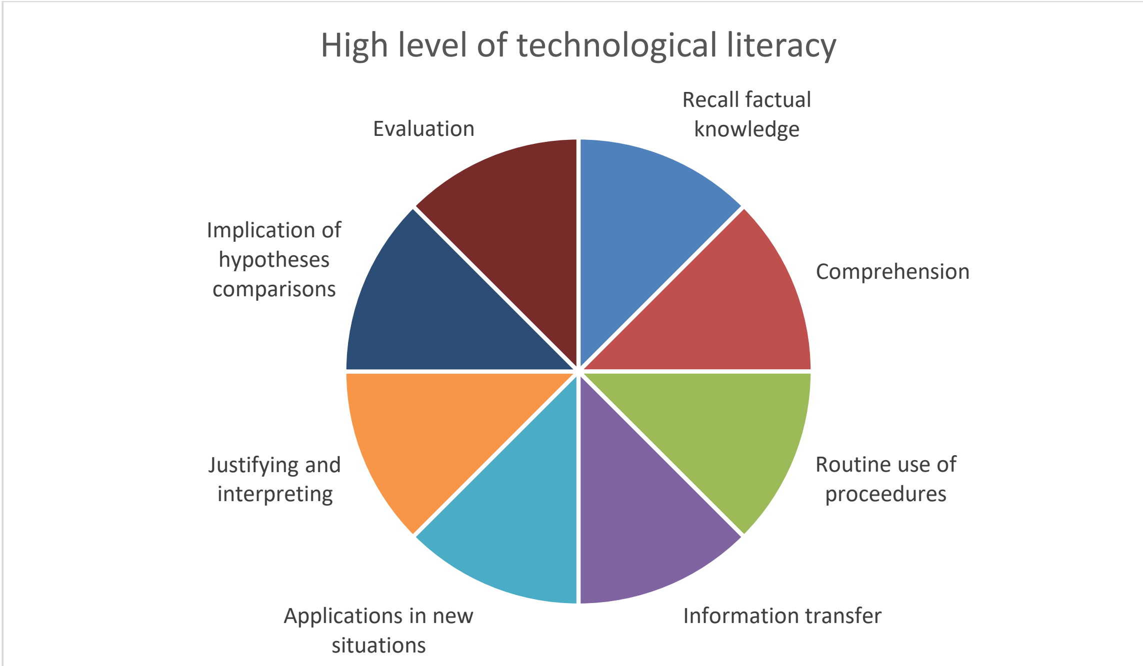


Figure 2.1: High level of technological literacy.

Necessary design skills appreciate relevance through observation and correct use of formulas. Technological literacy skills are an ultimate position of advanced learning and higher-order thinking foregrounded in a universal standard of communication. Competency in technological design provides a practical argument that enhances mind, eye and hand coordination in the form of a practical solution.

2.3.2 Interdisciplinary nature of Technology

Interdisciplinarity is a systematic intersection of concepts within two or more learning areas. Interdisciplinary concepts involve techniques, specialised skills, and instruments used in the interpretive phase, through borrowed vocabulary and ideas that explain aspect of concepts learned theoretically (Chettiparamb, 2007; Lyall, Bruce, Tait, & Meagher, 2011). The essence of Mathematics itself is rooted in interdisciplinary concepts as it embraces architectural study, geometrical study, astronomical study, Technology and engineering (Van Sertima, 1999). The subject technology by its very nature is premised on interdisciplinarity and has overlaps between different fields of study (Mathematics, Science, Engineering, Design, etc.) which are quantified at basic levels using techniques of a particular section of Mathematics. In the case of Law of simple machine ($W_{input} = W_{output}$) the dimension of this equation may not be visualised but the most important thing is ‘what mathematics can do’ to provide a practical argument. Technology becomes reliant to Mathematics because it quantifies the application of Mathematics concepts in procedural knowledge of design in Technology. Letters are used in conjunction with binary operation in Mathematical to represent proportional quantities in equations, e.g. $W_{in} = W_{out}$ implies that $F_{in} \times S_{in} = F_{out} \times S_{out}$, where F is force applied and S is distance moved. In this context, a typical algebraic problem compels the solving of equation ($F_{in} \times S_{in} = F_{out} \times S_{out}$) by substituting terms, observing general behaviour and patterns of sets of numbers and variables with their operations. Furthermore to observe the combinations, series and summation that concludes the ultimate algebra.

The meaning of information is determined by the intended use when complex application is required (Wicklein & Schell, 1995). Learners understand the underlying concepts of Mathematics when they interact with Technology hands-on. They will be able to apply product-based knowledge from activities and Mathematics concepts to solve real-world problems technologically. If learners understand Technology and Mathematics concepts taught in class, they cope well with the quantitative requirements of design. Within the school context, learners accomplish competency in Technology when they produce technological solutions through the combination of technological knowledge, comprehension of social issues and practical skills required for technological solutions (Smits, 2000). The ultimate purpose of interdisciplinarity in Technology and Mathematics is the enhancement of a high level of competency in learners’ achievement and a new perspective to teaching and learning that leads to the desired learning outcomes (Childress, 1996). Concerning Technology, interdisciplinarity endeavours to help learners to link Technology with other school subject as a united-whole and identify aspects that are fundamental to Technology and other school subject with the purpose of effective Technology implementation. Wicklein and Schell (1995) indicated that school curricula was a segregated approach to instructional topics which did not address endeavour of combining related topics into a coherent body to be used by learners.

2.4 Advanced learning skill required in Technology

Advanced learning relates to an introduction of new knowledge to practiced expertise where learners use acquired information to unique situations (Wicklein & Schell, 1995).

The essence of advanced learning embraces the concept of thinking, where higher- order thinking is expected. Higher-order thinking is necessary for multiple solutions that emanate from coherent concepts in Technology. Mathematics justifies judgements required in the ability of design where more than one criterion is required to solving complex problems. Concepts of Mathematics and Technology can be fully understood through their use in a practical situation that changes the designer's view of the world while adapting to the existing situation where Technology is applied (Ankiewicz, 1995; Erekson, 1992).

The outcome of a design involves more variables than the representation of logic in a sequential process of steps. If the whole concept of design is limited to a school curriculum, it may be inadequate towards sustaining Technology literate population needed to solve real-life problems. Different concepts are learned in abstract ways which help the advancement of concepts of authentic activity. The ultimate goal of teaching Technology and making it complementary to Mathematics is to provide learners with necessary competences grounded on acquired knowledge that will enable them to apply mind-eye and hands-on skills to technological solutions (Mawson, 2003). If Mathematics concepts are taught in a vacuum, without any relationship to real-life problems, learners fail to interpret people's needs/problems and cannot make a meaningful attempt to design. Advanced learning in Technology encapsulate the adequate use of formulas and proper interpretation of Mathematics language.

2.4.1 Numerical science and Technology

Numerical science is a systematic and ordered arrangement of ascertained knowledge deemed to provide the truth about aspects of practical description of all the applied sciences. It has a practical value and instructional use that may only be expressed in numbers (Dautray & Lions, 1993). According to Devlin (2000) it is the invention of numbers and arithmetic notation that provides proof of logical arguments in worldwide Technology activities. Numerical science prods the comprehension of numbers that provide logical quantities in phenomena. An effective implementation of numerical science is grounded in the comprehension of Mathematics language for the interpretation of abstract ideas that involve thinking and speaking technologically (Jamison, 2000).

As highlighted in Devlin (2001), numerical science informs the science of abstract patterns, abstract shapes, and patterns of motions that are visual, imaginary or mental in a qualitative and quantitative manner. This science of numbers can be used in Technology (Mechanical Systems) for collecting relevant techniques, counting, measuring and classification of abstract notations. For that matter, numerical science is a treatment of numbers and notations in a particular language, either verbally or in writing, in order to model how different parts of the system are connected in the world of Technology determinism (Erekson, 1992; Kavanagh, 2009). Number systems and notations have moved away from silence and individual activity. Therefore numerical science changes the nature of children's experience in algorithmic handling in the classroom by reducing activities that involve solely text comprehension while increasing practical activities that are appropriate to societal needs, especially to more social and verbal communication. Furthermore, efficiency in numerical science and Mathematics language empowers learners to delineate purposeful processes of design through an articulate consideration of binary operation commands.

2.4.2 Mathematics language symbolism

Mathematics language symbolism is inherent in Mathematics and hence Technology is the use of the common language symbolism used to communicate. According to Jamison (2000), Mathematics language contains algebraic sentences, grammar and vocabulary. Grammar provides statements that contain complete precisions and clarity of components contained and operations required. Mathematics sentences are devoid of emotional context but provide clarity and simplicity. They are slightly different from English language to an extent that they do not have past, present and future tense but use nouns and verbs. 'One plus one equals two' is commonly rooted on a strong oral foundation but extends to reading and writing skills. Grammatically, there are three nouns '1', '1' and '2', a verb 'equals', as well as a conjunction, 'plus'. Plus may be used as 'and' in the case where two or more people behave in the same way, e.g. in Sipho and Mandla love sweets, 'and' is combining two sentences (Sipho loves sweets and Mandla loves sweets). As a matter of fact the word 'and' provides two distinctive uses:

a) to link nouns; and
b) to join whole sentences together as mentioned above.

A numerical adjective quantifies the noun, e.g. ‘four boys and three girls’. In the case where a number is used to modify the noun, it is classified as an adjective that acts as a different kind of notation model reflecting the disparity of societies in a form of Mathematics language that uses symbolic patterns which are sometimes similar to those of spoken language. Numerical science and Mathematics language require grammatical rules to ground authenticity of some aspects in Mechanical Systems. Mathematics language is applicable to different fields. The language of Mathematics emerges as an essential aspect that communicates the abstract idea uniformly and coherently. The language of Mathematics is profound and provides a major pedagogical tool informed by language learning and language writing. Learners need to understand HOW things are said, in order for them to better understand WHAT is being said in order for them to know HOW things are said beyond the collection of secret rules for manipulating strange symbols (Jamison, 2000). In Technology it provides logic and accuracy in problem solving where learners are expected to make decisions based on calculated interventions.

The potential of Mathematics is to make the invisible visible. Sets are useful in proving mathematical statements that concern the process of mathematical reasoning. Sets assist people to devise a simple language with a small vocabulary and uncomplicated grammar in the form of principles that translate mathematical arguments. Sets reduce a number of parts of speech into elements or objects categorically and reduce objects into nouns. Mathematics language enhances definitions and proof that foregrounds appropriateness of mathematical principles in Technology and design. Definitions identify some interesting objects worth of study and can be used as a solution to problems, while proof explains why statements are true, with conviction of the truth in expression/statement through the use of logical steps and application of definitions (Houston, 2009).

2.4.3 Use of formulas in Technology

Communication in Technology requires many formulas which are expressed using mathematical symbols. A formula is a representation of verbal patterns in a form of symbolic expression using algebra (Jamison, 2000). Formula interogate science of numbers and shapes relating to algebra, arithmetic, geometry and trigonometry, where letters and symbols are dominant in the presentation of quantities of equations. For example in the law of simple machine (W_{in}= W_{out}), aspect of algebra with binary operation within the language of Mathematics. W_{in} = W_{out} implies that $F_{in} \times S_{in} = F_{out} \times S_{out}$, where F is force applied and S is distance covered. . In symbolic expression learners are expected to:

a) Extend number patterns and extend these patterns in different forms;
b) Provide a relationship between input and output using functional relationships; and
c) Deduce algebraic expressions from number patterns and solve equations that occur out of functional relationships.

Mechanical Systems in Grade 9 revolves around levers, inclined plains, screws, gears and pulleys. The main purpose is to engage the operation of mechanical power to achieve desired force and motion, to transmit energy from one place to another and to multiply forces. The following formulas are dominant in executing and quantifying mechanical functions, but all of them are foregrounded on the principle of simple machine (W_{in}= W_{out}) as an aspect of algebra with binary operation within the language of Mathematics. W_{in} = W_{out} implies that $F_{in} \times S_{in} = F_{out} \times S_{out}$, where F is force applied and S is distance covered. For making any of the unknown elements the subject of the formula ($F_{in} \times S_{in} = F_{out} \times S_{out}$), you need to know how to organise like terms for simplification of addition and subtraction, the inverse of operation between addition and subtraction, the inverse operation of multiplication to division, cancel down fractions, and how to calculate with fractions using the basic language of algebra rooted in the BODMAS rule (Evans et al., 2001). For example

Analysis of the BODMAS rule means:

B: Brackets
O: Order/Off
D: Division
M: Multiplication
A: Addition
S: Subtraction

F_i x S_i (circumference) = F_o x S_o (pitch)

$F_i(2\pi r) = F_o(pitch)$. This is a combination of different binary operations that compel the basic language of algebra

Mechanical Advantage (MA) = $\frac{\text{Load}/F_{out}}{\text{Effort}/F_{in}}$

This requires an understanding of fractions

Multiply forces – MA ≥ 1;

Multiply speed – speed ratio, where MA < 1;

Pascal's law
$P_1 = \frac{F_1}{A_1} \quad and \quad P_2 = \frac{F_2}{A_2}$

Principle of the law of simple machine
$W_{in} = W_{out}$
$P_1 = P_2$

$$\text{Efficiency} = \frac{\text{work out}}{\text{work in}} \times 100\%$$

This is a higher-order level of thinking where learners are expected to apply their understanding of Mathematics language and numerical science in formulas to predict the usefulness of a machine through calculations. The knowledge of MA is extended to efficiency using ratio understanding.

$$\text{Efficiency} = \frac{\text{mechanical advantage}}{\text{velocity ratio}} \times 100\%$$

Calculation of efficiency is not limited to MA but can combine into a relationship between MA and velocity ratio. Mathematics is used as a body of knowledge beyond the school level to provide meaning, value and symbolic properties of mechanisms entrenched in Technology. Competent use of formulas becomes a symbolic medium for emphasising the specialisation of Technology (Lave, 1998).

Learners are expected to explore formulas by applying them to relevant solution-seeking calculations based on problem statements, graphical representations and/or diagrammatical representations (Houston, 2009). Most algebraic manipulation combines the rules that appear very basic but are used subtly to yield to a desired outcome. Learners will be expected to remove brackets and apply the rules to directed numbers as well as the laws of indices and BODMAS simultaneously, which requires learner to engage more on practise (Morrison, 2006). We cannot eliminate algebraic fractions. Algebraic fractions can be simplified, added, subtracted, multiplied and divided. However, in order to perform these operations you need to consider basic principles of Mathematics. Furthermore, skills that learners have acquired in algebraic manipulation can be applied to formulas containing fractions, negative numbers and brackets through the application of Mathematics rules and principles at the same time (Morrison, 2006). Formulas are rules for finding certain quantities by combining others, and are used in Technology, Science, Engineering and other subjects. Using a formula means replacing certain variables with numbers. The formula for calculating work done using law of simple machine in a screw is F_i x S_i = F_o x S_o where S_i is (circumference) and S_o is a (pitch). $F_i(2\pi r) = F_o(pitch)$.

This formula can be manipulated effectively by observing a number of mathematical rules when changing the subject of the formula (Morrison, 2006). Learners need to be taught the essence of imagination, ingenuity and figuring out technological problems through the use of related data to consult the geometrical relationships and a technical approach to algebraic equations. According to Dolan, Neil, and Quadling (2008) algebraic procedures turn out to be more automatic and mostly lead more directly to desired conclusions. The natural numbers 1, 2, 3, … help us to analyse the world around us. Numbers themselves form an invisible world that is full of abstract relationship. Some relationships are composed of addition and multiplication as basic operations. A presentation of algebraic expression and formulas prescribes a comprehension of Mathematics language that serves as a tool, leading to discovery of new Mathematics and heuristic exposition of complex Mathematics ideas essential for design, as well as emotional experience of applied Mathematics with a great consideration for environment and safety in design.

2.4.4 Binary operations and morphism

Binary operation is an expression that consists mainly of two components of functions that require an action which takes two processes of data and produces new data. It is underlined in Hazewinkel (1987) that binary operation on a set of two elements is a rule of calculation that is assigned to each ordered pair of elements of the set to produce another new element of the set. This process is a mathematical operation (Evans, Speed, & Gordon, 2001; Jamison, 2000). Mathematics application of addition, subtraction, multiplication, division and fractions revolutionised solutions to social practical problems. The concepts of binary operation showcase a part of a programme that performs basic operations to work in a correct way; e.g.one plus one equals two is a characteristic of a binary operation that yields to a noun phrase more than just a sentence. Basic binary operations that characterise effective mathematical operations are indicated in Table 2.1.

Table 2.1
Binary operation and mathematical application Modified from (Morrison, 2006)

Binary operation	**Mathematical symbol**	**Interpretation**	**Application**
Plus	+	Three plus two equals five	3+2=5
Times	×	Three times two equals six	3×2=6
Minus	-	Three minus two equals one	3-2=1
Divided by	÷	Three divided by two	$3 \div 2 = 1\frac{1}{2}$
Raze to the power	X^2	Three to the power two	3^2
Brackets	( )	Three plus two	(3+2)=5 (3×2)=6 but(3+2)≠(3×2)

The addition of two numbers is a binary operation where one number is added to another, e.g. 5 + 7. However, the addition of three numbers (2 + 4) + 7 compels the addition of 2 and 4 and thereafter to add 7 to the result. Therefore 2 + (4 + 7) yield to the same result for the associative law of addition. Both the associative law and commutative law of addition work in a similar way as the commutative and associative law of multiplication. Binary operation encapsulates distinct quantities whose values depend on the varying values of another. A binary operation on a set x becomes a function that takes pairs of elements of a set. Every child must learn the results of the addition combination at a very early stage of his/her arithmetic experience, which is accomplished through rote learning and/or constant drilling rather than the development of a formal pattern. Distributive property permits a multiplication of terms inside the brackets by the term outside the brackets individually, e.g. t. (r + s) = t . r + t . s, for r, s, and t any whole numbers. Subtraction can be considered as an ‘undoing’ addition. Similarly, division can be thought of as ‘undoing’ multiplication. For this reason division is used as a multiplicative inverse to multiplication, and subtraction the inverse operation to addition (Webber & Brown, 1963). Commutative property of addition $n(X) + n(Y) = n(Y) + n(X)$, $x + y = y + x$.

In some cases more than one binary operation may function simultaneously in one expression or equation, e.g. $3\times2-2+3\div2+(3+2)$; here the BODMAS rule should provide a guide. According to Evans et al. (2001) there is an order of operation that should be observed when working the sums; with a mixture of binary operations the x should be done before the addition. The BODMAS rule embraces the sequence of operation when a multitude of binary operations needs to be operated simultaneously.

Basic rules for mathematical operation

Rule for multiplication

(+) × (+) = (+)
(+) × (-) = (-)
(-) × (+) = (-)
(-) × (-) = (+)
Rule for division
(+) ÷ (+) = (+)
(+) ÷ (-) = (-)
(-) ÷ (+) = (-)
(-) ÷ (-) = (+)

As an element of design in Technology, segments of binary operation and rules associated with the operation requires individual attention that may be integrated into a single symbolic expression referred to as a 'formula**'.**

Morphism is a process used to change the condition of a person smoothly to a unique character by influencing a specific form of interdependent behaviour that has been singled out for attention (Macauley, 2016). Technology is interested in comparing input to output, hence employing the formula $W_{in} = W_{out}$ as a law of a simple machine. All areas of knowledge in Mechanical Systems (levers, pulleys, gears, inclined plains, and screws) are solely dependent on $W_{in} = W_{out}$ but guided by different formulas related to behaviour of a simple machine. All formulas are tailor-made to manipulate the process of mechanism that makes a difference between the input and the output to gain mechanical advantage ($MA \geq 1$).

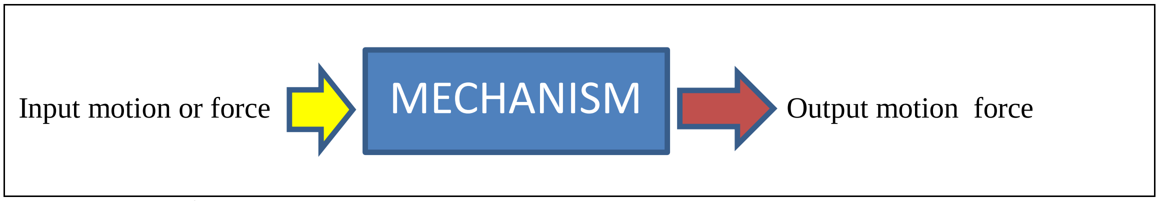


Figure 2.2: Process of mechanism.

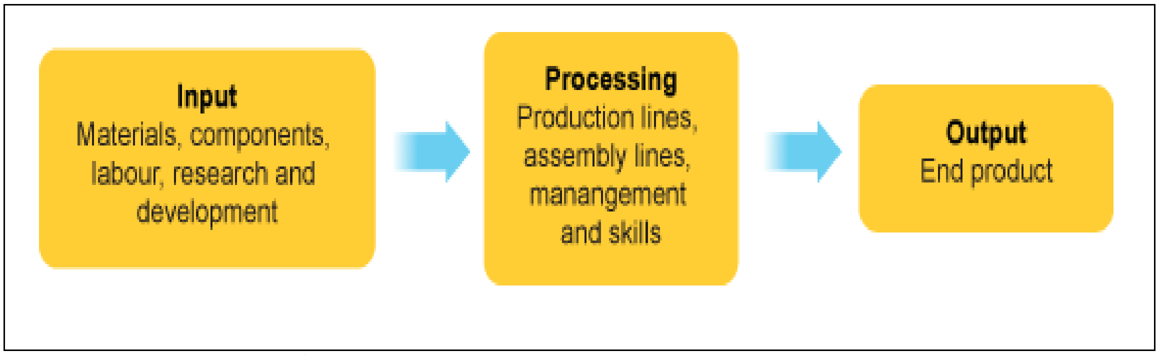


Figure 2.3: Detailing the process of mechanism.

Technology predetermines outcomes in relation to safety of persons and sustainability in the environment. Hence we manipulate processes harmoniously when we intervene to address human needs and wants technologically. Skills acquired, knowledge accumulated and attitudes developed endeavour to address the question 'HOW' we influence the process to better produce a desired outcome. Providing relationships between significant stages of design relies on Mathematics principles and proper use of Mathematics language as well as a language of instruction. Proper application of Mathematics in different fields of study proved it to be inerrant; hence its reliability is profound in Mechanical Systems.

This study on the learning of Mechanical Systems in a non-hearing environment focuses on experiences that are highly complex but influenced by learning acquired extrinsically. Technology deals with abstract combinations of the properties of words (work done) and the operations within them (force × distance moved). The meaning of expression, equations and exercises in Mathematics may be irregular if not aligned with practical utility. Integration of a formal language used in Mathematics and precise terminology entrenched in Technology is based upon morphism of input to output as a pattern for problem solving. Morphism is a function in learning algebra and learning transformation that acts as a continuous function with two related objects (input and output) that need to be used by learners with understanding. Although $W_{in} = W_{out}$ is palindromic to Mechanical Systems, different formulas are used in different areas of knowledge, confirming the accuracy of Mathematics principles and relevance of Mathematics language to problem solving in Technology. Hence morphism provides a structural preserving map from one mathematical structure ($force_{in} \times distance_{in}$) to another ($force_{out} \times distance_{out}$) within the same equation.

2.5 Language

Language is a brain exercise that requires involvement through interaction and interpretation. In the critical cognitive stages of children aged 0–2 years, the brain requires adequate stimulation from different sources, e.g. family, community and school. Language competence is significant to convey thoughts, ideas and emotions that are informed by the language instruction. It is estimated that the brain may waste up to 30% if not exposed to the effective stimulus of language acquisition (Baker, 1990; Matlosa, 2010). Language development should form a strong foundation for literacy and communication essential for equipping children for success in a broad range of educational subjects (Hoff et al., 2012; Knoors & Marschark, 2012; Meadows, Neel, Scott, & Parker, 1994; Piaget, 2014; Qi & Mitchell, 2012). Language policy advocates a bilingual approach to education to enhance the knowledge of the subject content where a mother tongue becomes fundamental to comprenension in the classroom (Bateman, 1997; Jamison, 2000; Kemp, 2009). Hence mother tongue is used as the medium of instruction in Early Childwood Deavelopment (ECD) while additional language is introduced in the progression of childrens' education. South Africa designated 11 official languages in order to promote multilingualism. However, the 2011–2012 Census (2011), revealed that IsiZulu is used by the great population in South Africa (Nel et al., 2012). Within a population of 41 million Africans in South Africa, at a percentage of 72.9%, iSiZulu is used by 11 587 374 people, making 22.7 % of the entire 11 languages used in South Africa (Gonasillan, Bornman, & Harty, 2013; Southwood & Van Dulm, 2015). According to Jegede (1998), language is esential to remove barriers to teaching and learning. Language can provide ambiguity when unfamiliar concepts are used to prove rational reconstruction of reality between knowledges as they are and are known.

2.5.1 Language learning and Deaf learners

When Deaf learners enter the formal schooling system, they do not have a background of spoken language, since families communicate with them naively to meet their daily needs. Hence, part of their schooling involves initiating them into a new language for communication and learning simultaneously. In terms of local curriculum construction and local choice of content, Deaf schools have less effective curriculum delivery than hearing public schools, because of inadequate facilities in unpacking the curriculum (Samuels et al., 2013). The English language is structured in such a way that speech and sound are coherent and formalised into a system of writing. Deaf learners have to be initiated into both languages: English and Sign Language. They learn Sign Language concurrently with the language of instruction (English). Learning material, libraries and proper training in Sign Language are inadequate, resulting in the academic under-achievement of Deaf children (De Meulder, 2016). Furthermore, policies dealing with the academic curriculum for Deaf children are developed simultaneously with the accumulative strategic development of Sign Language, which makes it difficult to guarantee learners' personal development and promote creative thinking as envisaged in school curriculum. However, the researcher wants to look at how Mechanical Systems is learned in a non-hearing environment in the Grade 9 Technology classroom. Since Deaf learners are included in the mainstream curriculum in Grade 9, where they have to choose a career for the FET pursuit, the findings of this study will prepare curriculum developers to design a curriculum that ensures effective balances between academic performance and efficient social competency within a diverse population of learners. A focal point of this study is what happens in the Technology classroom when Mechanical Systems is mediated and the attention will be directed to the available means to facilitate learning that reflects values and attitudes grounded in their classroom culture. The two major concerns in this study are: (a) Mechanical Systems in Technology in a non-hearing environment, and (b) the way in which content knowledge is communicated using Sign language. Therefore findings will contribute to the appropriate intervention for knowledge creation, acquisition and application by Deaf learners in a form of efficient social competence in their lifelong learning. As for the fact that Mathematics is related to Technology, findings will underline the significance of the prescriptive language of Mathematics in informing the accuracy of design in Technology that facilitate the mediation process through Sign Language (Alexis (2010).

In consultation with *South African Sign Language Curriculum for Grade R – 12* report, the following points were identified to be challenges in Deaf education (South African Government. www.gov.za, 2017):

- The South African Sign Language curriculum emanates from the existing CAPS framework even though it is a fully fledged language in its own right.
- South African Sign Language needed speedy implementation in education, both as a language of teaching and learning and as an autonomous subject.
- As a new subject South African Sign Language (SASL) needed a unique post provision where a qualified educator would be paired with a Deaf assistant, and the requirement for an SASL educator should be the same as for other language educators.
- Pre-service training and in-service training for teachers had an artificial training in a short space of time with an inadequate consideration in providing Sign Language.

Natural and human resources required to offer SASL as a subject with a minimum resource pack for schools were expensive (Samuels et al., 2013).

2.5.2 Multilingual approach to learning

Multilingualism means the application of several languages by individuals in their communication for diverse roles fluently (Kumar & Singh, 2014). Multilingualism in education is derived from different approaches to education participation through language aimed at supporting curriculum goals. These approaches are: 1) language of instruction where a specific language is used to deliver curriculum in education; 2) multilingualism where more than one language is used to communicate the curriculum; and 3) multilingualism where an average of three languages are essential for instructional purposes in the curriculum. Multilingualism commonly includes the mother tongue, English that is commonly used as a medium of instruction and Mathematics used as a universal language. According to Cenoz and Genesee (1998) a multilingual approach to education is attributed to numerous factors that influence social interaction, e.g. linguistic heterogeneity for the country, specific social attitudes and a desire to promote identity.

Although this study is not projected to language, it is paramount to consider it as an appropriate foreground for educational application and an essential social link. Effective learning encompasses social attitudes towards and practical use of a language, the purpose of using a particular language in a society and the relationship between language use and social factors. Multilingualism provides a positive effect in the understanding of concepts of Technology subjects. Multilingualism provides coherence between language of instruction, language used for social communications and a language related to Technology (Mathematics language). Moreover, it (multilingualism) lays a solid foundation for learning and application of Technology; it promotes literacy in Technology and enhances better communication in problem solving, improving outcomes and facilitating the learning of Technology by informing an understanding of instructional design. It ensures a multidimensional nature when a person is carrying out educational decisions. Clarkson and Galbraith (1992) alluded that multilingualism has a significant influence on numerical science, while numerical science is considered a cornerstone of Technology through a similar application of concepts. Integration of concepts in the multidimensional nature of Technology ensures a threshold of competency in technological design envisaged in education. This ensures language appropriateness that extends to the cognitive level of a child and their social and emotional readiness to adapt to a range of skills, and aligns the abilities of a learner for prescriptive learning (Gestwicki, 2013).

2.5.3 Some challenges for Deaf learners

The endeavour to include persons with deafness in mainstreaming education curriculum was guided by adoption of White Paper 6 on an Integrated National Disability Strategy that encouraged an alternative perspective from the medical model to a social model in approaching interventions for persons with disabilities. A later development that was targeted to special needs education was the White Paper of Special Needs Education. Rooyen, Le, and Lesley (2003) advocated an educational institution that strives to accommodate and include all learners, regardless of their disabilities, using the construct of a social model of disability in promoting inclusion, equality, and full participation in mainstream education. These legislative pieces were entrenched in the Constitution of South Africa (1996) Chapter 2, Section 29 (1), that guarantees equal access, full participation, overall protection and a guarantee of fundamental rights for all as well as the right to basic education. For that reason, this study wants to explore how Mechanical Systems is learned in the Grade 9 Technology classroom by Deaf learners.

By definition, deafness is a condition of disability. Disability refers to how societies classify physical or behavioural difference of persons based on their physical appearance in relation to a particular culture in a given time (Lane, 2002). A disability is a limitation to human function because of the impairment. It is characterised by the unusual functioning found in a minority of the population. Deafness refers to a member of a particular linguistic population that depends on the visual language for communication. This population is known for distinctive tradition, habits, behaviours, ethics and values as they lack the hearing sense. In relation to inclusive education 'Deaf' concern about distinctive culture more than limitations as an acquired label (Knoors & Marschark, 2012). A tangible discourse of social class in the meaning of Deaf is that Deaf community lack an essential sense that restricts their choice of aspiring education and employment. Therefore the physical constitution characteristic of this minority is that they rely solely upon vision and communicate mostly in a natural Sign Language. A critical concern of deafness is rooted in the perceptual deafness and perspectives of deafness.

Perceptual deafness is a personal ability to understand the true nature of deafness, informed by ideas related to the nature of deafness (Prinz, 1990). A belief about the potential of a person with deafness, the image the society has as a result of how they understand deafness, and the way they perceive the Deaf person influences the way they categorise a Deaf individual. Society characterises a Deaf individual as a 'disabled' person based on a limitation of their normal operating procedures. Perspective deafness is a particular attitude towards deafness that is influenced by intentions. It influences the ability of a person to select an appropriate approach for intervention within the meaningful rules for engagement and participation. A greater challenge is based on the deviant physical make-up of a Deaf person that suggests/justifies intervention. Therefore disabilities are not the physical characteristics of a person but social issues that are constructed within a particular belief system in a particular time, as a response to the efforts of community participation regarding a human variation of functional limitation (Pfeiffer, 2002). The social theory of disability upholds the notion that a limitation of a person is judged according to work conditions set out by capitalist society. The effectiveness of common curriculum in the Deaf community does not justify a limited career choice, as this population is found in all fields. Audism maintains the view that social construction of a person suggest the distinguishing factors that determine individual's potentials centred around capabilities in a social constructed environment, leading to identifying Deaf population as disabled (Eckert, 2010). The view that people with abnormalities set the stage for resorting to assistive devices based on their disabilities, suggests that the normal population entices them to participate in normal operating procedures through interventions. People who are not permitted to participate to employment are those whose disability may not be accommodated reasonably to work environment, yet obliged to meet all the basic needs that the rest of the society have. This makes a claim for the politics of discrimination that overrides the cultural power and the beauty of Sign Language.

2.6 Research about learning experiences of Deaf learners

In South Africa, the Constitution guarantied 'basic education' to all learners on the basis of inclusivity and the Curriculum is packaged to ensure accessibility to education for all learners in accordance to the constitutional right. Basic education emphasises the importance of different approaches that should be used to include every learner in education to facilitate adequate participation in societies. Nevertheless, studies have shown that Deaf education for Deaf learners is approached differently in developed countries and developing countries. In developed countries, deafness is considered as a social issue that needs to be integrated to social activities while developing countries like South Africa looks at deafness as a discriminated minority population that needs an identity.

2.6.1 Studies in the developed countries

Recent studies in developed countries explored the association between the acquisition of Sign Language and spoken language with the purpose of including Deaf learners in hearing communities. They focus their attention on aspects of education that create opportunities for Deaf learners to be included to the larger society and to provide Deaf children with the best opportunity for educational and personal success. Knoors and Marschark (2012), indicated that scholars went beyond language policy provision to ensure appropriateness in providing adequate communication skills to Deaf children. The concepts that served as an area for enquiry were communication competence, age, interpersonal interaction and social participation of children, speech perception, vocabulary knowledge, reading outcomes, expressive and receptive spoken language abilities, ability to obtain meaning from print, and alphabet knowledge.

Based on intensive studies on cognitive development in children's Sign Language, researchers were at liberty to explore the differences that could exist between the acquisition of visual language against the spoken language, thus scrutinising their input conditions as well as their linguistic properties. The health education context of Deaf children was the foreground for intervention in language acquisition for deafness at infant stage.

(Miller, Lederberg, & Easterbrooks, 2013) wanted to examine the influence of an explicit coaching on the morphological skills of Deaf and hard of hearing children, who are able to understand spoken language. The goal of this study was to explore how the hard of hearing children develop spoken phonological awareness. Coaching took place in a setting where teachers used Sign Language simultaneously with spoken language. Three questions were addressed: (1) Can Deaf, hard of hearing and functional hearing learn to segment spoken words into syllables?; (2) Can these children recognise rhyme between words?; and (3) Can these children learn to isolate phonemes and words?, and if so how do they use alphabets knowledge to isolate phonemes at the beginning? The instructional method used was tailor-made to explore the effects of detailed instructions on the phonological skills of young children with hearing challenge. The method used in the study combined: (a) pre-teaching of concepts of words, sounds and the beginning phonemes, (b) clear instructions emanating from words taught during graphemes with similarities on phonemes interactions, (c) organise a set of graphemes that provide visual support for phonemes segregation, and (d) progressively advancing skills through instruction and practice that include auditory presentation of words that did not begin with the taught phonemes.

This study endeavours to highlight the essential pre-reading skills rooted in alphabet knowledge, interpretation of printed words and reading based on comprehension level. This study looks at the effective strategies of filtering visual language into spoken language with maximum use of a mono channel of input modality encoding at an early age of a child. This study focuses on foundational literacy skills where children have to identify words and comprehend language. The finding was that Sign Language did not influence the development of spoken morphological awareness for Deaf children who had a functional hearing challenge. The key issue here is a language development in toddlers. Basically scholars do not want to deviate from the normal cognitive developmental stages of children, but wish to take advantage of discoveries in hearing children and manipulate intervention strategies pertinent to the inclusion of Deaf children in the hearing communities. Findings were that the use of Sign Language did not affect the development of phonologic awareness for Deaf children. There is no correlation between the developmental stages of children and the acquisition of phonological awareness skills. Toddles were able to notice rhyme at the beginning and were able to identify and separate initial sounds much quicker than other children.

Batten et al. (2014), attempted to investigate the communication competency of Deaf children when they are interacting with peers. Expectations of this enquiry were that it was an opportunity to practice key competences related to interpersonal relationships encapsulated in helping, sharing and negotiating with peers. A major hypothesis in this enquiry was that friendship between Deaf and hearing children is able to provide a chance to Deaf children to develop social, emotional and co-ordinating skills. In the process of enhanced esteem, it was discovered that improved friendship increased socio-emotional stability for Deaf children. This confirmed the significance of communication in the learning environment for Deaf learners.

Giezen et al. (2014), wanted to explore if exposure to Sign language affects the processing of spoken language vocabulary, measured against the novel words and signs with a different morphological segments used to teach children in relation to cognitive development levels of a child as stated in Piaget (1970). It was discovered that facial expression and hand movements accompanying speech are closely linked to auditory instruction in understanding language among hearing children and adults. These gestures were confirmed to be useful in understanding foreign language in children and adults, as stated in (Zaslavsky, 1973). Sign-supported speech did not contradict the processing of spoken words, instead it benefited children in perceiving ambiguous words. (Rinaldi, Caselli, Renzo, Gulli, & Volterra, 2014) wanted to explore how Deaf toddles acquire Sign language from birth in order to understand lexical production. Two interesting areas of concern were: (a) the beginning of first sign and the sign benefit in relation to lexical repertoire, compared with hearing infants acquiring spoken language, and (b) the alignment of the fundamental sign vocabulary that shows the relationship between nominal and predicates in the lexical growth of signing children. Because of the intense discovery in early cognitive development of a child, recent studies are now able to focus attention on the implication of the method used in teaching language to the acquisition of either the visual or the verbal language differences that might exist between the acquisition of signed and spoken language in consultation with the input conditions and language properties. As stated in Rinaldi et al. (2014), “Deaf children who are exposed to sign language from birth or early in life have been reported to acquire it mostly in the same way as hearing children who acquire a spoken language, following similar maturational milestones”. Furthermore, the level of understanding of visual and verbal toddles was identified within the same content as they refer to people, animals and things when selecting their first words. Research conducted on toddles acquiring visual and verbal language from different cultures showed that comprehension of language is higher than production of language. Both groups presented a higher individual inconsistency in production than in comprehension. This gap observed in lexical skills amongst Deaf and hearing children could be influenced by the bilingual status of Deaf Italian children. In any case, both signing and hearing children behave the same in comprehension and production of language at the same age. In consideration of the findings, scholars are of the view that gaps in lexical production among toddles could be influenced by the way in which language is taught, the way is which language is developed and the bilingual status of toddles. Deaf children appear to have a greater proportion of establishment in their early lexicon than hearing speaking children because of the modality of Sign Language that make actions and motion more noticeable.

Because of a delayed formal approach to Sign Language development in pre-primary education in South Africa, Deaf learners are denied a full access to language attainment yet language is the building block of normal development and an essential component for discovering the world (Hoff et al., 2012). Access to Sign Language assists Deaf learners to communicate, and the hypothesis is that if Sign Language is easily accessible to Deaf communities and a community at large, they will not be disabled in any social sense. In this study we hope to develop Sign Language vocabulary to assist in the learning of Mechanical Systems in Technology education.

Studies in education and psychology indicate that available knowledge in one's mind embrace the visual and auditory exposure that influence effective comprehension, learning and application of skills (Luckner et al., 2005; Odom et al., 2005). This is not evident to Deaf learners. Some concepts of Mathematics, like pairing, comparison, sorting and quantifying, are acquired during the informal stages of learning, at home and through interaction with social agencies. Moreover, Mathematics puts emphases on patterns and relationships that are guided by prescriptive language in giving precise association between mathematical terms and symbols (Thabethe, 2012). If these concepts are interpreted through mathematical language and are essential for design, it is possible that Deaf learners could experience challenges in perceiving mathematical concepts without a variety of significant hands-on mathematical experiences that need to be extended to practical implementation.

Language specialists in mathematical and linguistic sequencing in written Mathematics problems make it more difficult for Deaf learners, particularly in concepts dealing with volume, shape, size, comparisons, and measurements and reasoning (Ray, 2001). Learners need more experience at the concrete and semi-concrete level and some assistance to bridge the gap from concrete to abstract concepts, so that they can make a smooth transition from concrete to abstract symbols of Mathematics.

2.6.2 Studies in South Africa

Research provides evidence that learners have a strong preference for a more tangible and visual approach to Mathematics instruction leading to the interpretation and implementation of technological design (Nyaumwe, 2006). Furthermore, two scholars - Ganiso (2012) and Dalvi (2012), endeavoured to explore Sign Language in schools in South Africa at Master's level, Language Planning and Policy challenges and the case study of the composition of school Mathematics for the Deaf in primary school classrooms respectively. The first scholar (Ganiso) undertook research in Sign Language planning and policy in South Africa by exploring the way in which Deaf learners' language rights are equivalently used in comparison to the 11 official languages. Observation was used as an instrument to explore language, teaching and learning in Grade 7 classes in the Western Cape. It was observed that no specific curriculum for Deaf learners was in place, challenging teachers to develop their own curricula. The point of interest was how teachers creatively used curriculum guidance to support Deaf learners. Furthermore, it was discovered that spoken language was different to Sign Language.

The second scholar, Dalvi (2012), explored the components of Mathematics for a group of Deaf learners in the intermediate phase. Different topics in Mathematics were taught to Deaf learners through Sign Language, and it was discovered that integers were constituted as whole numbers, fractions in the form of templates, and fractions were represented in the form of character distribution matters. The findings were that teachers did not use relevant mathematical terminology in their signing. Teachers were the major sources of facilitating the process of sponsor-sponsee, where knowledge was completely dependent on resources made available by teachers. Furthermore, no guidelines were provided for contextualisation of knowledge.

A recent study conducted by Ram (2010) at PhD level explored the link between Deaf teachers' identity and their teaching practice with the intention of addressing a void in Deaf education and advancing the existing theory about the Deaf community in education. The main focus was on two aspects:

1. The construction of identity of teachers with deafness; and
2. Negotiation of their deafness in relation to identity in teaching practice in South Africa.

Participants were professional teachers from a three-year pilot education training programme designed to train Deaf teachers for Deaf schools. Participants had 8 years of experience in teaching. A foreground to this study was the evidence of identity from childhood, through training, and experiences in teaching practices. Individual stories were used as data to narrate experiences in the post structural perspective and deafness discourse.

This study by Ram (2010) endeavoured to explore the personal identity of professional Deaf teachers and policy that regulates teaching practices. Exploration was argued through a post structural perspective that depicted the subjective identity of Deaf teachers when they interact within the professional fraternity. This study was echoing projections in rationalising educator posts, thus enforcing mainstreaming of the Deaf with hearing communities within a democratic education system. It is stated in this document that rationalisation of educator posts and provision of a common curriculum for mainstream schools and special schools addressed an economic challenge but had a gap in the way that gateway subjects were presented in Deaf schools based on their prescriptive language. The focus was not on particular/specific subject mediation, but mainly on socialisation of professional Deaf teachers within their practice.

Findings (Ram, 2010) highlighted that:

- Deaf teachers experienced social tension resulting from a resistance to change from hearing teachers and contradictions that were ignored by policy in their everyday practice.
- Hearing teachers refused a horizontal capacitation from Deaf teachers in Sign Language after Deaf teachers had identified a harmful limitation in curriculum delivery.
- It was emotionally distracting for Deaf teachers in the in-service/workshops training when facilitators could not understand the complexity of deafness, while policy expects mainstreaming.

Data highlighted that Deaf learners developed a positive self-image through the observation of professional Deaf teachers in their teaching and learning practice. A post structural perspective was used to avoid confusion between teachers' and learners' involvement in the study as participants, with a focus on social tension when executing their professional duties. However, the mediation of Technology in non-hearing classroom has not yet been studied. Scholars attest that effective teaching of scientific subjects depends mainly on language ability and language demand, and practices that enhance effective understanding, e.g. reading ability, drilling method and constant practice (Awofala, Awofala, Nneji, & Fataji, 2012). There is no evidence of research conducted in gateway subjects through Sign Language in South Africa; only developed countries have gone to the extent of exploring effective ways of teaching content learning subjects, i.e. scientific subjects to Deaf learners (Easterbrooks & Stephenson, 2006). This study will highlight practices used in classrooms for the Deaf and the way in which learning of Mechanical Systems in Technology is approached.

2.7 Conclusion

This chapter provided an overview of aspects that contextualise the use of Mathematics in Technology through the guidance of education policies. It discussed challenges of Deaf learners within the projected mainstreaming of gateway subjects. The following chapter will discuss a theoretical framework that highlights the importance of blended learning as evidence of the effectiveness of different learning styles.

CHAPTER 3

Theoretical framework

3.1 Introduction

The previous chapter addressed issues around educational policies that influence curriculum presentation, the contribution of Technology in social participation and levels of Technology literacy expected in the current age. In looking at the interdisciplinarity between Technology and Mathematics, mainstreaming was the foreground to underline the essence of language for communication and a language in Mathematics. Standard presentation of formulas, common concepts in related sciences, and the advanced development of numeracy marked reduced learning opportunities for Deaf communities. This chapter will provide learning approaches foregrounded on cognitive and social constructivism with the intention to explore the learning of Mechanical Systems in a non-hearing environment. The chapter also discusses a model used to guide data collection and data analysis of the study.

3.2 Technology literacy projected by CAPS through integrated concepts from different sciences

Technology is a learning area that integrates theory and practice and involves the application of concepts of different sciences that inform adequate technological designs. This study is directed to the learning of Mechanical Systems in a non-hearing environment. As stated in the CAPS document (DoBE, 2011, p. 8):

> 'Technology education was introduced into the South African curriculum in recognition of the need to produce engineers, technicians and artisans needed in modern society and the need to develop a technologically literate population for the modern world. The subject stimulates learners to be innovative and develops their creative and critical thinking skills. It teaches them to manage time and material resources effectively, provides opportunities for collaborative learning and nurtures teamwork. These skills provide a solid foundation for several FET subjects as well as for the world of work'.

This study encompasses the notion of blended learning, which is a strategic approach to learning that integrates the best aspects of theoretical learning and practical engagement (Djenic, Krneta, & Mitic, 2011). Blended learning organises the knowledge structures essential for using related concepts in analysing design through critical thinking. Curriculum projection of Technology is based on learner-centredness where learners construct their knowledge rooted on prior knowledge and experiences evident from solutions to real-life problems. The interdisciplinarity of Mechanical Systems is a difficult matter because it integrates the body of knowledge and skills concurrently. For this reason a blended learning model (BLM) will be used as a framework for this study. Hadjerrouit (2008) explains that within blended learning knowledge is donated from learning theories related to cognitive theories where an individual learner interacts with concepts of a particular topic and practical involvement that enables learners to communicate their perspectives about design as a socially situated knowledge.

BLM will be used to look at how Deaf learners develop the practical insight required for the various technological concepts embedded in the study of Mechanical Systems. For each of the mechanisms (pneumatics, pulleys, gears and levers) their learning will develop through successive cycles of cumulative learning, assimilative learning and transformative learning. Each time they engage in a topic, they will go through these cycles, which are explained in further detail in section 3.3.

3.3 Types of learning

3.3.1 Cumulative learning

This type of learning implies something new that is not part of anything else; it operates within a qualitative phase where knowledge accumulates from pre-structural through uninstructural up to multistructural level (Illeris, 2009). For example, it is apparent that most devices used in families and industries are machines and they serve as tools that make our daily activities easier. It is expected that learners at school going age are able to use most of these domestic machines. Any force applied to these machines to perform targeted tasks is work. From the scientific perspective, work is done when we sweep floors using brooms, open cans using tin-openers, provide gardening services using garden forks, etc.

These machines have no internal sources of energy but are able to change the magnitude of forces to the benefit of mankind.

An introduction of a lesson pertinent to these machines speculates a pre-structural stage where learners are struggling to make sense of scientific concepts. As the learning progresses, learners are able to make sense of concepts, gradually fulfilling a uninstructural stage. Ultimately their knowledge is further increased when demonstrations are presented in class and done together with them. Such knowledge (knowledge from demonstrations) can be retained for the useful application to similar learning context (Illeris, 2009; Myers, 2016).

3.3.2 Assimilative learning

Assimilative learning links new elements of knowledge to the pattern that is already established (Illeris, 2009). Assimilative learning is adequate in the classroom where learners are expected to apply acquired knowledge to different simple machines. For example, an introduction of the Technological process concept using any domestic device (simple machine) allows learners to:

- Identify an input force and an output force in the process of operation of a machine;
- Relate the input force to effort and the output force to load; and
- Calculating MA with an appropriate application of load and effort.

In calculating MA learners are expected to compare output to input in a ratio form and apply knowledge advantage that is existent in relation to MA ≥ 1. The concept of MA is applicable to pneumatics, hydraulics, levers and gears. Wrenn and Wrenn (2009) explain that an integration of theory and practical application in comprehending aspects of Mechanical Systems may be more easily understood when a learner has to recall and apply concepts that are relatively orientated to Mechanical Systems.

3.3.3 Transformative learning

Transformative learning is what enables learners to apply what they have learnt to a new situation. It brings about a personality change that has an influence on learners' purposive learning, projection and practice in the context of Mechanical Systems (Illeris, 2009).

Transformative learning resembles an extended stage where learners are expected to design a project that integrates different strands of Mechanical Systems. In their projects learners are able to provide an understanding of concepts in different strands of Mechanical Systems and are able to combine the principles in operation in one project.

3.4 Domains of theoretical learning and practical engagement

The ultimate goal of Technology is to design technological solutions that will address people's needs and wants in order to improve their life style. The focus of Technology strands is on the comprehension of the manmade world and provide relevant solutions. Technology advocates the application of knowledge to manipulate the natural world with the intention of achieving specific goals (Marshall, 1999). As explained in the previous section, BLM encompasses the theoretical learning of Technology, and practical engagement with Technology, Mechanical Systems in this case. These two main strands can be expanded into six categories which can be used to elucidate the various kinds of knowledge that are involved in the learning process. Table 3.1 illustrates the six categories that have been adapted from the work (Hildreth & Kimble, 2004; & Fleck, 1997). These authors provide components of knowledge that underpin the interests of societies.

Table 3.1

Knowledges associated with Technical learning and Practical engagement. (Adapted from Hildreth, 2004; and Fleck, 1997)

Theoretical learning	**Practical learning**
Formal knowledge Formal knowledge is about developing new theories, facts and subject knowledge that provide evidence-based reasoning. It is about developing tools to control natural processes and predict patterns of events. Technology requires formal knowledge acquired through guided educational practices organised as a text or illustrations in dense representational inscription. Formal knowledge provides	***Informal knowledge*** Informal knowledge is deals with the tricks of the trade transmitted by verbal means. It is evidence of interactions with classmates in work situations. Classmates exchange verbal informal knowledge when sharing a common interest about the project. Verbal exchange is more flexible than text but is paramount in highlighting the tricks

expertise in different strands in Technology that is consulted from the past proven utility to ensure current tradability.	of the trade and knowhow from experienced people. It does not rely on a formal programme of teaching and develops through informal interactions.
Contingent knowledge Contingent knowledge is specific to particular content. It refers to the specific knowledge that learners have to draw upon. For example it includes specific facts such as how pneumatics work, and what principle is involved in the functioning of pneumatics.	***Instrumentalities*** Knowledge is rooted in the use of tools and instruments. Technology uses instruments that have readings and involves interpreting safe use as a central focus. Technological mechanisms shape scientific developments into an instrumental level to benefit human beings. Instrumentalities include knowledge about practical operations and understanding the instruments and how they work.
Communicative knowledge Communicative knowledge is about basics which are implicit and taken for granted. It values all forms of information in all areas of expertise, like representations. Social aspects of informal communication relate to the development and maintenance of knowledge with aspects that cannot be supplemented by the factual information.	***Tacit knowledge*** This knowledge is an evidence of skills gained through experience after an intensive practice. It is communicated through a 'watching and doing' form of learning. It entails skill formation through demonstration and modelling and is related to how an individual interprets learning in the form of intimate interpersonal learning experiences.

Mechanical Systems embraces both technical interest and social interest within the bigger question of how knowledge can be learned in the classroom.

3.5 Learning theories influencing the BLM

In this study I look at cognitive constructivism and social constructivism as learning theories related to cognitive learning. These theories provide an understanding of the meaning behind the actions of an individual (Mkonto, 2010). I concur with Hadjerrouit (2008) that designing a theory of blended learning curriculum and an activity in a blended learning curriculum requires a pedagogical approach that takes advantage of learning theories encapsulating content knowledge and skills. According to Singh (2002) learning is a mental exercise that influences the body. It emphasises active participation in co-operation, investigation, discovery, play, discussion and exploration. Both constructivism and social constructivism are informed by thinking, communication and language, as illustrated in Figure 3.1.

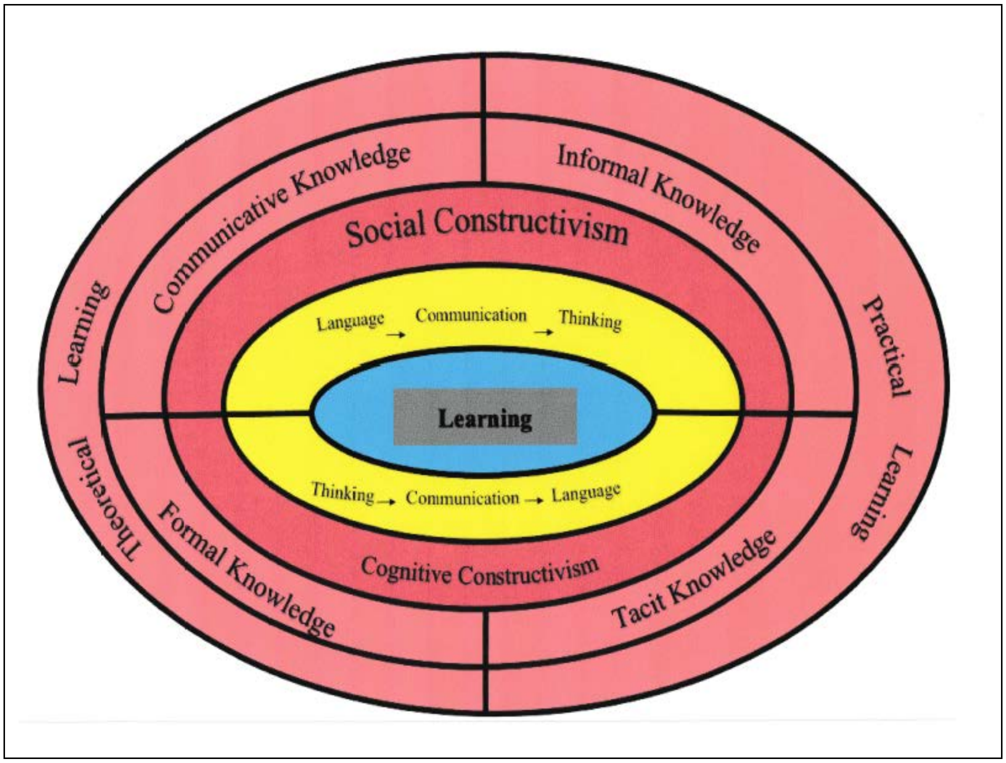


Figure 3.1: BLM and associated knowledge.

The theory of learning suggests that learning should include coherence, experiments, performance and application as major principles of educational objectives. Learning is an exhibition of change that modify behaviour in a permanent manner that is noticeable by an observer. As emphasised in Snelbecker (1974), learning is concerned with a change that occurs in accordance with the objective of the school and the community which has an influence of psychology and education. Based on Instructional theory, instruction is an integrated set of principles that prescribes guidelines for arranging conditions to achieve educational objectives (Snelbecker, 1974; Tennyson & Rasch, 1998).

3.6 Constructivism

Constructivism is a theory of a scientific study based on observation of how people learn. It is a cognitive theory with a notion that:

> 'Learning is more than memory. For students to really understand and be able to apply knowledge, they must work to solve problems, to discover things for themselves, to wrestle with ideas. The task of education is not to pour information into students' heads, but to engage students' mind with powerful and useful concepts' (Slavin, 1997, p. 269).

Constructive theorists believe that through experiences, people contract their knowledge and understanding of their world and are able to reconcile the new ideas with previous experiences for the new perspectives. Constructivism is a major element of cognitive learning theory underpinning a mental process essential for learning. Principles of constructivism are rooted in Piaget's approach to learning. Of greater concern in this study is 'How do learners learn Mechanical Systems in a non-hearing environment?' Piaget's approach to learning is that individuals construct knowledge when they are actively involved to learning and are exposed to facts. This means an abstraction of knowledge. Abstraction is not only drawn from the object that is acted upon, but also from the action itself. It seems that this is the basis of logical consequences and numerical qualifications of project resign. Knowledge gained from the process of interaction about design does not stem from experience but rather from the interaction between experience and pre-existing knowledge structures (Olivier, 1989). I adhere to Brooks (1994, p. 12) on constructivism theory in design, that

> 'learners have their own ideas, that persist despite teaching and that they develop in a way characteristic of a person and the way they experience things, leads inevitably to the idea that, in learning, people construct their own meaning'

The idea interacts in the child's mind and new ideas are interpreted for understanding by the learner according to his/her current knowledge and previous experiences. This area in the child's mind is known as the 'schema' (Olivier, 1989).

Technology is known for implementing scientific findings in real-world problem solving. Technology communicates solutions symbolically and quantifies implementation through Mathematics language using the following principles:

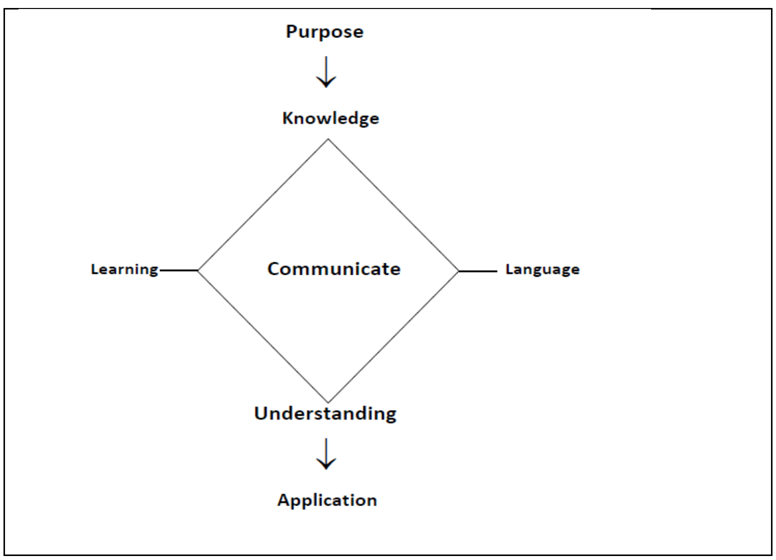
1) Providing relevant learning that simulates the real-world environment.
2) Using technological content to provide a realistic approach to real-world problem solving.
3) Employing practical projects to model a bigger project on a small scale.
4) Allowing brainstorming to negotiate instructional goals.
5) Emphasising the interrelationship between concepts that showcase the essence of interdisciplinarity.
6) Symbolic communication and mathematical language comprehension should be used as a tool to help learners interpret several perspectives present in the real world.

Technology allows learners to manipulate mathematical concepts within the context of problem solving through active participation in learning. A situation of active participation in learning creates a platform for learners to create ideas about the problem, test ideas through experiments and simulations, and evaluate ideas through practical problem solving that consciously deviates learners from memorising ideas but rather guides them to use prior knowledge. In Technology a child is not receiving knowledge passively. Through projects and simulation a learner becomes an active participant in constructing his/her knowledge that is further translated into relevant skills essential in design of new technological projects (Olivier, 1989).

A greater hypothesis of this study is influenced by Piaget's view of cognitive development of a child: that knowledge is actively constructed by a child and that intellectual development is a shift in focus from the properties inherent in a real-world object as actions are applied to them. He believed that knowledge is gained from the actions which a person performs, leading to a constructed abstraction of the action process (Piaget, 1970). The adoption of CAPS was directed at the development of competent children who will apply acquired knowledge and skills in a meaningful way that will impact their lives. Technology is one subject that needs abstract thinking, active involvement, and group participation. Technology integrates Mathematics concepts, scientific concepts and language skills with the purpose of developing a competent learner who is able to 'contract and communicate thoughts and ideas coherent' in a form of specific genre of context' (DoBE, 2011). Through the purposefulness of Technology, data accumulation in this study will be informed by knowledge, skills and competency as pillars of Mechanical Systems in Technology. Aspects of purposefulness will be used vertically and horizontally, as illustrated in Figure 3.2, to ensure effective application of Technology.

Figure 3.2

Purposeful approach to Technology learning.



3.7 Social constructivist theory

Social constructivism theorists believe that people are responsible for social construction and its conditions through language. Social constructivism is foregrounded on Vygotsky's work that emphasises a good learning rooted on social interaction as a fundamental role of cognitive development (Mace, 2005). As an aspect of social constructivism, language is an instrument of communication used to express the inner thoughts and emotions of an individual to other people. Social constructivism is of the view that the construction of knowledge is informed by the understanding of culture and context in which learning takes place (Kim, 2001). Young children mature in thinking skills through interacting with adults in an informal setting as they engage in language issues. As emphasised by Jakobson (2007), language consists of a vocabulary that depicts the literacy level of a particular community through the systematic use of symbols, and is a way of expressing emotions in a comprehensive manner, making the language a method of interaction between human beings, either in written or spoken words. Vygotsky's philosophy relates to Piaget's philosophy of cognitive development stages in his work from 1896 to 1980. In critical cognitive stages 0–2 years, the brain requires adequate stimulation from different sources, e.g. family, community, school, etc. Symbol systems in language, logic and mathematical systems are part of the factors contributing to the development of a child, and these symbols systems determine how to learn and what is learned.

On that note, social constructivism sets priorities of education on important concepts, e.g. relations in Mathematics, concepts in Technology and competences in design (Gredler, 1997). However, visual language in Deaf learners is paramount in feeding sensory memory, whereas the cognitive system is fed by outside information. Numerical Science serves as an instructional symbolic subject that becomes essential for instructional practice, purposed at influencing the brain. In this learning theory (constructivism) truth is judged in relation to multiple social realities and recognition of natural creation of knowledge, aimed towards an interpretation of subject meaning. Language ability is therefore of paramount importance to convey thoughts, ideas and emotions that are used to facilitate design in Technology education. It is estimated that the brain may be weakened to 30% if not exposed to the effective stimulus of language acquisition (Baker, 1990; Matlosa, 2010). As a philosophy of knowledge and learning, constructivism is a method of reflecting on the students' own experiences in their learning of Technology while developing a deeper understanding of their environment (Thompson, 2004; Von Glasersfeld, 1984). Hence knowledge is contracted through active participation in a learning process that is informed by prior learning and experiences emanating from interactions as an evidence of social interaction (Van Niekerk, 2002).

3.8 The interphase between the 'types of learning' and the BLM

The sole purpose of societies is knowledge growth and knowledge transmission. This study explores the learning of Mechanical Systems within the bounded limits of theoretical learning and practical learning as shown in Figure 3.1. These limits are highly influenced by social constructivism and constructivism, within which communicative knowledge, informal knowledge, tacit knowledge and formal knowledge are encapsulated respectively. When knowledge is transmitted, it relates to a variety of learning types like cumulative learning, assimilative learning and transformative learning. These types of learning are also associated with BLM, as outlined below.

Cumulative learning is gained through informal knowledge where individuals are introduced to something new at different levels. In different activities with individuals, learners embrace knowledge that they take to school to form a foundation of scientific concepts related to mechanisms in simple machines. Learning through informal knowledge is accumulated by exposure and participation is informed by the theory of social constructivism. This is concerned with practical operation of simple machines by highlighting tips from experienced people such as parents, teachers, coach, etc. This knowledge is gained through communication in a relaxed environment sometimes without considering formal programmes.

Assimilation learning is gained through communicative knowledge sourced from all social aspects while tacit knowledge is gained through watching demonstrations and simulating modelling. At this stage individual learners are able to link new elements of knowledge to patterns established by their societies, and that knowledge could be applied to different situations. For example, learners are able to recall concepts related to each topic in Mechanical Systems and to apply their enhanced understanding in each topic.

Transformative learning is gained through formal knowledge. This type of learning emanates from the application of acquired knowledge to a unique situation and expanding it to personality change. Formal knowledge is chronologically structured to inform the learning of pertinent aspects and concepts of specific content. For example, transformative learning is a result of integrating aspects of Mathematics and Science to quantify technological intervention to human needs. Interdisciplinarity experienced in transformative learning is foregrounded on the principles of constructivism theory where principles of Mathematics, Mathematics Language and scientific principles are cognitively used to enhance technological literacy in Mechanical Systems. Therefore in social constructivism all forms of knowledge are mediated through a particular language to present particular ideas. Ideas are actively communicated to stimulate thinking. In constructivism cognition stimulates the thinking that produce ideas and ideas generated are presented in a structural manner to communicate knowledge that is essential to inform language as an ontological medium of society.

3.9 Conclusion

This chapter employed the BLM as a theoretical framework influenced by cognitive constructivism and social constructivism. It highlighted aspects of BLM that inform the approach to data gathering within cognitive constructivism and social constructivism. It also looked at aspects of learning in different components of knowledge that underpin the society interest. A general overview of learning theory was provided, including cognitive constructivism and the social constructivist approach to learning. These theories provided guidance to this study as it was conducted in the Deaf school. The following chapter will discuss the research design and methodology selected for data collection and data analysis. Challenges and limitations will be discussed as well.

CHAPTER 4

Research design and methodology

4.1 Introduction

The previous chapter discussed theories that guided the classroom activities and design of research instruments. Cognitive and social constructivism were identified as having an impact on the BLM as a framework in exploring the learning of Mechanical Systems in a Grade 9 Technology classroom in a non-hearing environment. This chapter harnesses the methodology and principles that are suitable for the pertinent data type. Methodology is a paradigmic assumption that contains a perspective rooted in methodological choice that demands a consideration of various research methods (Cohen, Manion, & Morrison, 2013). This chapter is important because it has a specific bearing on the form of research instrument to be selected. This is intended to tailor the instruments that will define participants and address other situational factors. This study seeks to provide knowledge that will assist in curriculum development for Deaf learners in Technology, understanding that knowledge and skills are not neutral but are socially constructed to determine what could serve as the objective for interaction. Furthermore this chapter will touch on the sampling method and research instruments that provide interest-based knowledge to address the research questions in this study.

4.2 Research approach

This study is aimed at exploring the learning of Mechanical Systems in a Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal. Mechanical Systems is a strand in Technology that entails the following mechanisms: levers, linked levers, wheels, camps, cranks, pulleys, and gears as well as pneumatics and hydraulics systems. This study focused on pulleys and gears as well as pneumatics and hydraulics systems as concepts taught in Grade 9 Technology in a non-hearing environment. This implies a detailed understanding of competencies applied in Mechanical Systems. A qualitative approach was chosen to facilitate this process. Such an approach is one in which a qualitative strategy assist in data collection and data analyses in a single study (Creswell, 2008).

4.2.1 Qualitative research approach underpinning the study

According to Merriam (1998, p. 6) “qualitative research is an effort to understand situations in their uniqueness as part of a particular context and the interactions at the research site”. In real life situation “Qualitative research explores the traits of individuals and settings in a narrative or descriptive way” (McMillan & Schumacher, 2006, p. 6). Qualitative research methodology allows the use of various research strategies for data collection that highlight the perspectives of participants. This approach is effective because it categorise, organise and interpret relevant information that has been gathered qualitatively (Onwuegbuzie, Dickinson, Leech, & Zoran, 2009). This enquiry was intended to give clarity on social phenomena without interruption of the natural setting. As stated in (Kitto, Chesters, & Grbich, 2008), I am of the same opinion that the quality of qualitative research is a proper alignment of data gathered from talks, observation and documents where a researcher facilitate data collection and analysis.

Sign Language is newly adopted to facilitate effective learning for Deaf children. Data collected in Deaf communities are likely to be more silent and will require intensive data collection and data analysis. For that reason most avenues indicated above should inform a qualitative approach for research in the Deaf classroom.

4.2.2 The purpose of qualitative research

A qualitative study design was chosen based on its subjective perspective. It allows a researcher to be part of the social events that are unfolding naturally when collecting and analysing data (Cohen, Manion, & Morrison, 2011). The qualitative approach is a special enquiry into a social context that is natural, from the time that a researcher begins to take field notes. As highlighted in Flick (2009, p.16), “qualitative method takes the researcher’s communication with the field and its members as an explicit part of knowledge instead of deeming it an intervening variable”. Hence I intended to highlight the mediation of Mechanical Systems in a non-hearing environment. The qualitative approach enables a researcher to get information and crucial reactions from participants and perpetuated by experience that are difficult to get objectively. It allows for diverse responses that produce descriptive data.

I concur with Stake (2010) that analysis of field notes starts on the research site when a researcher identifies elements that are likely to pause threads on a study with an intention to deviate the focus of enquiry. Choosing qualitative enquiry was based on the willingness to address research questions that will assist in data capturing in the Grade 9 Technology classroom during theory and practical sections within CAPS curriculum delivery. At Grade 9 level learners have accumulated experiences that are preparing them for FET phase of their career, as shown in Figure 4.1.

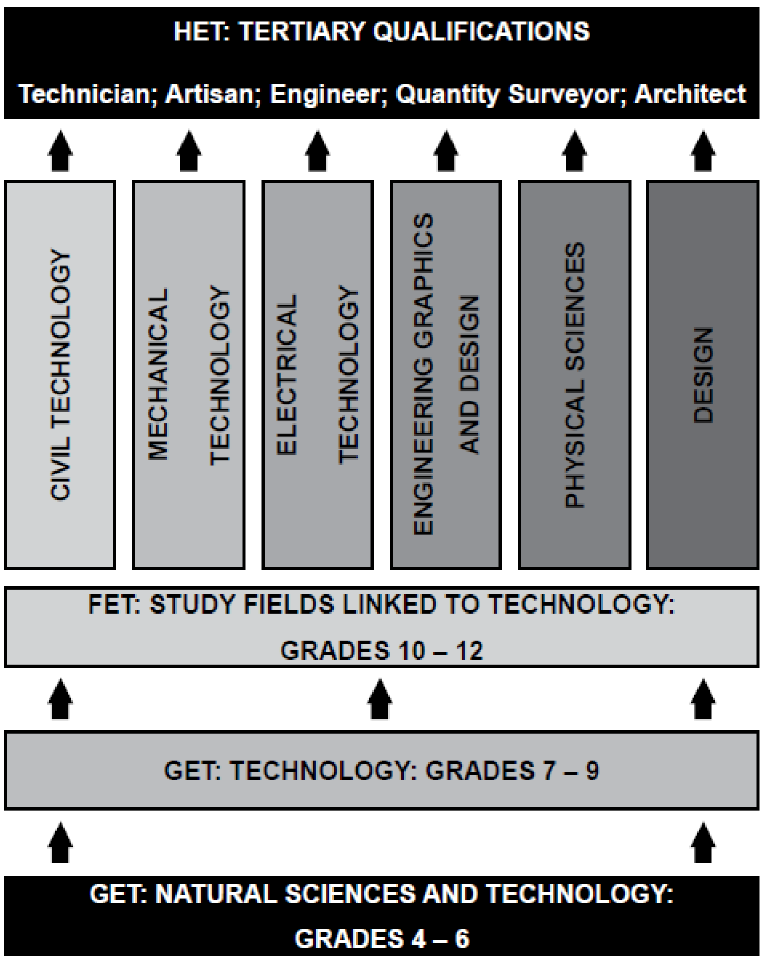


Figure 4.1: Segregation of academic levels for a career pathway in the South African curriculum (Captured in DoBE, 2011)

For this study learning of Mechanical Systems required an in-depth, thick description through qualitative data. In agreement with (Creswell, 2007), qualitative method is strong at providing a descriptive understanding on individual’s experience and exploration of a phenomenon’s context from the participant's perspective. This study was conducted in the Technology classroom where Mechanical Systems was mediated through Sign Language but guided by a compulsory curriculum. Although English is prescribed as a language of instruction in most schools in South African education, in this study Sign Language is used to translate writings in learning materials and to facilitate a variety of communications in the Technology classroom in a non-hearing environment. The range of communication in this classroom includes speech, body language, graphics, and symbols through Sign Language. Communication of any sort was perpetually used to inform the acquisition of knowledge, skills and competences in Mechanical Systems. I contend that learning and understanding of concepts in this study is inferential, as it is foregrounded in a qualitative approach and influenced by the hypothesis that learning is a brain exercise. This study is influenced by three domains: knowledge, skills, and competency. Hence this study allows for a qualitative approach as an appropriate method that will brings a clear picture of how Mechanical Systems is mediated in a Grade 9 Technology classroom by Deaf learners.

4.2.3 Interpretive paradigm

In interpretive paradigm, education is regarded as a process accumulating knowledge and a school as an institution that organises necessary experiences with an intention to understand inductive hypothesis found on gathered theories (Merriam, 1998). Interpretive research focuses on the "subjective understanding or interpretation of human action" (Babbie, Mouton, Vorster, & Prozesky, 2010, p. 30). The interpretive paradigm was appropriate for this study because it was using verbal and visual communication practised in the classroom. The interpretive approach incorporates some research approaches that underline the true and the meaningful nature of Deaf learners participating in learning activities (theoretical and practical). Since I needed to analyse the meanings in theoretical and practical lessons, visual tools were my focal point. All data were collected in the classroom where Deaf learners engaged in various activities at different levels, and I was able to understand meanings, reasons and actions behind their interactions.

4.2.4 The choice of interpretive paradigm

Concepts of Mechanical Systems are mediated through Sign Language. As highlighted in Cohen et al. (2011, p.17), the interpretive paradigm was preferred to "understand the subjective world of human experience". In this paradigm the I investigate Deaf learners' engagement with Mechanical Systems subjectively and interpret it in the way in which they experienced the classroom environment. In this study I expected a Grade 9 Technology class to provide an understanding of the learning of Mechanical Systems from different perspective through theoretical learning, and practical engagements. In agreement with Cohen, Manion and Morrison (2007), this paradigm depicts a behaviour that is socially situated, content-related, content-dependant and content-rich. This study took place in a Deaf school in a Grade 9 Technology class in Mechanical Systems. The interpretive paradigm allowed an opportunity for the voice, concerns, perceptions and practises in Mechanical Systems to be highlighted. The interactions during Mechanical Systems are informed by the curriculum, and I contend that the researcher should be subjective to the learning environment for Deaf learners (Creswell, 2008). In this case I wanted to infer why learners behave as they do; hence one needs to understand how the learning situation appeared to Deaf learners, what they thought they had to struggle with, and what opportunities they saw open to them. A researcher can perceive the particular condition through structured, inconsiderate subcultures, social norms, and other commonly emerging explanations of behaviour, only by seeing participants from the artistic perspective within Mechanical Systems mediation.

4.2.5 Case study research

This study resembles the case study. A case study is regarded as a meaningful source of acquiring research data in educational research: "A case study is not a methodological choice but a choice of what should be studied" (Stake, 2005, p. 443). Bertram and Christiansen (2015) contends that a case study is developed within qualitative research with an intensive and varied description of actions. The focus of this study is the learning of Mechanical Systems in a Deaf school because the school mediates learning through Sign Language. For this research a case study improves the understanding by pursuing scholarly research questions in a continual manner throughout the period of study. A case focusses on the knowledge that emanates from experiences and draws attention to the influence of its social context. A case study advocates organisation of clusters of phenomena that share particular patterns (Mertens, 1998). Stake (2005) describes a case study as a strategic enquiry in a single case where a researcher explores in-depth programmes, events, activities, process and/or individuals. I concur with Henning, Van Rensburg and Smit (2007) that a case is the Grade 9 Technology class where I examined the learning of Mechanical Systems in action with the intention of analysing some entities in qualitative, complex and comprehensive terms as they unfolded over the second quarter of the year. I had little control over learning as I could not manipulate the content of Mechanical Systems, since it is confined within the bounded approach of the CAPS document. As a matter of fact, I had no influence over the mediation of Mechanical Systems but to follow a curriculum prescription and the duration of tasks, activities and practices conscripted to this section. As stated in Cohen et al. (2011), a case study provides an exclusive example of real people in real situations; hence my observation took place in a natural environment of theory learning and participation in simulation and project developments in a Deaf school. I was focusing on the learning environment in a non-hearing environment through the eyes of the participants subjectively. In my approach I used "more than one tool for data collection and many sources of evidence" (Cohen et al., 2011, p.289). A case study approach enabled me to grasp the holistic understanding of the learning process through "explanation, description and enlightenment" (Yin, 2009, p.19).

Case study was appropriate since: 1) a case study is intensive, holistic and descriptive; 2) it provides analysis of a bounded system; 3) it can be fluently combined with the qualitative research approach based on its descriptive and interpretive nature; and 4) a case study approach is used to gain an in-depth understanding of the situation and situations involved. Both descriptive case studies and interpretive case studies are:

> 'entirely descriptive and move in a theoretical vacuum; they are neither guided by established or hypothesised generalisations nor motivated by a desire to formulate general hypothesis. They are useful, though, in presenting a basic information about areas of education where little research has been conducted' (Burgess, 1985, p.27).

Evidently not much research has been done to explore learning of Technology in a non-hearing environment. This element of a case study contains a rich and thick description. "This type of data collection approach is used to develop a conceptual category that illustrates or supports theoretical assumptions held before the data gathering. A case study researcher gathers information about a problem with the intention of interpreting or theorising about the phenomenon" (Stake, 2005, p.28). As stated in Cohen et al. (2011), a case study assists the researcher to see through the eyes of the participants. This study concurred with the interpretive paradigm that opens up interpretation of a phenomenon. I concur with Creswell (2014) that a case study develops an detailed understanding of a single case by exploring the learning of Mechanical Systems in a Grade 9 Technology classroom by Deaf learners within a real-life context as a choice of what needs to be studied within a bounded system (Grade 9 Technology curriculum).

4.3 Participants

According to Cohen et al. (2007) selecting relevant participants is paramount in research as it is difficult to study the entire population: "Sampling involves making decisions about which people, settings, events or behaviours" (Bertram & Christiansen, 2015, p.59). I chose purposive sampling. This research approach was aimed at providing in-depth answers to the research questions. The participants were selected based on their accessibility and willingness to be part of the study, as well as on the fact that they take Technology in Grade 9 in the same school. Through the perspective of the case study within qualitative approach, Deaf learners were suitable participants for the purpose of exploring the learning of Mechanical Systems in Grade 9 Technology as a specific phenomenon. Pertaining to this case, the Grade 9 Technology class constituted five learners, a Technology teacher and a Sign Language interpreter. I am a teacher by profession, and have an albinism condition. I was cautious in prohibiting any influence of my disability on this study. All learners were included in the study, and the table below shows identity codes for participants in the study which were used for observation and interviews.

Table 4.1
Codes used for participants in the Deaf classroom

Learners' Codes
Sphesihle
Sphelele
Zekhethelo
Nosipho
Mxolisi

4.4 Research instruments

4.4.1 Location of the study

This study was conducted at the Deaf School. This school is a special school situated in Newlands Township in Durban, KZN, and is one of the local primary and secondary schools in Pinetown district with ECD programmes. The school has 90 staff members with 38 full-time teachers, 4–15 learners in each class and a learner population of 320 that include Deaf learners and those learners that are able to pick very little sounds. It was indicated that recruitment of teachers is determined by the DoBE. The enrolment of learners is highly influenced by referrals at all levels and stages of the discovery of inadequate hearing. Not all learners are born Deaf; some lose their hearing as they grow. All learning areas are offered as per CAPS prescription, and all educational standards are expected to be met until Grade 9 at all costs. Not much has been done in South Africa to explore approach to gateway subjects through Sign Language; only developed countries have gone to the extent of exploring effective ways of teaching content learning subjects, i.e. scientific subjects (Maiorana-Basas, 2015)

4.4.2 Observation

According to Jorgensen (1989, p.13) "participant observation is a qualitative method with roots in traditional ethnographic research, whose objective is to help researchers learn the perspectives held by study populations. As qualitative researchers, we presume that there will be multiple perspectives within any given community". We are interested both in knowing what those diverse perspectives are and in understanding the interplay among them. This implies that the researcher joins the everyday routines and stays for a long time. Classroom observation was targeting the Mechanical Systems topic scheduled for the second quarter. Eleven weeks, with two periods per week were allocated for relative concepts in Mechanical Systems (gears, pulleys, pneumatics and hydraulic systems), and two weeks were allocated for common assessment in the whole school. Nine weeks were spent in the classroom observing the mediation of different topics in the Grade 9 Technology classroom for Deaf learners.

I observed full lessons two times a week. Each lesson constituted an hour, with a double period of 30 minutes per period on Tuesdays and Thursdays. Observations were made throughout the teaching and learning process. The Tuesday periods took place immediately after the break, while the Thursday periods were before break. A semi-structured observation schedule was used to guide the observation and direct attention towards how the learners engage with particular aspects of Mechanical Systems, and the communication between the teacher and the learners themselves during simulation, how educators communicated with learners and how language was used during mediation of learning. I chose to be an overt researcher, since the expectations of the study was shared with gatekeepers and participants.

In relation to this study, a direct observation was used to enable the researcher to observe the coaching between the teacher and the learners (participants) as well as guidance from the curriculum content without interruption for the whole period. My main focus was on observation of the learning of Mechanical Systems, and sometimes included some extramural activities. In the process of participant observation I chose selective observation where I focused on different activities to describe the use of Sign Language, including symbols used to sign for communication purposes (Gall, Borg, & Gall, 1996; Gill & Johnson, 2002).

The Technology class constituted five participants, three females and two males of a similar age. Two teachers (Technology and Signing teacher) were engaged in mediation of Technology. Video recording was paramount for recording activities that could not be questioned during the tuition time. Field notes provided descriptions without inferring meanings, and included relevant background information to classroom events. Field notes provided complex descriptive and interpretive data that the researcher needed to capture and to triangulate the information gathered during participant interviews. Data sources (participant observation, document analysis and project involvement) promulgated paramount aspects of the threshold cognitive development of Deaf learners.

4.4.3 Position of an observer

As stated in Lincoln and Guba (1985), as an observer I chose to be an overt researcher since the purpose of the study was made known to gatekeepers (the Department of Basic Education and the Principal of the school) and participants (learners in the Grade 9

Technology classroom). The process of research and internal curriculum development of Mechanical Systems was developed in partnership with the Grade 9 Technology teacher in consultation with the Grade 9 Technology curriculum. Pertaining to this study a direct observation was appropriate to enable me to observe interactions between a teacher and learners (participants) without interruption for the duration of the Mechanical Systems topic in the second quarter of the year. In the process of participant observation I chose to carry out a selective observation where I focused on different activities to describe the raw use of Sign Language, including symbols used to sign for communication purposes (Gans, 1999; Gill & Johnson, 2002). Field notes were taken to capture the data collected from participant observation.

Video recordings played a vital role in capturing signing conversation, as this conversation included informal conversations over and above formal tuition. I recorded activities that I could not question during the tuition time. I concur with (Gill & Johnson, 2002) that observation is not data until it is recorded, but field notes recorded after observation form part of the analysis. Several sections of narratives were formed and reflected the interpretation of certain things that make the cultural sense clear to the reader (Lincoln & Guba, 1985). From these data variables I managed to interpret and discuss events and then identified themes for further examination and analysis. This created a multi-stage process of organising, categorising, synthesising, interpreting and reporting on the available data (Gay & Airasian, 2003).

4.4.4 Semi-structured interview

Interviews are intended to seek crucial information from an individual for a particular purpose. Cohen et al. (2007 p.350) contend that the "interview provides access to what is inside a person head which makes it possible to measure the knowledge or information, value and preferences as well as attitudes and beliefs". In this study I used the semi-structured interview because of its flexibility and allowance of open-ended questions. As stated in Cohen et al. (2007), I allude to the fact that semi-structured interviews allow for probing questions without offending participants. The method is 'semi-structured' in that the similar questions are asked to each participant in order to guide the data collection, making possible systematic comparison and accumulation of findings of cases, as shown in Appendix J. The method is 'focused' because it is a selective theoretical focus that guides analysis of the cases and it deals with only certain aspects of the cases. The theoretical focus that guides this case study endeavours to explore the understanding of learning of Mechanical Systems in a non-hearing environment. Bennett and George (1997) proposed that the structure and focus of such studies are more easily attained when a single investigator plans and carries out all of the case studies; hence I executed this study on my own.

4.4.5 Document analysis

My focus was on the Mechanical Systems in grade 9 Technology. I consulted all sources of data used for Mechanical Systems mediation. Data sources entailed related policy documents, classroom exercises, worksheets and guidance on project instruction, as detailed in Table 4.2.

Table 4.2
Sources for the document analyses

Document	**Source**
CAPS document	CAPS policy Senior Phase Grades 7–9
Simulation	Exercise on gear train
Worksheet	Planned document
Project guide	Researcher-designed material

This part of engagement is done after the completion of each concept within the topic of Mechanical Systems.

4.5 Data analysis

Data analyses of this study was crafted through qualitative enquiry using an inductive and deductive approach. The deductive approach facilitated the signs of similar behaviours and patterns, while the inductive approach allow for formulation of new themes that emerged from data. Patterns in data presented were not predetermined, as it happens with deductive approach. The type of inductive analysis allowed the study to construct patterns that emerge from the data in order to make sense of them in a narrative manner (Creswell, 2003; Gay & Airasian, 2003). In this analysis the study started with a large issue (learning of Mechanical Systems in a non-hearing environment), through an interactive process (lessons on Mechanical Systems), and progressively narrowed them down into small important groups of key issues (themes). In this study, classroom observation, interviews and document analysis were identified for data collection. An objective was to explore the perspective held by Grade 9 Technology class in a non-hearing environment. For participant observation, the instrument helped the researcher check for non-verbal experience and determine the frequency of interactions and the manner of communication within participants .In this study, the participant oberver stance was of paramount importance, since I was an observer who was not part of Technology class in a non-hearing environment, but interested in developing appropriate learning material as means for conducting a better observation that will ultimately generate effective understanding of group activities.

As stated in Lincoln and Guba (1985), I chose to be an overt researcher since the purpose of the study was made known to gate keepers and participants. Moreover, the process of research and internal curriculum development of Mechanical Systems was developed in partnership with the grade 9 Technology teacher in consultation with grade 9 Technology curriculum. Pertaining to this study, a direct observation was appropriate to enable a researcher to observe interactions between a teacher and learners (participant) without interruption for the whole period. In the process of participant observation, I chose a selective observation where I focused on different activities to describe the raw use of Sign Language including symbols used to sign for communication purposes (Gans, 1999; Gill & Johnson, 2002). False names were used to code participants on the basis of confidentiality and anonymity. Field notes were taken during participant observation to ensure that all events are encoded. Video recording played a vital role in capturing signing conversation as this conversation included informal conversation. I recorded activities that I was not in a position to question during the tuition time. As stated in (Gill & Johnson, 2002), observation is not data until it is recorded but field notes recorded after observation form part of analysis. Field note provided descriptions without inferring meanings which included relevant background information that located events. The analysis of interview information and field notes from observation enabled a researcher to develop sense-full models of what participant do. Several sections of narratives were formed and reflected the interpretation of certain aspects that made the sense of their culture to the research (Lincoln & Guba, 1985). From these data variables that can be interpreted and discussed are then identified through further examination and analysis. This therefore created a multi-stage process of organising, categorising and classification of data. In ensuring that data collected during Mechanical Systems lessons in a silent environment was authentic, video, photos, interviews and field notes taken as lessons unfolded in different aspects and activities.

4.6 Ethical considerations

As I interacted with the participants (Deaf learners and teachers who work alongside these learners) I wanted to ensure that they did not feel coerced or obliged to be part of the study. I therefore clarified the nature of the study and specified that their willingness to be part of the study or not would in no way impact on their participation in opportunities for promotion in Technology. I kept the identity of participants anonymous, as indicated in Table 4.2 and data collected from participants (Deaf learners in Grade 9 Technology classroom) were treated with confidentiality (Cohen et al., 2007). In approaching the participants the following steps was followed (Gay & Airasian, 2003):

- The purpose and an outline of the study was provided to the school and the school will be asked if it would consider availing participants.
- It was emphasised that their participation is entirely voluntary, but guided by the school in consultation with parents.
- The school promised full confidentiality and anonymity of the participants in events that take place during the study and the faces of participants will be obscured. The school will be asked to provide full release of the video data for use in public domains such as actual learning in the classroom.
- Video tapes were deleted after consensus with the university and the supervisors immediately after the whole process of research has been concluded.

4.7 Conclusion

This chapter provided an outline of the methodology and research approach used in this study. This chapter began with the research approach using the interpretive paradigm and the case study as a meaningful source of enquiry. The research content and the research participants were highlighted for the purposefulness of this study, as was the role of the researcher and the sampling strategy. The research instruments that guided this study were participant observation, semi-structured interviews and document analyses. Ethical considerations were also discussed. After all data were collected, the data analysis process started. The next chapter of this study will provide an analysis of data collected in the field through observation, document analysis and interviews.

CHAPTER 5

Presentation and discussion of data

5.1 Introduction

The previous chapter discussed research design and methodology that guided this study. This chapter presents findings in the following manner:

1) Observation of each topic (pneumatics, hydraulics, gears and pulleys);
2) Responses of participants on classroom exercise on gears and the worksheet in Appendix G.
3) Presentation of the working model of learners' choice.
4) Interviews

All activities were carried out in the classroom during the Technology periods. Data will be presented to explore how the purposefully designed lesson enhanced the learning of Mechanical Systems in Grade 9 Technology in a non-hearing environment, and how the use of simulation improved the learning of Technology in a non-hearing environment. The Verbatim quotations are used in data presentation to ensure that the voices of participants were not lost and maintained the rest of the text as my paraphrasing of their words to ensure the preciseness of discussions around the issue of the learning of Mechanical Systems in a non-hearing environment.

5.2 Research setting

This section provides the location of the study, the profile of the Technology teacher, the profile of the Sign Language interpreter and the background of participants. This background is crucial to highlight the nature of the classroom in a non-hearing environment and participants therein.

5.2.1 Focus of the study

This study took place at the Deaf School. This school is a special school situated in Newlands Township in Durban, KZN, and is one of the local primary and secondary schools in Pinetown district with Early Childhood Development (ECD) programmes. The adoption of democracy in 1994 benefited Deaf learners of all races when the issue of equal education received proper attention (Stander & Mcllroy, 2017). English has been used for writing and the language of instruction to maintain the status of the school as the mainstream school but manual language has been used as a medium of communication within Deaf schools and their classrooms. The employment of the Technology teacher was guided by appropriate qualification in Technology and the delivery method was ensured by the Sign Language interpreter. This study did not focus on the socialisation of Deaf learners but rather looks at how Deaf learners adjust to the customary way of life when participating in equal education opportunities. Furthermore this study wants to look at the application of Technological content that promotes motivational values which foregrounds the usefulness of Technology and the substantial gain in Deaf learners' ability to relate Mechanical Systems to the real-world

5.2.2 Profile of the Technology teacher

The Teaching Team (TT) was composed of the Technology teacher and the interpreter. The Technology teacher had 15 years of teaching experience made up of 8 years of the Zimbabwean curriculum and 7 years in South Africa. In Zimbabwe she taught from Grade 9 to Grade 11. In South Africa she taught at an FET College, teaching Engineering subjects specialising in Mechanical Engineering, and at a high school teaching Mathematics in Grades 10 to 12 for 5 years in total. Finally, 2 years had been spent teaching at the Deaf school and the focus was on Technology:

> '*I have 4 years teaching qualification from Zimbabwe. In that programme we were trained to handle Engineering modules and Mathematics; that is where I got sufficient experience. I did Mechanical Engineering at teachers' college in Zimbabwe, it was a 4-year programme and my majors were Engineering Mathematics and Engineering Science*'.

The Technology teacher indicated that a difference between the South African and Zimbabwean curriculums approach is that:

> *'…in Zimbabwe they separate manual skills from concepts that demand intellectual abilities (e.g. cooking, welding, plumbing and bricklaying), while in South Africa they employ an integrated approach to Technology…'*

The interpreter has experience in Sign Language but did not have a qualification in Technology; however, their combination is justified in the policy on Sign Language (DoBE, 2014).

5.2.3 Profile of the Sign Language interpreter

The Sign Language interpreter had more than 20 years' teaching experience. She had a Home Economics background and was currently teaching Hospitality Studies in the Deaf school. The Sign Language interpreter was familiar with the units of measurements as mainly used for ingredients (e.g. grams, millilitres, area, temperature, etc.). She got involved in Sign Language when her niece lost her hearing, 10 years ago:

> '… *my passion for Sign Language was stimulated when my niece was discovered to experience hearing loss. Her family and relatives were called for counselling and elementary training on communication skills in Sign Language'*.

The Sign Language interpreter went for training on Sign Language to enhance her signing skills. She taught in a Deaf school for 9 years as a professional teacher with Sign Language skills.

5.2.4 Background of learners

The classroom included learners who rely on visual language for communicative functions and learning purposes. Participants were enrolled in this special school after referrals from medical practitioners at different ages. This classroom community held three girls and two boys. The learners in this study consisted of three girls and two boys. Four of the five learners (80%) starting their academic career from Grade R, with the exception of Sphelele, who joined the Deaf school in Grade 2 as the result of referrals from medical practitioners.

Participants seem to enjoy being at school because the rate of absenteeism is very low. It may be that they get a sense of belonging, and the environment provides social interactions for them. There is a relaxed environment on the school premises, with intense peer communication and silent excitement evident.

5.3 Lesson observation

The classroom was relatively small, allowing direct, face-to-face communication, as illustrated in Figure 5. The classroom was well constructed with a ceiling board and a white board fixed in the front of the class. The classroom was constructed in the form of a workshop where windows are placed above the head level as illustrated in Figure 5.1. This classroom set-up enhance the attention of learners while providing sufficient light and ventilation.

Figure 5.1: Technology classroom set-up in the Deaf school and classroom construction with the TT in action.

Windows served the purpose of providing ventilation and light Figure 5.1 below. The classroom set-up allows teachers to move freely around learners for closer interaction. Deaf learners were the participants in this study, who interacted with the lesson designed by the Technology teacher and the researcher through the guidance of the CAPS document. Data was collected from lesson observations which focused on five categories of Mechanical System:

1. Theory on pneumatics as an introductory lesson
2. Hydraulics;
3. Simulation of pulleys;
4. Gears;
5. Project development and presentation

I now briefly present descriptions of the various lessons that were observed.

5.3.1 Introductory lesson: Pneumatics systems

Mechanical Systems is one of the four strands in Technology. CAPS prescribes that Mechanical Systems should be taught in the second quarter of the year. Levers, pneumatics, hydraulics, pulleys and gears are concepts encapsulated in Mechanical Systems. The school timetable allocated Technology to a period after the first break. I joined the TT team during break and observed them preparing for the lesson. When learners were entering the classroom, the TT drew their attention to my presence and we greeted each other with a smile, without verbal utterances. All movement to their places was silent, and then they were ready for the lesson to begin.

I observed the way in which the TT was conducting the lesson. The Technology teacher would ask a question and the interpreter would interpret what the Technology teacher was saying. Their pace was very slow and their communication was complementary in the sense that the Technology teacher (TT) would say few words and then the sign language interpreter would interpret those words (they are shown working together in Figure 5.1). This process enhanced the comprehension of the participants. A lesson that needed an effort of the Technology teacher and the interpreter was a new experience to me as opposed to a direct teaching and learning I have been exposed to. The teaching approach was traditional, as the TT was applying the question and answer approach. After all greetings and introductions had been made, the teaching team (TT) introduced the lesson as follows:

TT: What do you understand about the compressed air?

There was a silence in the classroom as the participants did not respond.

TT: Where do we find compressed air?

This question was an attempt from the Technology teacher to probe the responses from participants, but still participants did not respond. The Technology teacher asked the third question:

TT: Where do we use compressed air?

I expected that learners would raise their hands to indicate when they wanted to respond, but they would sign their answers without waiting for permission from the teacher to respond. In my observation, the size of the class and the face-to-face contact was an advantage for the teaching and learning situation, enhancing attentiveness in the sense that every move was noticeable to both the TT and the Deaf learners. Sphesihle responded after three different attempts of question to get learners to respond:

Sphesihle: Plastic pocket.

TT: Do you put compressed air in a plastic pocket? Think of something that needs a pump.

Mxolisi: Water.

The Technology teacher was not satisfied with the answers provided by the learners. She kept on shaking her head at learners' responses and her facial expression showed dissatisfaction. She ultimately asked probing questions that cued learners towards her expected answer, as follows:

TT: Do you know a pump, the one you use when you put air inside the ball? In the bicycle, what is in the bicycle that needs a pump? What made the bicycle to move?

Mxolisi: You apply pressure on pedals and the bicycle moves.

Mxolisi was beginning to get a grip on what the lesson was all about although he seemed to be missing the point. He was focusing on the process of moving the bicycle while the TT was trying to point the class towards the concept of pneumatics systems.

TT: If bicycle tyres are flat, can it move?

Mxolisi: Yes if tyres are pumped.

TT: Yes, because you need air inside the tyres.

At this point the TT found a common point for moving forward with the lesson together with the participants.

In my observation the lesson on pneumatics was supposed to be a revision lesson, but learners could not make sense of what the TT was asking for. The TT was presenting the question in different ways before they could arrive at a satisfactory answer. This was observable in different questions from the TT and responses from learners. Learners were giving answers that were not addressing the question asked of them. At this point there was confusion between symbols that the learners were using for water and air. The teacher explained that she was not talking about water but air, and in her explanation was compelled to present the two words by spelling them out alphabetically, as illustrated in Figure 5.2B and 5.3 respectively.

Nosipho is providing her answer as water when the teacher was expecting air. The interpreter picked up immediately that there is confusion between water and air amongst learners. The interpreter used finger spelling as illustrated in Figure5. 2B and Figure 5.3 to differentiate between water and air.

Figure 5.2A Nosipho is answering a question but providing a wrong answer on her honest account

The words water and air were spelt out by the teacher using the letter symbols below

Water

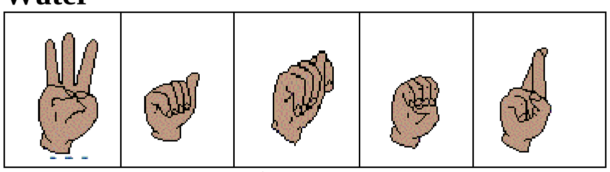


Figure 5.2B Finger spelling for 'water'.

Air

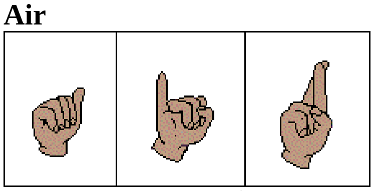


Figure 5.3 Finger spelling for 'air'.

The TT resorted to giving the term 'pneumatic' alphabetically using the symbols shown below.

Pneumatic

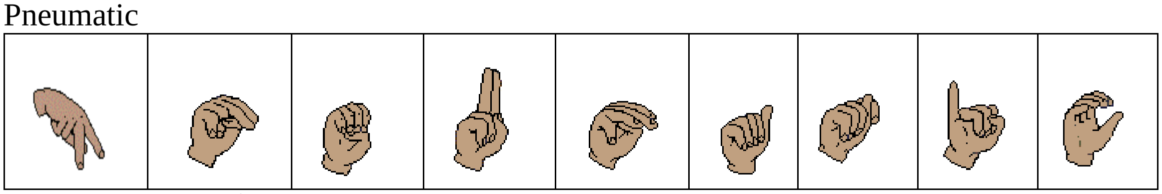


Figure 5.4 Finger spelling for 'pneumatic'.

The learners found it demanding to recall concepts on pneumatic systems. The TT was compelled to use leading questions to provoke the right responses from learners, as follows:

TT: Think of other examples that need to be pumped before use.

Zekhethelo: Car.

TT: Yes, good, a car, and another one?

Sphesihle: Motor bike.

TT: What is the purpose of tyres in given examples car, bicycle, and motor bike? [Technology teacher made an example of the bicycle tyre saying that the wheels have two tyres circumference with a rubber and that needs air. What can you use to put air inside tyres?

Mxolisi: You use a pump to put air inside tyres and the car moves.

TT: So what is the use of putting air inside the tyres?

Zekhethelo: To move the car easily

TT: What will happen if we keep on pumping the tyre?

Zekhethelo: The tyre will be full.

Such questions were probing learners' understanding about 'air' and 'pumping' as well as their conceptual understanding of the purpose for pumping. Although the examples the learners provided about equipment using air (car and motorbike) were ambiguous, the TT used these responses to lead the learners to practical examples that are practised on daily basis. The whole lesson on pneumatics presented by the teacher focused on a balloon, but the lesson was still theoretical (Figure 5.5).

The Technology teacher is talking about a balloon and the Sign Language interpreter is illustrating the balloon and the concept of inflation. The facial expressions of the TT are always important in miming the words and expressing the concepts.

Figure 5.5: The TT is illustrating a balloon using hands and facial expression.

An observable behaviour of participants was that before they presented an answer they would negotiate the understanding and come to a consensus before responding to the TT.

TT: What do people use to paint cars?

Zekhethelo: Showed a symbol of a gun.

TT: Excellent. In that gun full of paint, the compressed air is used to spray a car and the big container where the pipe is connected to blow air is called a compressor.

This question and answer approach by the TT was encouraging learners' involvement by provoking their thinking based on their daily experiences. It was observed that Zekhethelo and Mxolisi were active in providing responses and their engagement in the lesson depicted some grasp of the concept of pneumatics. In the process of teaching and learning learners had their Technology exercise books and Technology textbooks but the TT did not consult the textbooks and never checked the learners' books until the lesson was completed. Learners were told to prepare for the hydraulics lesson that was to take place the following week. I was eager to observe how the hydraulics lesson would be mediated in a classroom.

The introduction of pneumatics to learners was abstract in the sense that the concept of ‘compressed air’ did not have a concrete meaning to them. For example, questions asked by the TT (What do you understand about the compressed air? Where do we find compressed air? And/or where do we use compressed air?) Did not have a meaning to learners. This lesson addressed theoretical issues based on nonconcrete examples. For example ‘air in the confined space’ was illustrated by balloon, ball and/or bicycle tyres. As indicated in Smith (1993), the absence of vocabulary and exposure to pneumatics concepts limited participation of learners in this lesson since Sphesihle indicated plastic pocket for compressed air. Learners’ lacked ‘Communicative Knowledge’ found in Sign Language competencies and ‘Informal Knowledge’ based on exposure through experience.

5.3.2 Hydraulics

A lesson on hydraulics systems was introduced the following week. This lesson was slightly different to the lesson on pneumatics systems because it was developed from a demonstration. Before the lesson began, we greeted one another as a Technology team and allowed the lesson to unfold. When the TT introduced the lesson on hydraulics, they said “*Last week we learnt about pneumatic systems and today we are going to look at hydraulic systems.*” There were no questions relating to the previous lessons, it was just an indication of what was done the previous week. The Technology teacher prepared a simple model of hydraulic systems. She brought it to the class and drew the learners’ attention to the model (Figure 5.6).

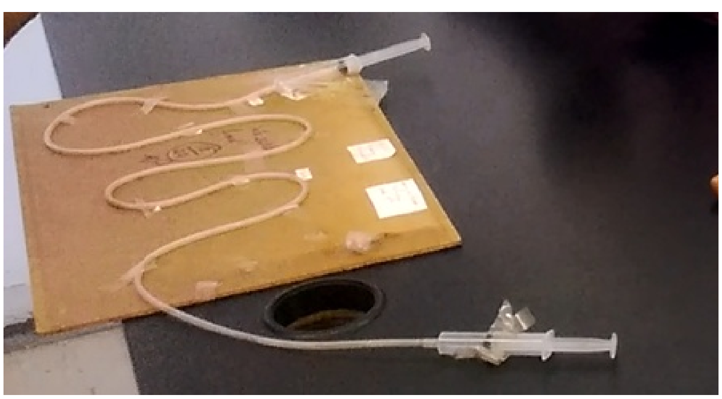
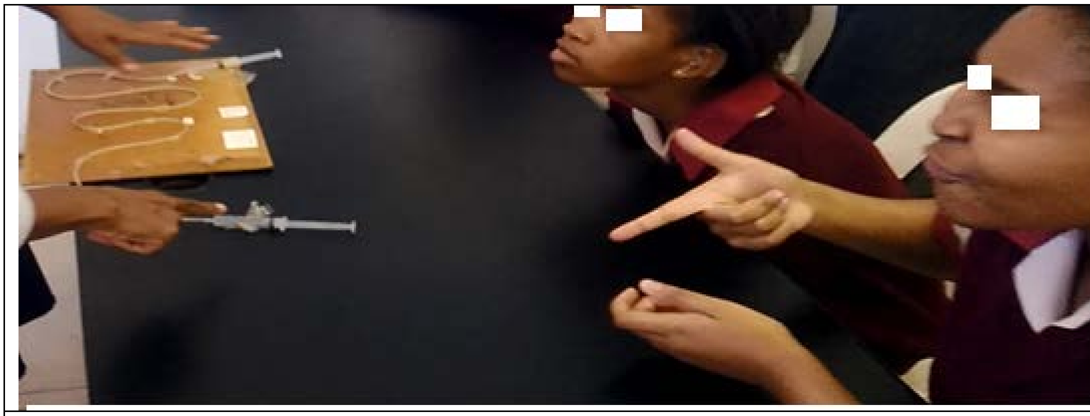


Figure 5.6: A model of a hydraulics system.

The TT asked questions related to the model. They pointed to the syringe and asked the learners what the object was used for. Unanimously the learners showed a symbol of a gun, as shown in Figure 5.7.



The teacher is asking for the normal function of the syringe. Sphesihle is showing a symbol of an injection. She is using both hands and her facial expression to emphasise the issue of the injection penetrating the body and injecting the medicine inside the body of a human being.

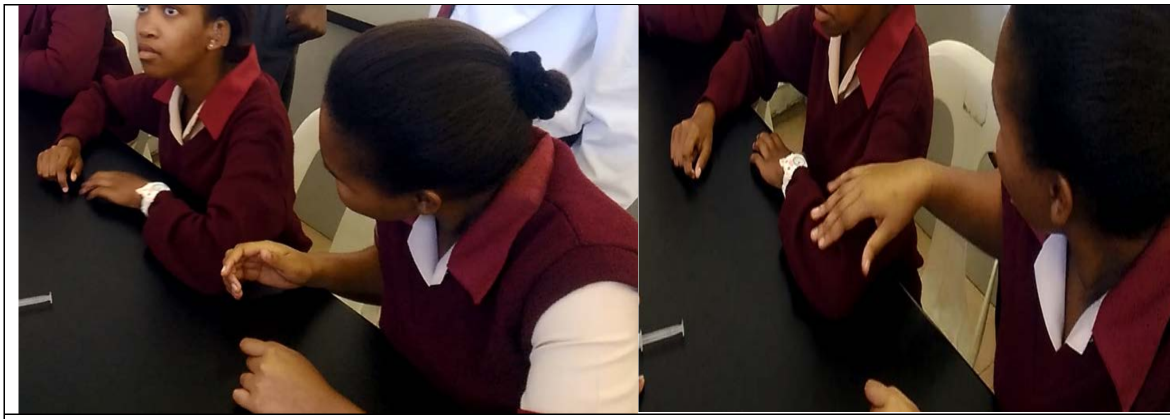
Figure 5.7: Description of the syringe

The TT further asked them for the use of the object. Learners directed their pointing fingers at their behinds, as shown in Figure 5.8.

Sphesihle is pointing at her bottom to illustrate the function of an injection.

Figure 5.8 Illustration of the function of a syringe.

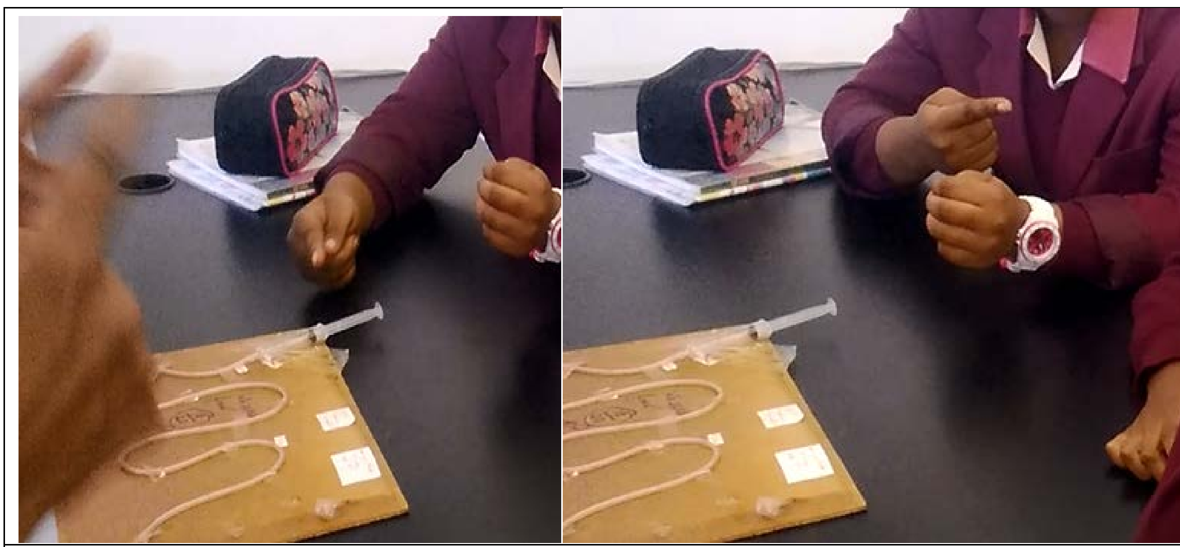
An observable behaviour in learners in the hydraulics lesson was that they were quick to respond to questions related to the model. If there was anything that learners could not make sense of, they negotiated the response before they provided an answer. They kept on teasing their fellow learners and explaining what they thought the question was looking for, as illustrated in Figure 5.9.



Sphesihle is teasing Nosipho to negotiate the answer.

Figure 5.9 Participants behaviour when they are asked questions, teasing and interacting with one another.

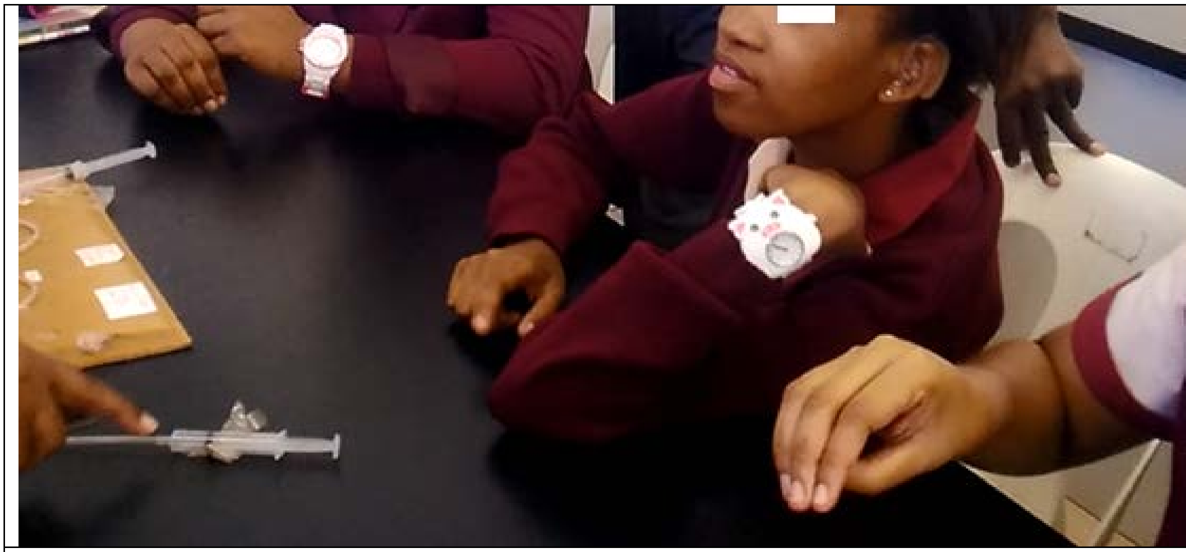
The TT allowed learners to operate the model. Zekhethelo applied a force on a syringe, and the other side of the syringe popped out. Sphesihle on the other side applied a force on a syringe, and the other side also popped out. The TT allowed learners to explain their observations. Zekhethelo gave a detailed explanation of how the model was operating, as shown in Figure 5.10.



Zekhethelo is explaining the operation of the two syringes in her own words, stating that when pressure is applied on the syringe on her left, the piston on the right syringe is forced out.

Figure 5.10: Zekhethelo is providing an explanation of the operation of the hydraulics model.

In the process of explanation the whole class was able to understand that this model of hydraulics systems was providing movements in the syringe when force was applied on the other end. As a result they showed a sign for 'movement' (Figure 5.11).



All learners are engaging in explaining the operation of hydraulic systems, with happy faces.

Figure 5.11 Participants reflecting on their observations about the hydraulics model.

Classroom participation was high and learner involvement was satisfactory. From the learners' explanations, participation and involvement, the TT was able to introduce the concept of hydraulics. Noticeably, there was no sign representing the word 'hydraulics' but the TT had to denote the word alphabetically, as shown in Figure 5.12.

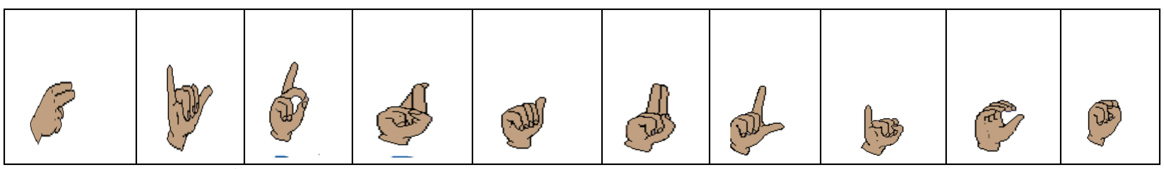


Figure 5.12 Finger spelling for 'hydraulics'.

Learners were exposed to an object (injection) that they had experienced at some stage. Their experience assisted them to focus their attention onto the operation of the syringe system. Learners knew that a syringe is carrying a liquid substance to inject them. As a matter of fact, learners were able to assimilate the lesson on hydraulics with their experiences of injection. For that matter, they were able to interact and their ability to understand the concept was enhanced. It was clear that the purpose of applying on the syringe, was to push the inside solution (water) as it was done for the injection to their bodies. This lesson approach provided a platform for 'Tacit Knowledge', where participants were able to watch and perform, as highlighted in (Mace, 2005).

The presentation of this lesson used the knowledge of pneumatics systems and a model of a hydraulics system as the prior knowledge which sets the platform for the class to get a grip of this lesson and participate fully. Both lessons (pneumatics and hydraulics) focused on the application of force in a limited space, even though air and water was used to enhance teaching and learning. A lesson on hydraulics integrated theory and practical. The TT extended the lesson by de-schooling the knowledge gained in the classroom to a real-life situation on the basis of daily activities. This is how the teacher introduced the application of a hydraulic system in a practical situation:

TT: To get to higher level of a building, what can you use?

Sphelele: Steps.

TT: What about a tall building with a great number of floors, can you use steps?

Sphelele: A lift.

TT: Good. What do the technicians use to get the lift up and down?

Sphelele: They use compressed air.

TT: No, they used compressed oil, which is also known as hydraulics.

TT: What does the word 'hydro' mean?

Class: *Attempted different signage and communicated amongst each other for clarity.*

TT: What is the scientific name for water?

Zekhethelo, Mxolisi and Sphelele: Signed H_2O.

TT: Excellent!

Learners were honest in any responses they provided as an answer. If the TT was asking for means to get up to a higher level of a building, they were sincere in saying 'You use steps'. Each time the teacher had to stretch their thinking through probing questions, I observed that learners were not showing similar understanding of daily activities, but through their peer support the learners were able to support one another. Zekhethelo and Mxolisi were better at understanding most concepts that were dealt with in class. In their cooperativeness they wouldn't mind attempting the question in different forms, irrespective of whether it was right or wrong. Learners were clued up about the chemical formula for water. The whole class responded with an understanding in unpacking a scientific formula for water, and the teacher exclaimed her pleasure with the whole class.

In concluding the lesson the TT highlighted the fact that two hydrogen plus oxygen molecules make up water. Now in talking about hydraulics they borrowed the word hydro from hydrogen. So hydraulics means compressed water or compressed oil, and for lifting heaver objects they used oil.

5.3.3 Lesson on pulley systems

The third lesson that I observed was a simulation of pulley systems using a model of a tackle, as it appears in Appendix E. The Technology teacher brought a complete model to class and the pieces of a model to be assembled by the learners. Instructions on how to assemble the model were given in an exploded view (separated small pieces) in stages. Each stage led to the next one until the model was completed. Learners were expected to carefully follow the instructions in the execution of each step. The TT greeted the class and revised the concept of pulleys with the learners. It appeared as if the section on pulleys had previously been done and this model in Appendix E served as a practical experience for participants. The Technology teacher brought a box with pieces of the model. The main focus of learners was on what the Technology teacher was carrying in a box. Later the TT showed a complete model to the class and requested the class to assemble their own model.

They were expected to assemble the model, which was separated into 11 sections. Each section contains a spare part list, as illustrated in Appendix E. Sufficient parts were provided in the box and some of them were joined together deliberately. An instruction in this simulation was given in the form of pictorial drawing of pieces. Pieces were provided in different colours. Participants were expected to assemble each stage that forms building blocks of the successive steps until the completion of the simulation. The following figures (5.13 – 5.20) illustrate the participation of the learners in the execution of this task in Appendix E. At the initial stage of the assembly of the model the participants negotiated their approach. They discussed pieces and compared pieces to the picture that appeared in the instruction book. Mostly the learners were sceptical of participating in the execution of the simulation, but Zekhethelo kept on pointing at what needed to be done. Sphesihle was keen to follow instructions in the process of assembling the model. Learners were reluctant to engage in the simulation, I observed that the learners were observant and watchful of each other.

Mxolisi was quick to see Sphesihle attempting to break the pieces wrongly, instead of dismantling them in the right way. This process in illustrated in Figure 5.13 and Figure 14.

Sphesihle is holding a piece and Nosipho is explaining how the piece is joined together. Zekhethelo is explaining her perspective about how the pieces are joined together.

Figure 5.13: The wrong approach to dismantling pieces.

Nosipho is failing to get the logic of dismantling the pieces. While she is attempting to break the pieces, Mxolisi swiftly observes the wrong approach to dismantling the pieces and is intervening.

Figure 5.14 Wrong approach in dismantling pieces

I observed that Zekhethelo active in the theory part (question and answer part of pneumatics and hydraulics lessons) of Mechanical Systems, but in practical involvement, she wanted to be aloof. She kept on instructing Sphesihle on what to do after referring to the instruction book. Participants were effectively working as a group as they kept on consulting each other on any action to be taken and communicated any idea they had to each other, as illustrated in Figure 5.15.

Sphesihle and Zekhethelo are comparing the position of a piece, trying to identify the relevant position for it. Unfortunately, at this stage the participants were relying on each other in working out a way forward to assemble the model, and not following the instructions from the guide which was provided.

Figure 5.15: Teamwork in identifying relevant pieces.

In the classroom there were three females and two males. Coincidentally, the females ended up working together on one side of the simulation while the males were working together on the other. Sphelele had not been independent in responding in theory lessons, but was very active and effective in assembling of the model. The boys' team was quicker than the girls' team as they were leading in assembling their side (Figure 5.16).

The boys are working on the right tower and the girls are working on the left tower.

Figure 5.16: Competing approaches from boys and girls.

Observable characteristics of participants in this class were that both boys (Mxolisi and Sphelele) were active in assembling the model. They were able to follow steps as prescribed in the instruction book. Zekhethelo wanted to be totally clear on what needed to be done, before she made attempts at combining the compartments of the project. Sphesihle was hands-on and wanted things done quickly without consulting the instruction book, while Nosipho took too long in relating the drawings and the system's structure. She did things the wrong way due to lack of hand-eye coordination. It appeared that she was not used to physical work as she was doing most things haphazardly. Sphelele shows practical accuracy and observes the miniature pieces along with the steps involved in putting them together to complete the tower. The combination of Sphelele and Mxolisi was effective, as Mxolisi provided the necessary materials while Sphelele was doing the actual assembling. In the process of building towers there was constant communication amongst the Deaf learners. The taller tower was made by the boys (Mxolisi and Sphelele) and the shorter tower by the girls (Nosipho, Zekhethelo and Sphesihle) (Figure 5.17).

The girls are working on left side of the model while the boys are working on the other side of the same model. The boys' tower is developing quicker than the girls' tower. Sphelele is shining in the practical, making a positive contribution and forming a good team with Mxolisi.

Figure 5.17: Boys leading the girls in making the towers.

The TT also made a remark that the group of two boys was more effective than the group of three girls. The boys gained advantage through their co-operation and their delegation of tasks - Mxolisi identified the pieces needed while Sphelele assembled them. Sphesihle first substantiated her actions by comparing the instruction manual and the model structure; if she didn't understand the instruction in the instruction book, she referred to the boys' work (Figure 5.18).

Zekhethelo kept on referring to the boys' side to complete their side. It appears as if she wanted to maintain the height while giving instruction to Nosipho. Zekhethelo is good at instructions and Nosipho is good at hands-on work.

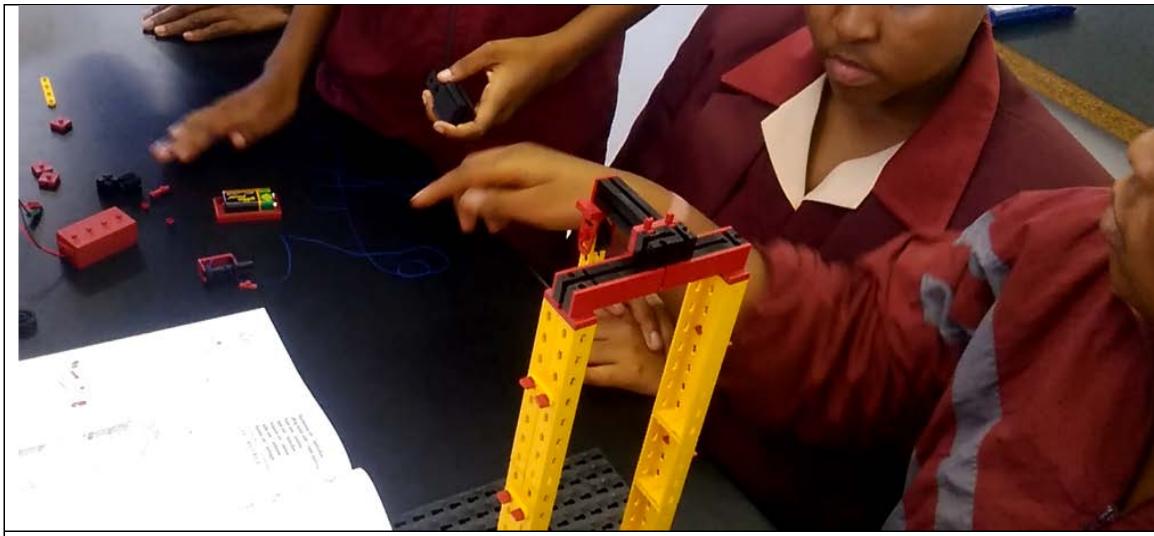
Figure 5.18: The girls are comparing their work to the boys' work.

Sphelele was assisting both teams (boys and girls) where there was misunderstanding. Nosipho, Zekhethelo and Sphesihle did not rely on the drawn instruction so much, but rather observed the other group's progress to check their project against theirs. Nosipho was not good at working in a team as she cannot take instructions or advice from her fellow group mates. Sphelele was active in suggesting alternatives drawn from the other group's project, the model and the written instructions. He was able to make informed decisions and conclusions in solving various problems encountered by both groups.

The tower is at its ultimate height. Nosipho and Mxolisi were looking for a piece for the top-most part of the tower. After an argument about a relevant piece from the class, these two have managed to identify the correct piece. Hence, Nosipho is alluding to Mxolisi with a thumbs-up.

Figure 5.19: Nosipho participating in decision making for appropriate pieces of the model.

In Figures 5.19 and 5:20 the Deaf learners are assembling the common section of the tower and the simulation that compelled them to work as a team. The boys were leading at this stage but the girls kept on making suggestions and commending the accomplishment of all the steps. The simulation of pulley systems emphasised the importance of instruction, cooperation and team work. Participants were always attentive when they look at something; they were quick to observe anything new or a strange movement. Nosipho was good in giving instructions, while Sphesihle was prone to relating the sketches to the project and its pieces. She was also able to ask for assistance from the others.



After the tower was completed, participants were forced to connect the electrical part of the model. The electrical part of the model was dominated with colour in the circuit diagram and learners were compelled to follow an instruction from the book without fail.

Figure 5.20: Participants working together to complete the model.

Simulation of pulleys was calling for observation, participation, communication and networking among learners. Learners shared thoughts and ideas that contributed to the development of both the Technology language and confidence. This is evidence of 'Communicative Knowledge' where the success of the model implies effective reading, contractive thinking and skilful handling of components. This practice (learning through simulation) concurs with the ides of Mace (2005), that good communication enables learners to better engage in social issues and learn from that environment, leading to receiving formal classroom instruction adequately.

5.3.4 Lesson on gears

I observed the TT introducing the learning on gears. I was familiar with the interpretation and the participation of learners in a non-hearing classroom. We greeted one another with appreciation. The Technology teacher had a model of different combinations of gears and worksheets for the learners. The worksheets that were prepared for learners appear in Appendix F. The TT greeted the class and went straight to the concept of gears. She asked the class to explain their understanding of gears.

TT: What is your understanding about a gear? What do you mean about a gear? Can you explain the gear?

In all these instances the TT was trying to put the question in an understandable way. Participants were communicating amongst each other, and Mxolisi responded: Gear lever.

The TT began their lesson from Mxolisi's response. They explained the gear lever as an arm for shifting the gears inside the gear box and the TT further indicated the difference between the gear and the pulley.

> **TT:** A pulley is a wheel with a groove. It is also a wheel over which you loop a rope, while a gear is a wheel that has teeth cut around its edge. Like pulleys, gears are held on a gear shaft allowing teeth of different gears to mesh to each other.

Technology teacher took a model of two gears interlocked into each other. She showed them the bigger gear and the smaller gear and demonstrated the movement of gears, as shown in Figure 5.21.

The signing TT is introducing gears using the model. While the Technology teacher was referring participants to a 'bigger' gear, the signing teacher is signing 'big' with a facial expression emphasising that.

Figure 5.21: Illustration of gear train with two gears.

The TT drew the learners' attention to the direction of the gears, asking as follows:

> **TT:** What is the direction of a smaller gear if the bigger gear is rotating anticlockwise?

Participants were demonstrating their understanding in different ways, as illustrated in Figure 5.22.

Individual participants are showing their understanding of the movements of gears. Fingers and hand positions are evidence of different symbols. The intention is to provide answers in relation to 'clockwise or anticlockwise'.

Figure 5.22: Identification of direction of gears.

The learners were talking about different directions, with some saying that the smaller gear moves. Observation of the movement of gears stimulated the thinking of all learners in the classroom. Learners expressed their thoughts in Sign Language within the limits of their vocabulary as shown in Figure 5. 22. (Smith, 1993). In this lesson, demonstration of the movement of gears was used as a tool for channelling thought processes in learners and allow them to predict patterns of the movement of different gears in a gear train. Of course, this lesson on gears requires a 'Formal Knowledge' where a proof of different directions are observed by learners. The TT emphasised the concept of clockwise and anticlockwise movement as an essential element for identifying directions relevantly. The Deaf learners were attentive in observing different movements, as illustrated in Figure 5.23.

The signing teacher is highlighting the directions, clarifying the ambiguity of left - anticlockwise and right - clockwise.

Figure 5.23: Presentation of a lesson on gears.

After the explanation of the concepts of gears based on the model with 2 gear, the Technology teacher took a gear train with three gears. The TT highlighted movements of each gear within the model of the gear train. They initiated the movement on the big gear, allowing the participants to explain the movement of the last two gears as shown Figure 5.24. Learners identified directions of gears on the model adequately. The TT focused the attention of learners on the purpose of the middle gear and the appropriate term used for it in (Figure 5.25).

Both hands of the signing teacher are identifying two similar gears beside the centred one. The Technology teacher is displaying a model of three gears in their different sizes.

Figure 5.24: Introduction of gear train with more than two gears.

Within the combination of three gears, the emphasis is on the middle (centre) gear. Hence the signing teacher is pointing at the palm of the hand

Figure 5.25: Equivalent signing for idler gear.

The signing teacher is showing a symbol for small. The body, face and hands are coherent in signing

Figure 5.26: Sign used to denote small gear.

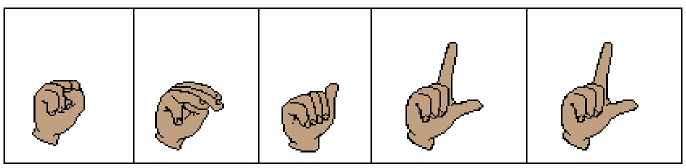


Figure 5.27: Finger spelling for ‘small’.

In another explanation of a set gear system with three gears, movement of hands together with a facial expression and the movement of the upper body was used to convey the message as shown in (Figure 5.28).

The emphasis is on relative movements of the three gears.

Figure 5.28: Total use of expression involving the whole body.

5.3.5 Symbols used for the direction of gears

After the lesson presentations were done, and the exercise was given to participants, they were given a chance to present their understanding and the signage for the important concepts in gear systems. The word ‘clockwise’ was signed as clock + wise, as shown in Figures 5.29 and 5.30 respectively, and ‘anticlockwise’ was signed in anti +clock + wise, as shown in Figure 5.31.

(i) Clockwise

Mxolisi and Zekhethelo are showing a symbol used for the word ‘clock’.

Figure 5.29: Signing ‘clock’ as the first part of clockwise.

The term ‘“clockwise’ is used for measuring and displaying time; a clock movement has been adopted by nations and been trusted for ages for time-space. A conscripted mechanism for a clock is commonly used as a point of reference in terms of direction. Its dependability is evident in a non-hearing environment. From the perspective of a clock arm movement in Figure 5.33, Mxolisi and Zekhethelo are relating a right movement of gears to the movement of a clock as their point of reference. The term clockwise is separated into ‘clock’ and ‘wise’ in Sign Language

Sphelele and Mxolosi are showing the symbol for the word 'wise'.

Figure 5.30: Signing the word 'wise'.

The word 'wise' is denoted by the fingers signing the symbol 'W'; 'wise' is complementing the term used for a right movement ('clockwise'), and participants in the class signed the term separately.

(ii). Anticlockwise

 Anti	 Clock	 Wise

Nosipho is showing a sign for the word 'anti', Zekhethelo is signing the word 'clock' and Mxolisi is signing the word 'wise'.

Figure 5.31: Anticlockwise.

The word 'anticlockwise' is signed as its three separate components in the Deaf community: 'anti', 'clock' and 'wise'. Nosipho, Zekhethelo and Mxolisi are signing the term with understanding. The Sign Language symbol for 'anti' is used relative to a finger signing 'a', which gains a meaning related to a left movement when it is used in conjunction to the whole term 'anticlockwise'. In both of the terms 'clockwise' and 'anticlockwise' there is intersection of negotiated context of Mathematics understanding and clock movement. This is integrated with finger signing to give an idea of a required vocabulary that interprets a Mechanical System's concept used in rotary motions through Sign Language, as indicated in (Chettiparamb, 2007; Lyall et al., 2011).

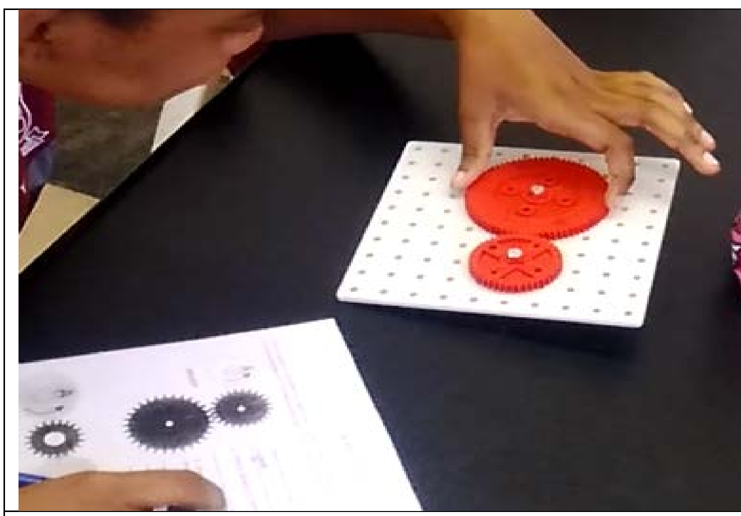
5.4 Written responses

This section focused on the written responses provided by learners during the learning of Mechanical Systems. This section encapsulated behaviour of learners to classroom exercise and their calculations done in the worksheet.

5.4.1*(a) Behaviour of learners to individual classroom exercise*

After all the teaching and demonstrations by the TT, participants were given a chance to work individually on their worksheets. The TT moved around helping individuals. Sphesihle was unable to relate the model of gears, the picture, and the instruction. When the teacher asked 'In which direction is the gear turning?', Sphesihle responded in reference to the speed instead. She says things that are related to the model and not the instruction. She struggled to find the correct technological term, although she went on to understand the model, picture and instruction, and grasped the conceptual aspect of the activity. She was very general in her response.

Nosipho could not relate the model, picture and instruction. When asked by the teacher in which direction Gear B was going, her response was that it goes left. As a result she could not find the correct term to relate the observation to the question asked. She concluded by responding "right-movement-wise" (Figure 5.32).



Nosipho is struggling to make sense of the gears on the exercise and gears on the model.

Figure 5.32: Relationship between the model of the gear train and the pictorial drawing.

Zekhethelo understood the terminology of clockwise and anti-clockwise and was able to relate the model, picture and instruction together along with observations and subsequent instructions (Figure 5.33).

Zekhethelo has turned the model vertically to simulate the picture on the worksheet. She is illustrating the directions to Nosipho.

Figure 5.33: Drilling of direction of gears as per instruction on the worksheet.

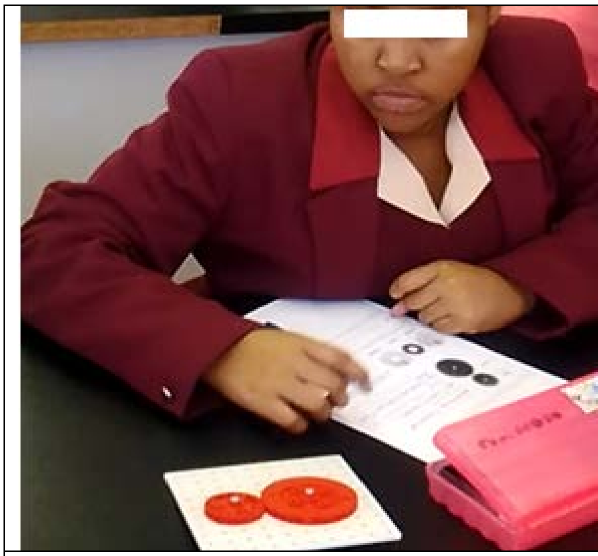
Nosipho and Sphesihle ask Zekhethelo whether or not he understands the activity, as he seems to be clued up on the activity (Figure 5.34).

Nosipho is teasing Zekhethelo to confirm her understanding about gears.

Figure 5.34: Participation in model interpretation.

Mxolisi understood the model, even when the third, idler gear is included, and he is able to explain the observations using the proper terminology of clockwise and anti-clockwise.

Mxolisi understood the concepts of anti-clockwise and clockwise, understood the model, and was able to take instructions and do work quicker than others. He was also able to identify the relative speeds of the gears, although he struggles with written instruction. Sphelele was assisted by the Technology teacher in the completion of the task as he was not able to give a relevant reason for the speeds in relation to the sizes of the gears. Zekhethelo was able to understand the written instructions and did not struggle in making an attempt at the given activity (Figure 5.35).



Zekhethelo is consistently using the models effectively

Figure 5.35: Comparisons of the model and the drawing.

5.4.1*(b) Written responses*

I watched the engagement of learners in an exercise on gear trains after it was taught and demonstrated. The word ‘gear’ did not have a signing symbol, but the TT signed it alphabetically. Demonstrating gears to participants developed the concept of gears and unpacked it more than mere words could say. Learners were able to recognise directions, the effects of interlocking and the influence of speed and size on gears. Although a worksheet was not intended to assess learners, it enhanced their understanding and empowered individual understanding of essential concepts on gears. The worksheet integrated short type questions and a graphical component approach.

In the short questions, learners were able to recall directions from the model they used to answer the classroom exercise (Questions 1 – 5). During the teaching and demonstration of gears the emphasis was on the effect of the input gear on the output gear, the idler gear and the direction of all gears included on the gear train. For that matter, learners responded appropriately to the first four questions of the worksheet with minor mistakes.

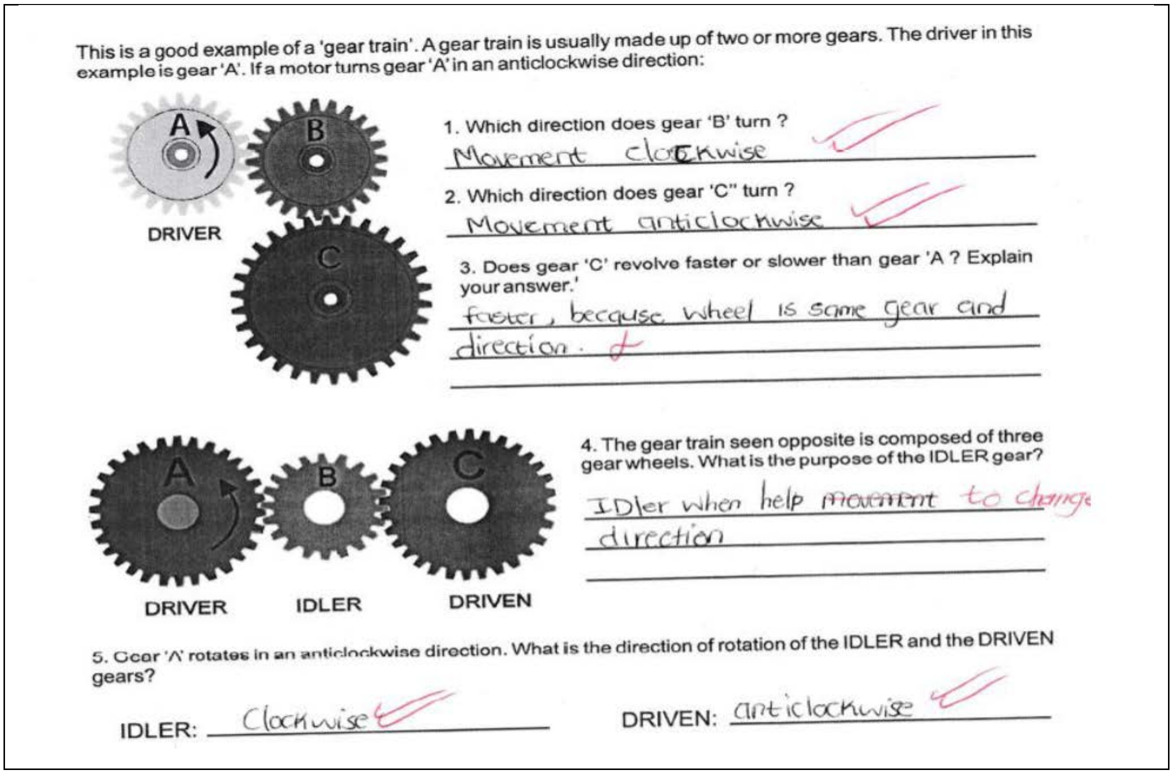
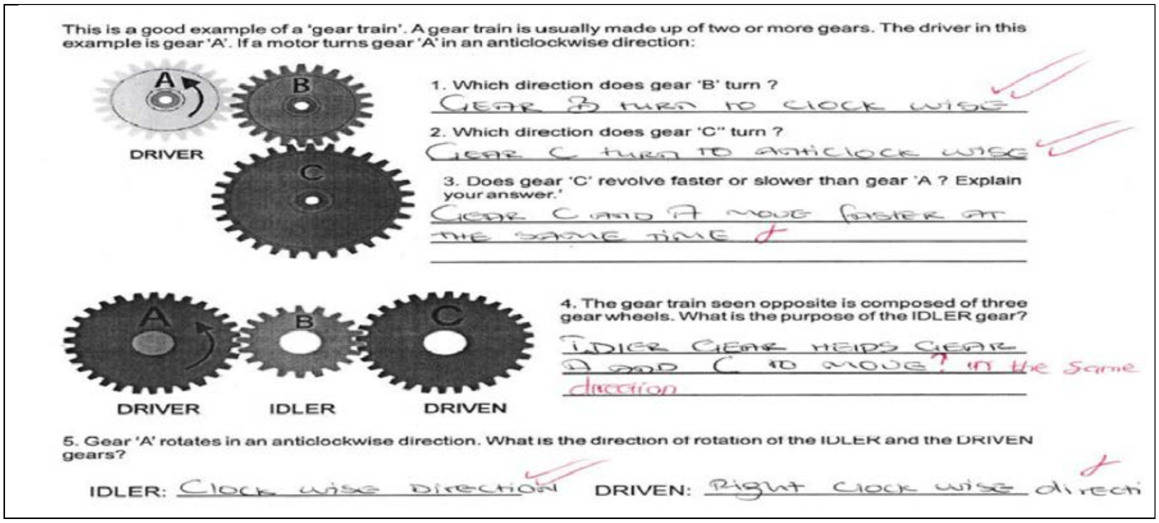


Figure 5.36: Zekhethelo's response to gear questions.

I observe from Figure 5.36 that Zekhethelo could fathom the rotational direction of the output gear from a two-gear system to a three-gear system. However in, Questions 3 and 4 she failed to identify which rotational speed was greater for the three-gear system provided. She seems to be of the opinion that since the gears are interlocking they should be moving at the same speed. Zekhethelo had a better understanding of the function of the idler gear and its influences the output gear.


This is a good example of a 'gear train'. A gear train is usually made up of two or more gears. The driver in this example is gear 'A'. If a motor turns gear 'A' in an anticlockwise direction:

1. Which direction does gear 'B' turn ?
GEAR B turn to clock wise

2. Which direction does gear 'C" turn ?
Gear C turn to anticlock wise

3. Does gear 'C' revolve faster or slower than gear 'A ? Explain your answer.'
Gear C and A move faster at the same time

4. The gear train seen opposite is composed of three gear wheels. What is the purpose of the IDLER gear?
IDLER GEAR helps GEAR A and C to move? in the same direction

5. Gear 'A' rotates in an anticlockwise direction. What is the direction of rotation of the IDLER and the DRIVEN gears?
IDLER: Clock wise Direction DRIVEN: Right clock wise directi

Figure 5.37: Sphesihle's response to gear questions.

Sphesihle (Figure 5.37) was not able to identify which speed of rotation was greater in Question 3. The rotational direction of gears in gear trains provided was understood by Sphesihle. He answered Question 4 as if the idler gear is spanning the gap between gear A and B, yet the focus was on direction. He managed to answer the first part of Question 5 based on the layout presentation of a gear train; however, he failed to identify the direction of the 'DRIVEN' in Question 5. Use of the term 'Right clock wise direction' by Sphesihle seems to show that he is acquainted with the words used to identify gears A, B and C as DRIVER, IDLER and DRIVEN gears respectively.

In my observation of the lesson on gears the TT did not highlight the importance of gear symbols. The gear symbol contains the meaning of graphical communication. The Technology teacher omitted the emphasis of using the gear symbol in answering Question 6 when she was marking the question too. As a result, all participants represented the combination of the gear train in number 5 as adjacent saddles, as shown in Figure 5.38.

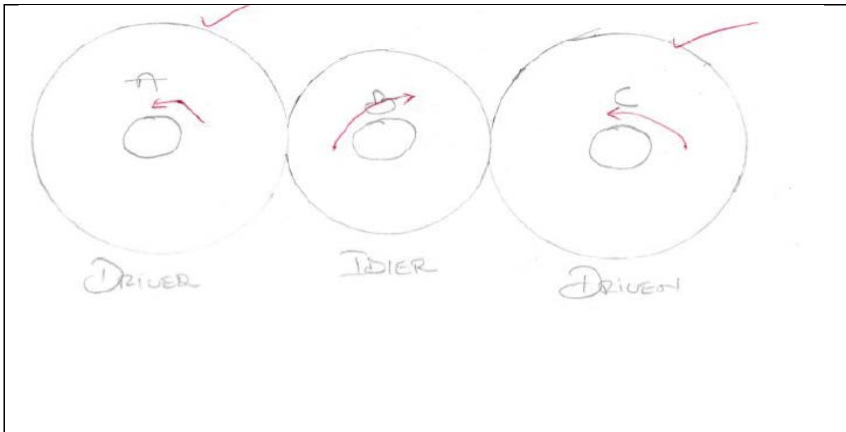
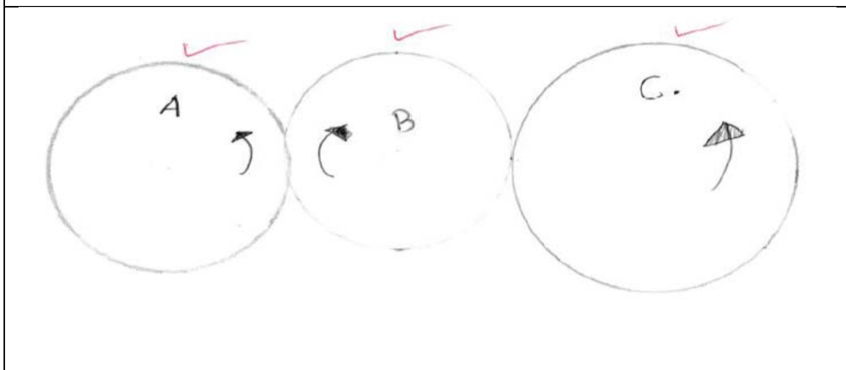
	*Sphelele provided adjacent circles with an indication of their middle parts. The middle part is not a proper indication of a centre used in drawing gear symbols. He did not provide the direction of movements on each gear but identified them as A, B and C. the Technology teacher indicated how the directions should be indicated using a red pen*
	*Sphesihle provided adjacent circles with no indication of their middle parts. She indicated directions of movements and identified each gear A, B and C. The gear symbols are not emphasised but the concept of clockwise/anticlockwise is emphasised*

Figure 5.38: Sphelele and Sphesihle on graphical representation of gears.

Of the five Deaf learners in this group, 60% did not provide a direction as requested by the question, but 40% managed to provide a proper direction, and the Technology teacher recognised this when she was marking. The Technology teacher marked the adjacent circles as the correct answers for all of the participants and indicated directions with a red pen for those who did not include directions.

5.4.2 Calculations done by learners in the worksheet

After observing the TT teaching different topics in Mechanical Systems, my attention was captured in assessing the understanding of the participants. A worksheet (Appendix G) was provided as a form of revision after all topics in Mechanical Systems had been dealt with. As a point of interest I focused on Question 6 on levers and MA on levers, and number 10 – calculations on hydraulics systems, as well as number 12 on calculations on gear train. Each of these sections gave learners' responses as evidence of their understanding of calculations. All of these sections have an aspect of MA in common. (Figures 5.59 and 5.60 show illustration of MA using Sign Language.)

5.4.2(a) Learners' responses to Question 5

MA is a specialised language used in Mechanical Systems, which qualifies the benefits of using a machine. The concept of MA centres on the comprehension of ratio. The understanding of the mechanism in each machine, e.g. hydraulics, gears, pulleys, levers, etc., enables participants to identify input/effort and output/load. Participants unpacked the concept of MA profoundly.

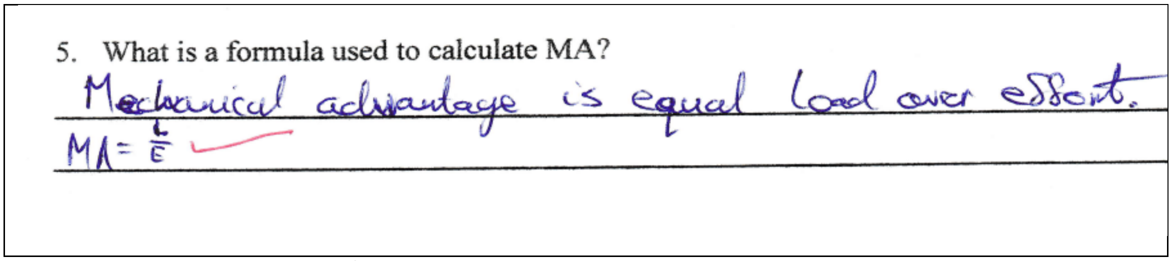

5. What is a formula used to calculate MA?
Mechanical advantage is equal load over effort.
$MA = \frac{L}{E}$

Figure 5.39: Mxolisi's understanding of MA.

Mxolisi provided a translation of verbal language and a shorthand version, as illustrated in Figure 5.39.

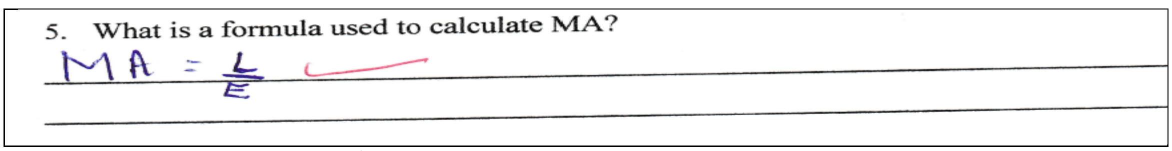

5. What is a formula used to calculate MA?
$MA = \frac{L}{E}$

Figure 5.40: Nosipho's understanding of MA.

Nosipho is presenting the MA formula using shorthand only.

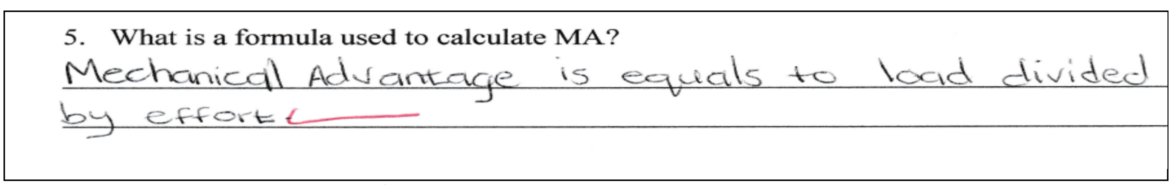

5. What is a formula used to calculate MA?
Mechanical Advantage is equals to load divided by effort

Figure 5.41: Zekhethelo's understanding of MA.

Zekhethelo provides an MA formula in words.

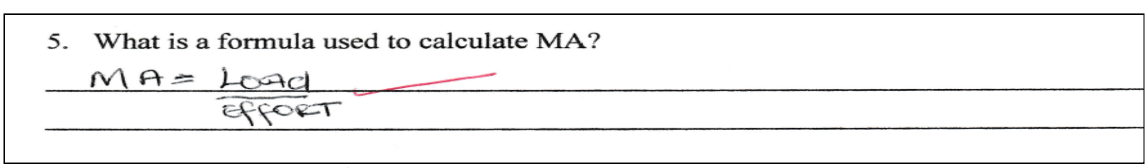

5. What is a formula used to calculate MA?
$MA = \frac{Load}{Effort}$

Figure 5.42: Sphesihle's understanding of MA.

Nosipho is presenting the MA formula using pertinent concepts (load and effort) used in MA based on their functional relationships.

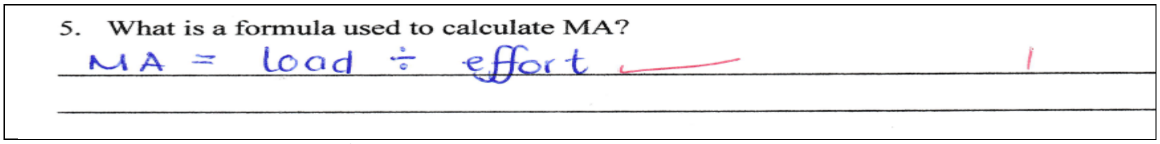


Figure 5.43: Sphelele's understanding of MA.

Sphelele is presenting the MA formula using pertinent concepts (load and effort) with a binary operation between them. This shows different approaches by participants from the same class. None of these approaches is wrong; they provide a diverse approach to learning. The responses provide ambiguity since the word 'over' has multiple meanings that are slightly deviant from Mathematics language. These are meanings contained in the word 'over' that have less to do with Mathematics: 1) ended, 2) again, 3) remaining, 4) talking about something that changes positions, etc. The implication in Mxolisi's response is that the word 'over' is used as the division. The formula provided for MA in Figure 5.39 suggests a process of dividing load by effort. Participants did not go to the terrain of highlighting the relationship between load and effort / output and input in the form of numbers that will quantify how each of these quantities (load and effort / output and input) behave in relation to one another. Although there is no standard format for representing a division operation in an MA equation, participants representing a formula for MA differently, as illustrated in Figures 5.39 - 5.43.

5.4.2(b) Written responses of learners on lever question (Question 6)

Question 6a (Table 5.1) demanded an understanding of MA. MA facilitates the core business of employing instruments to make work easy. This question required a procedural application of an MA formula where a general Mathematics rule is expressed using algebraic symbols. In this question all learners were able to use the context-specific rule appropriately, providing a relationship between load and effort through the guidance of the formula. Learners were able to recall patterns and relationships between input force and output force that will cause motion and represent that mathematically.

Table 5.1
Summary of the learners' responses to question 6a

Participation in Question 6a	**No. of learners that participated**
Correct identification of formula	5
Correct formula but error in substitution and working	1
Incorrect formula	0
No attempt	0
Did not write formula but provided an answer	0

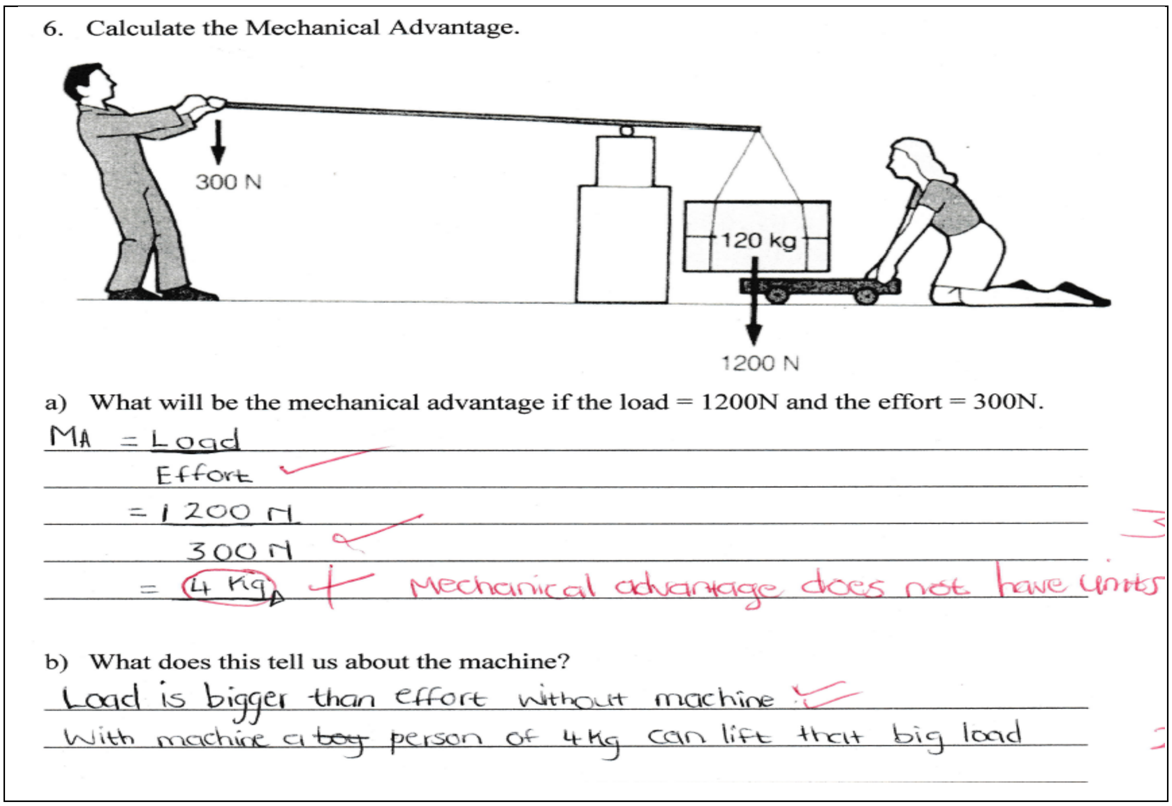
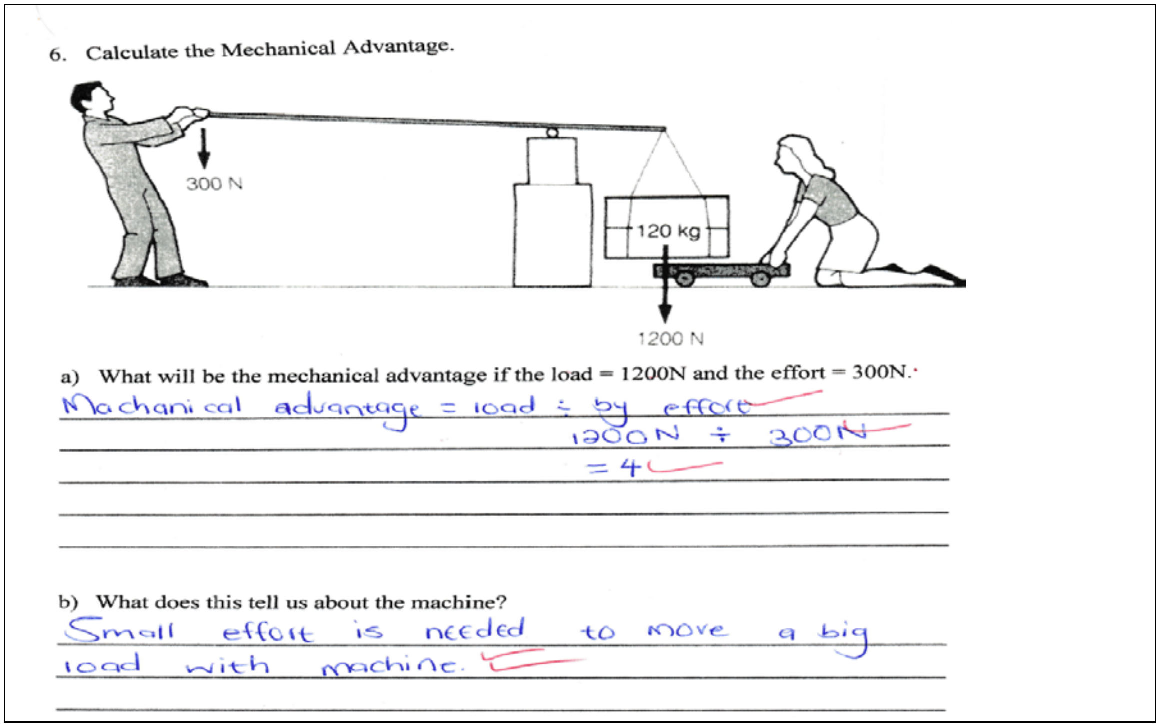


Figure 5.44: Zekhethelo's response on levers.

Zekhethelo approached her calculation of MA correctly but missed a conceptualisation of MA in a ratio form. In exploring why her answer was expressed in kg, she said:

> *… I was told to put units in all my answers for correct. I used N in load and effort now I used kg because N cancelled each other …*

She is missing the concept of comparing load to effort. She probably regarded an answer of 4 kg as human effort instead of being a ratio of output to input. Although she indicated that she used N for both the numerator and denominator, she did not identify this as a ratio


6. Calculate the Mechanical Advantage.

300 N

120 kg

1200 N

a) What will be the mechanical advantage if the load = 1200N and the effort = 300N.

Machanical advantage = load ÷ by effort

1200N ÷ 300N

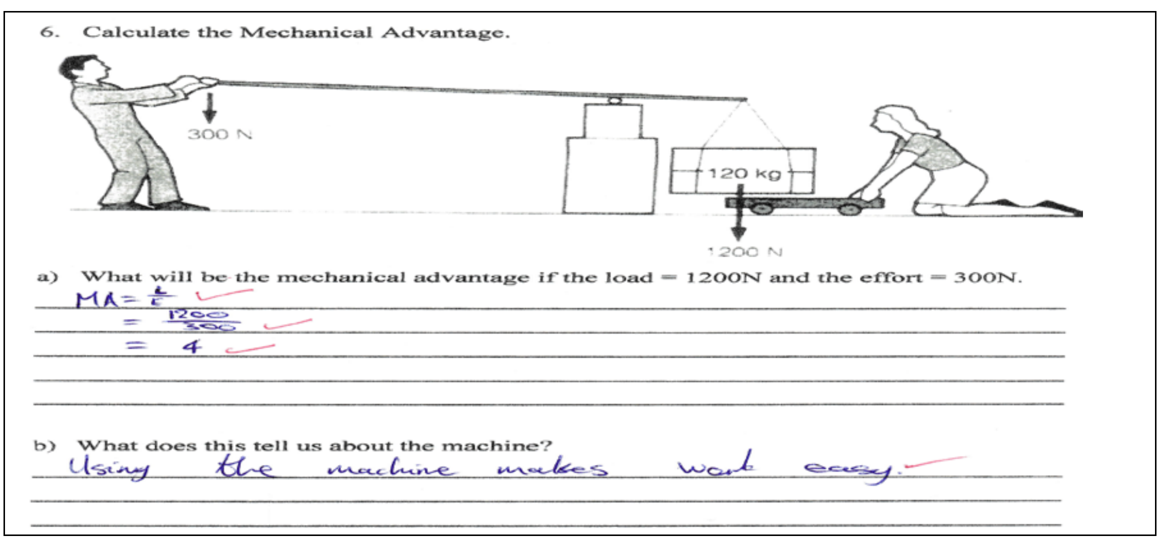
= 4

b) What does this tell us about the machine?

Small effort is needed to move a big load with machine.

Figure 5.45: Nosipho's response on levers.

Nosipho approached this question with understanding. She used a binary operation (division) in calculating MA. Her response to Question 6b is convincing that she can relate calculations to the real situation.


6. Calculate the Mechanical Advantage.

300 N

120 kg

1200 N

a) What will be the mechanical advantage if the load = 1200N and the effort = 300N.

MA = L/E

= 1200/300

= 4

b) What does this tell us about the machine?

Using the machine makes work easy.

Figure 5.46: Mxolisi's response on levers.

The general statement provided by Mxolisi to Question 6b says nothing about the ratio of 4 from his calculation.

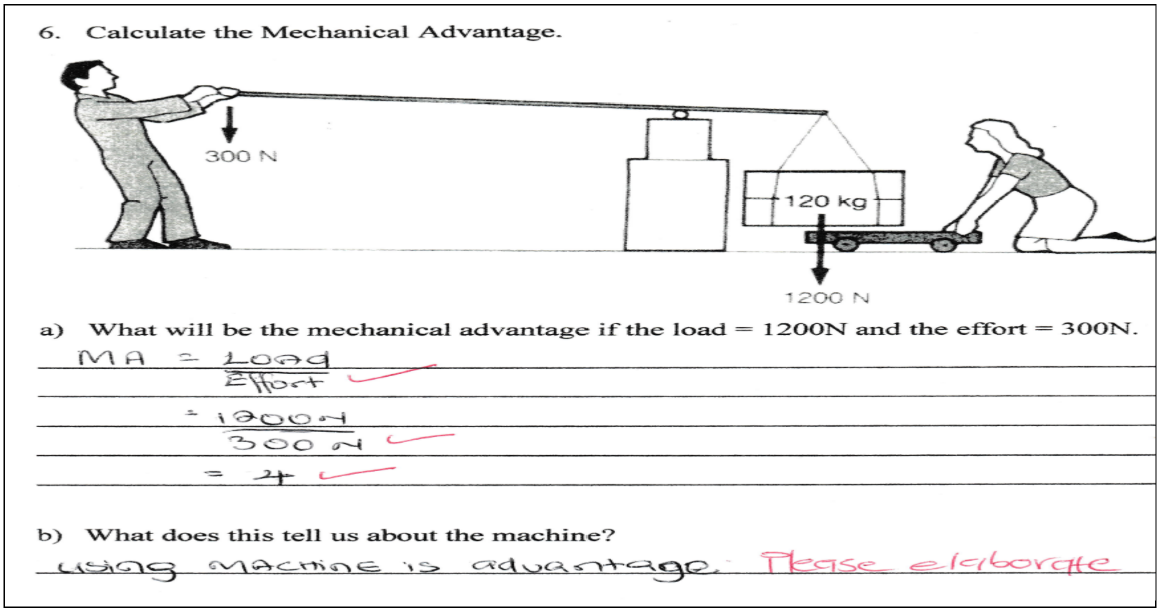


Figure 5.47: Sphesihle's response on levers.

Sphesihle presented a formula in a ratio form. Calculations are done adequately. However, he failed to extend his approach to unequal properties required to highlight the availability of advantage in using a machine.

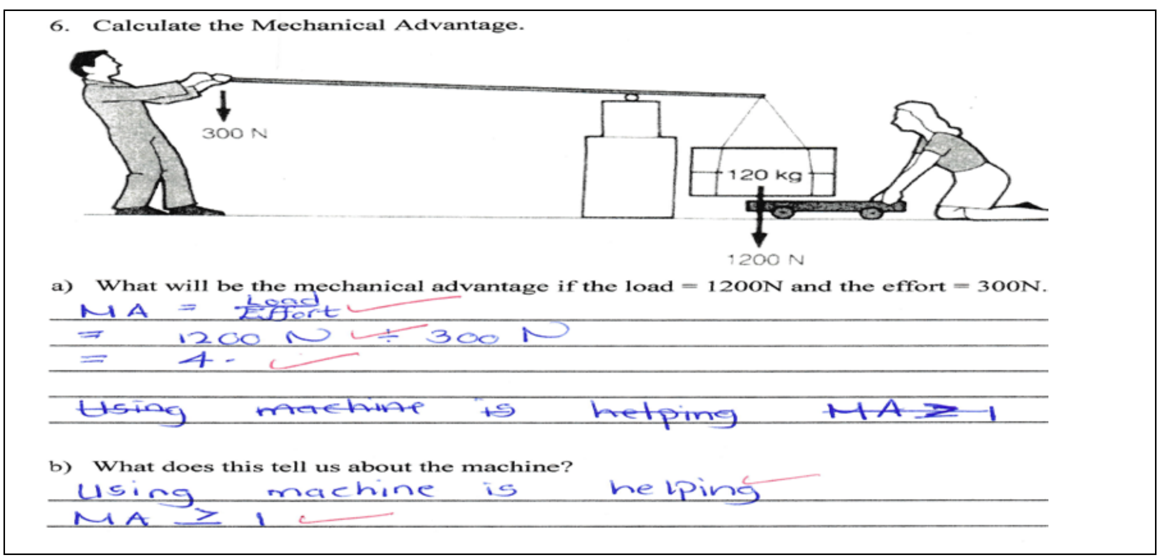


Figure 5.48: Sphelele's response on levers.

Sphelele provided an inequality concept used in machines that have an MA. This inequality was useful, as he realises that MA ≥ 1 applies a smaller effort.

We observe that Sphesihle wrote the ratio as $\frac{1200}{300}$ and Nosipho wrote it as $1200 \div 300$. These learners show different ways of representing a ratio which enhance their understanding of the operation of division to making comparisons between the output and input.

Eighty per cent of the participants attempted Question 6 adequately, which requested learners to calculate MA. A pictorial drawing was given together with an instruction. All were procedurally correct, with the exception of Zekhethelo, who felt that the answer is not sufficient without a unit of measurement. She appended ‘kg’ instead of giving the answer without the unit of measurement. Amongst the participants nobody talked about ‘ratio’ even though Question 6b expected an understanding of the fruitfulness of the simple machine based on the ratio of output to input/load to effort.

Elaborating on Question 6 as a whole, in Question 6b 70% of learners were able to provide adequate responses about Question 6a. Sphelele was able to provide the response mathematically, saying MA ≥ 1. Of the learners 80% managed to identify the association between output and input, and able to classify output and input to load and effort respectively. Ultimately they were able to formulate the relationship into a quotient without a unit of measurement, and the relationship of input and output into a quotient. However, while Zekhethelo was procedurally correct in calculating MA, she failed to represent the answer in a ratio form. Ratio does not have a unit of measurement.

5.4.2(c) Learners’ response to hydraulics system calculation (Question 10)

Number 10 demanded the calculation of hydraulics systems through Pascal’s law. In this question learners were expected to understand the principle of a simple machine and apply Pascal’s law. I observed different approaches from all of the participants. The identification of formulas was correct, but values that were substituted in formulas were considered differently based on their understanding.

Table 5.2
Summary of the learners' responses to question 10

Participation in Question 10	No. of learners
Correct identification of formula	2
Correct formula but error in substitution	0
Incorrect formula	0
No attempt	0
Did not write formula but provided an answer	3

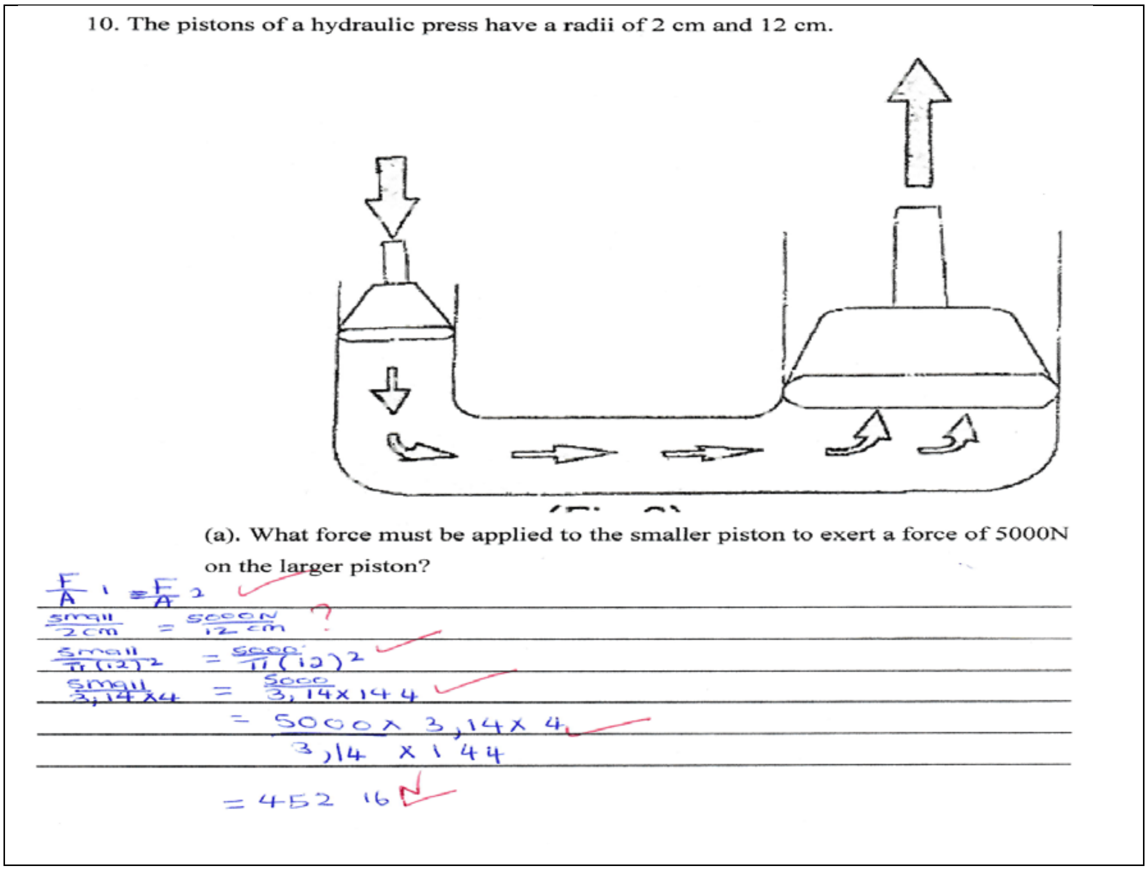


Figure 5.49: Nosipho's response on hydraulics.

The response of Nosipho in the second step (Figure 5.49) showed a misunderstanding of the given information. Pistons of the hydraulic press were given in radius and the radius was given in centimetres. Nosipho substituted radius values in the place of areas in the second step, but in the third step she is now calculating for an area. It is not clear whether the learner understands the procedure of calculating pressure clearly.

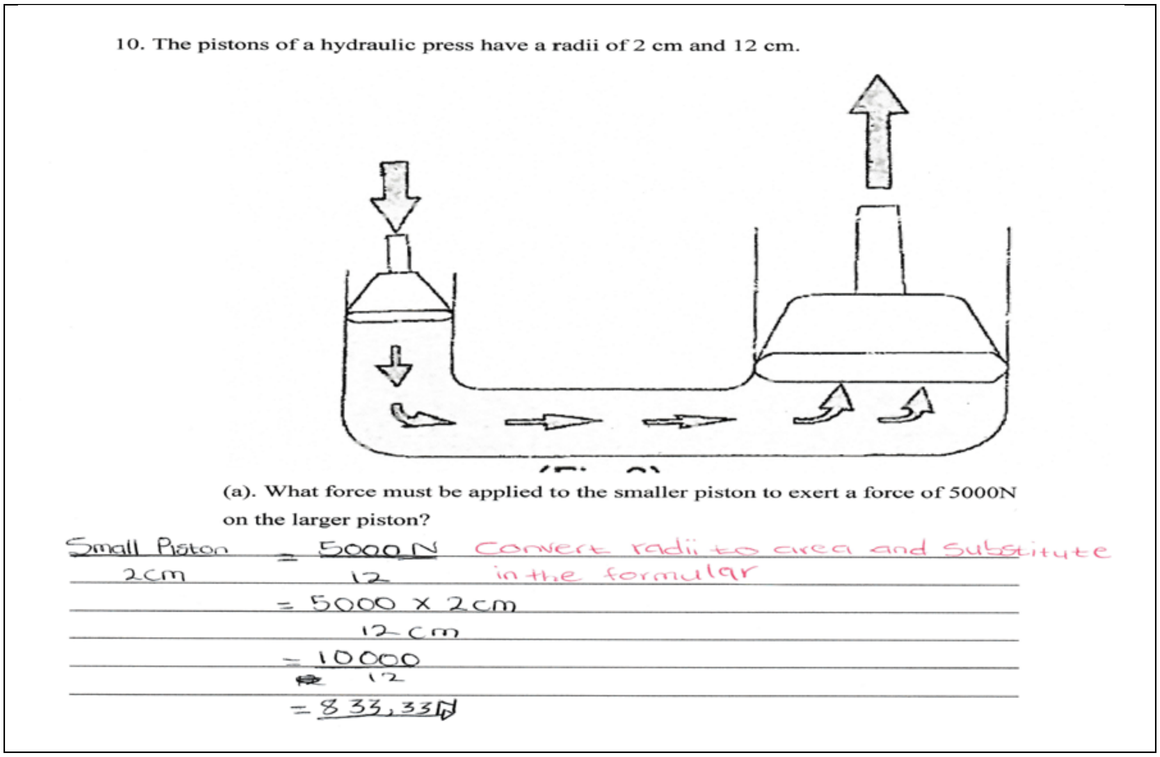


Figure 5.50: Zekhethelo’s response on hydraulics.

Zekhethelo seem to have understood the procedure but ignored the basics for calculating pressure (Figure 5.50). She did not provide a formula for calculating pressure. She did not calculate area but instead took the raw radius data and used them in centimetres. She did not bother to convert them into metres nor calculate an area. Instead, she stuck to the procedure and ignored the principles.

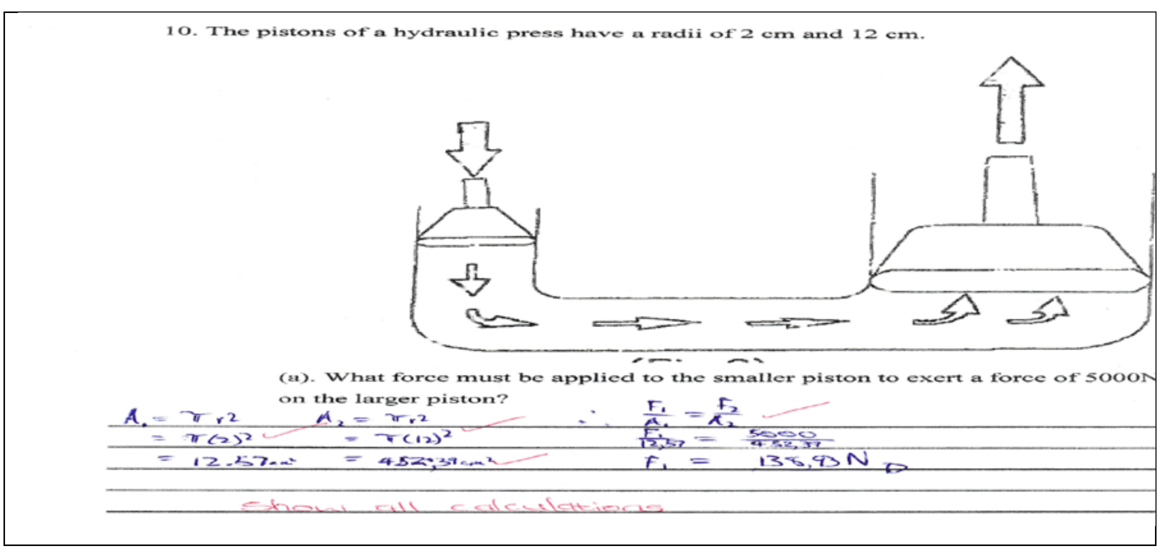


Figure 5.51: Mxolisi’s response on hydraulics.

Mxolisi knew that he had to calculate areas before substituting them in the formula (Figure 5.51). It appears as if Mxolisi calculated an area without converting centimetres to metres as per the requirement for pressure calculation. A measuring unit for pressure is N/m^2; this suggests that we completely and properly convert centimetres to metres before we calculate an area. When I asked Mxolisi as to why he did not do this, he said:

> *…two pistons are using centimetre. When I am calculating force, centimetres will cancel because they are equal to centimetres…*

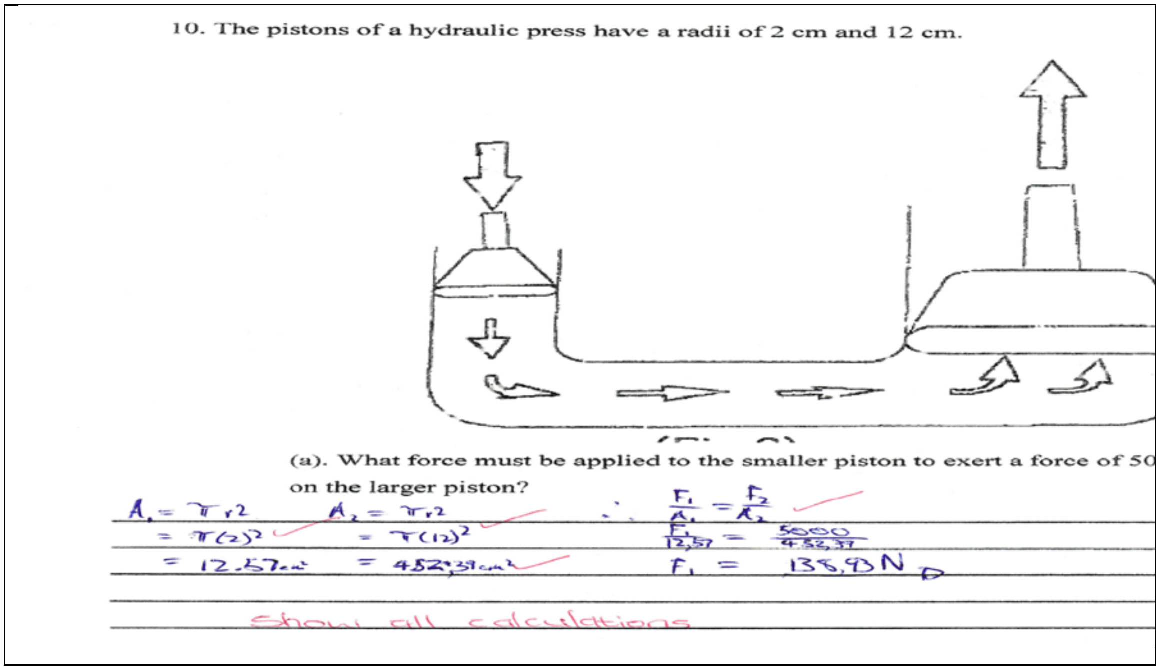


Figure 5.52: Sphesihle's response on hydraulics.

Sphesihle worked out the problem in the same way as Mxolisi (Figure 5.52). Both participants knew that they have to calculate an area before looking for a force required. They are not highlighting the issue of pressure in their calculation, but are more interested in finding the force required

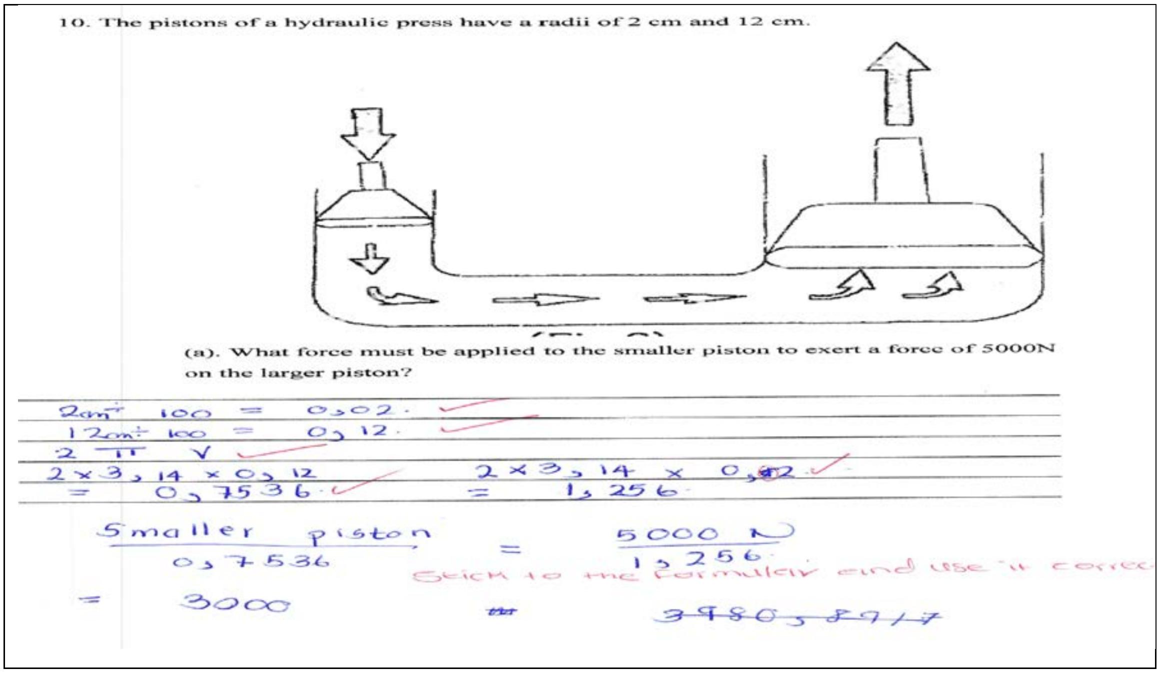


Figure 5.53: Sphelele's response on hydraulics.

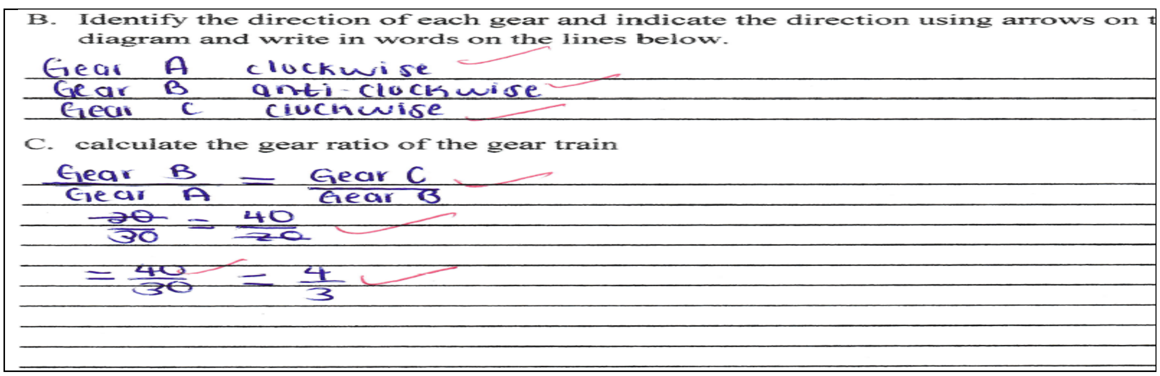
Sphelele converted centimetres to metres and thereafter calculated areas of each piston and substituted the answer into the formula for both pressures (Figure 5.53). The different approaches observed in the responses of the participants showed an independent approach applied to Question 10. One thing that the learners all had in common is that they understood the procedure of applying Pascal's law. They were able to differentiate between the piston on the input side and the piston on the output side, and were able to correspond the values accordingly.

All participants attempted Question 10, with a comprehension of how to apply Pascal's principle on a hydraulic jack. Two learners were able to identify the relevant formula for calculating pressure and their approach was mathematically correct. Three participants were procedurally correct in their endeavour to calculate pressure. They were able to identify the relationship between the force on the input side and the related piston and the force on the output side with a relative piston. Remarkably, Sphelele's approach was correct although clustered with many calculations all over the place. Calculations were not logically written, leading him to confusion for logical calculation. Sphesihle used the formula for calculating pressure. She substituted radius in the formula for calculation area without changing them from 'cm' to 'm' as suggested by the unit of measurement in pascal's principle (N/m^2).

5.4.2(d) Written responses of learners on gears (Question 12)

Table 5.3
Summery of responses to question 12

Participation in question 12	No. of learners
Correct identification of formula	3
Correct formula but error in substitution	1
Incorrect formula	1
No attempt	0
Did not write formula but provided an answer	0


B. Identify the direction of each gear and indicate the direction using arrows on t diagram and write in words on the lines below.

Gear A clockwise
Gear B anti-clockwise
Gear C clockwise

C. calculate the gear ratio of the gear train

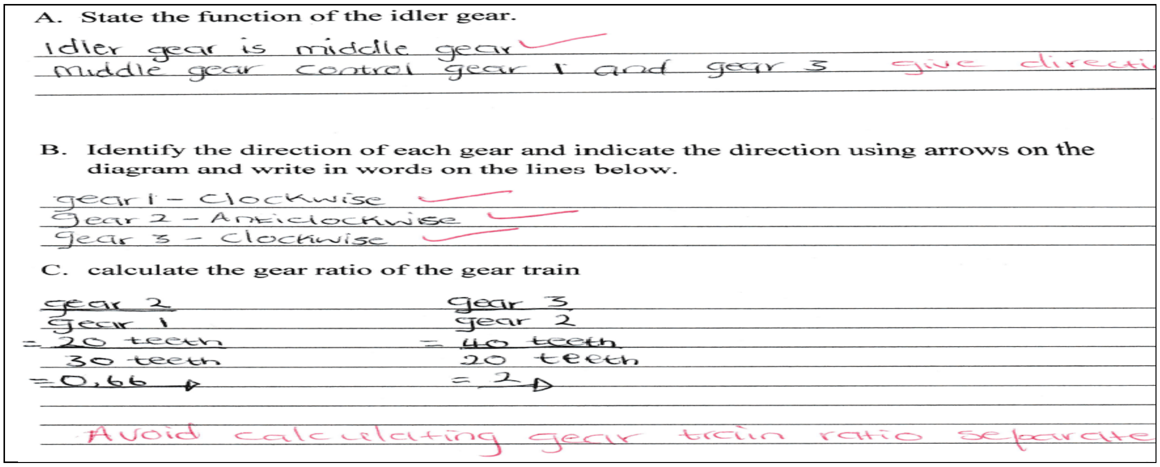
$\frac{\text{Gear B}}{\text{Gear A}} = \frac{\text{Gear C}}{\text{Gear B}}$

$\frac{20}{30} = \frac{40}{20}$

$= \frac{40}{30} = \frac{4}{3}$

Figure 5.54: Nosipho’s response on gears.

Nosipho identified her gears alphabetically from A - C and logically from left to right in Question 12B (Figure 5.54). Although she did not put GR as a subject of the formula in her calculations, her combination was adequate. Instead of doing the calculation in a compound gear train, Nosipho equated the first combination (Gear A and Gear B) to the second combination (Gear C and Gear D). She proceeded with the mathematical approach adequately but did not provide her answer in ratio form.



A. State the function of the idler gear.

idler gear is middle gear

middle gear control gear 1 and gear 3 give directi

B. Identify the direction of each gear and indicate the direction using arrows on the diagram and write in words on the lines below.

gear 1 – clockwise

gear 2 – Anticlockwise

gear 3 – clockwise

C. calculate the gear ratio of the gear train

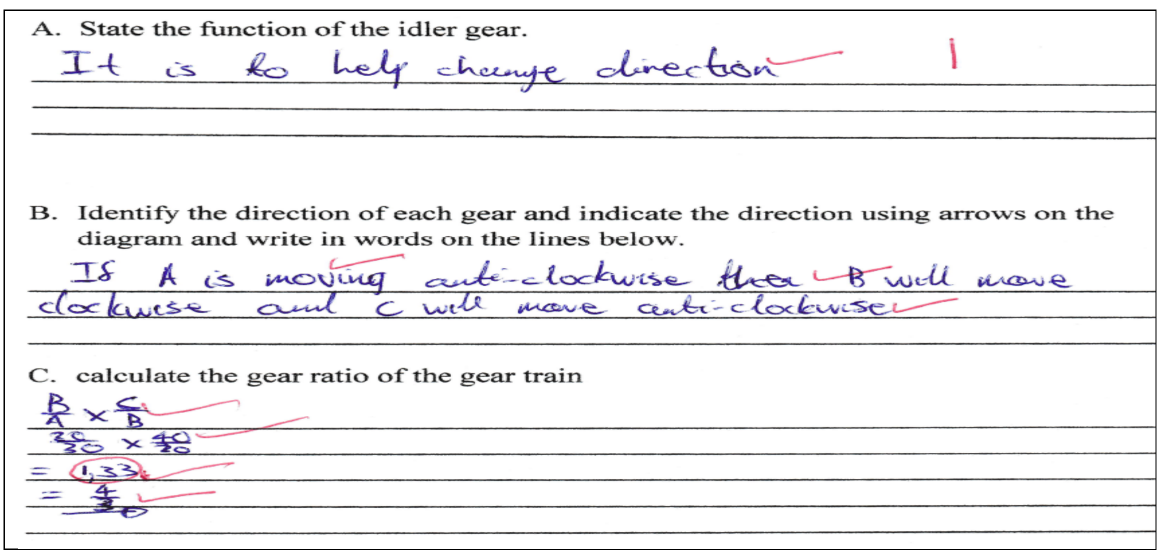
gear 2 / gear 1 = 20 teeth / 30 teeth = 0,66

gear 3 / gear 2 = 40 teeth / 20 teeth = 2

Avoid calculating gear train ratio separate

Figure 5.55: Zekhethelo's response on gears.

Zekhethelo identified her gears numerically as 1, 2 and 3 from left to right. However, she calculated gear ratios separately and provided two answers (Figure 5.55). This ambiguity could be the result of crafting a compound formula to accommodate all gears in the gear train simultaneously. Her answer is given in a mixture of decimal and proper fractions, but without considering a ratio, as required.



A. State the function of the idler gear.

It is to help change direction

B. Identify the direction of each gear and indicate the direction using arrows on the diagram and write in words on the lines below.

If A is moving anti-clockwise then B will move clockwise and C will move anti-clockwise

C. calculate the gear ratio of the gear train

B/A × C/B

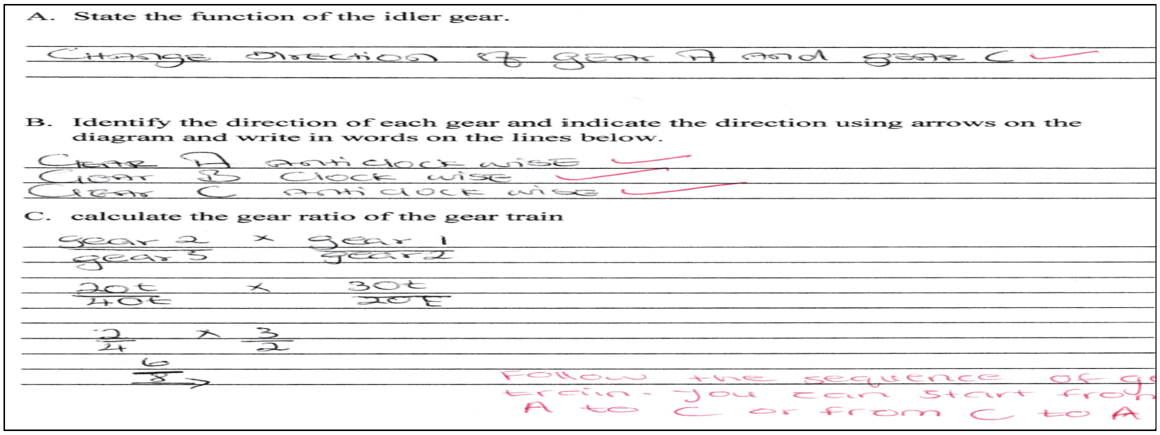
30/20 × 40/20

= 1,33

= 4/3

Figure 5.56: Mxolisi's response on gears.

Mxolisi is calculating a ratio as an expression and multiplied his combinations (A and B) and (B and C) for an answer (Figure 5.56). His answer was not extended to a ratio but was provided in a fractional form.


A. State the function of the idler gear.

Change direction of gear A and gear C

B. Identify the direction of each gear and indicate the direction using arrows on the diagram and write in words on the lines below.

Gear A anti clock wise
Gear B Clock wise
Gear C anti clock wise

C. calculate the gear ratio of the gear train

gear 2 / gear 5 × gear 1 / gear 2

20t / 40t × 30t / 20t

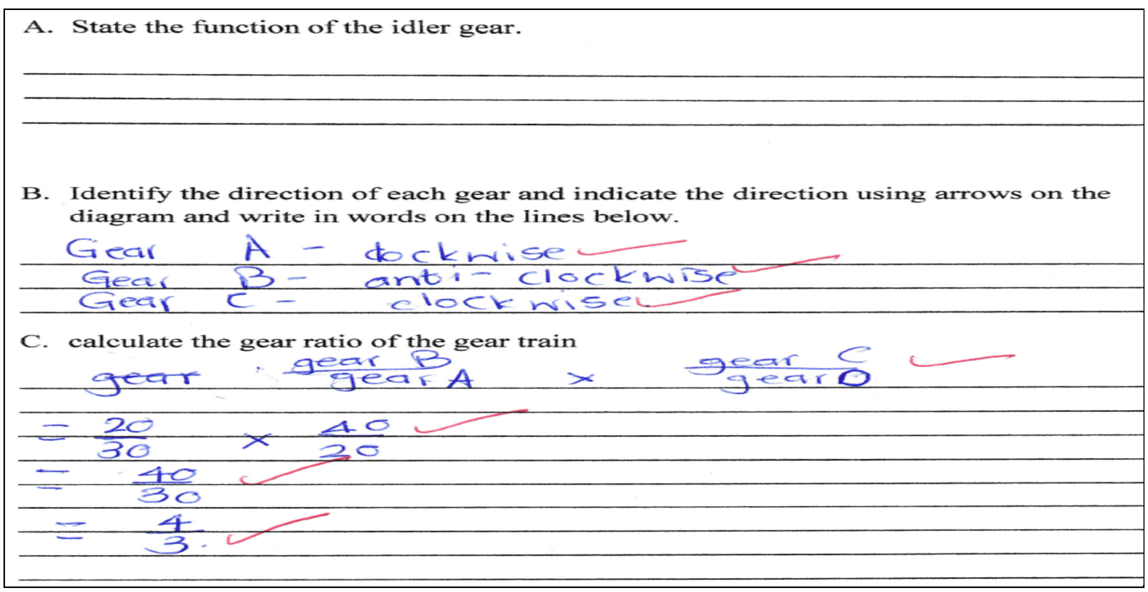
2/4 × 3/2

6/8

Follow the sequence of g
train. You can start fro
A to C or from C to A

Figure 5.57: Sphesihle's response on gears.

Sphesihle represented his gears from A to C and from left to right (Figure 5.57). There is no consistency on gear identification and the crafting of the formula. Furthermore, numbering on the formula does not have continuity from 1 – 3, but he introduced gear 5 from nowhere. The combination of his gears in the gear train is different, resulting in a different answer. His answer is not provided in a ratio form although supposedly based on the complexity of the gear train.


A. State the function of the idler gear.

B. Identify the direction of each gear and indicate the direction using arrows on the diagram and write in words on the lines below.

Gear A - clockwise
Gear B - anti- clockwise
Gear C - clockwise

C. calculate the gear ratio of the gear train

gear : gear B / gear A × gear C / gear D

= 20/30 × 40/20

= 40/30

= 4/3.

Figure 5.58: Sphelele's response on gears.

Sphelele represented his gear train alphabetically as A, B and C from left to right. Crafting a formula for calculating a ratio of a compound gear train, he started with the expression in question 12B in the first step (Figure 5.58). He proceeded to equate that expression to something not given in the first step. His answer is provided as a fraction.

Three participants were able to answer Questions 12B and 12C correctly, and their approach was mathematically and procedurally correct. Zekhethelo and Sphesihle confused the gear sequence, but their calculations were procedurally correct.

Mxolisi provided an answer in a form of decimal fraction and thereafter as an improper fraction. This approach by Mxolisi demystifies a chronological order of calculating the gear ratio in its simplest form, and there is no evidence of understanding what gear ratio is. Deaf learners missed the fact that from where their calculations stopped, they had to change the representation of their answers to a ratio, e.g. $\frac{4}{3} \approx 4: 3$.

In Mechanical Systems calculations foreground the essence of 'formal knowledge'. Mathematics skills were used to quantify Technological literacy in the learning of Mechanical Systems by participants where binary operations were applied to calculate MA and represent MA into ratio form. Mathematics is known for its accurate contribution to activities of different strands; hence the proven utility of patterns of numerical science is crafted into formulas, as analysed in section 2.4.1.

Tasks on Mechanical System need multiple competences found in cummulative learning (3.3.1), assimilative learning (3.3.2) and transformative learning (3.3.3). When participants were exposed to demonstrations and practical tasks, these were extended to the high cognitive demands essential for knowledge application in Mechanical Systems. Knowledge application reviled mathematical reasoning of learners and emphasised constructive understanding of Mathematics ideas. All tasks in Mechanical Systems have practical implications and demand meaningful participation that enhances cognitive and linguistic competency. Instructional tasks embedded in practicals and demonstrations shaped opportunities for participants to draw upon multiple knowledge-based problem-solving tasks that direct their perspectives on Mathematics as a discipline. As a result any person is able to learn anything on the use and application of knowledge; learning depicts knowledge internalised by a person.

Participants engaged better in lessons with demonstrations and practical involvement. For concepts that were not clear to them during lesson delivery, they were able to provide a balance between what they knew and what they observed and come up with solutions. Comprehension of concepts in the interdisciplinary relationship of Mechanical Systems and Mathematics satisfied the cognition of participants and enhanced their academic cognitive proficiency. Sign Language is a developing communication tool that instigates multiple knowledge-based and problem-solving skills because in the absence of relevant word in Mechanical System, learners had to understand the situation in order to craft the appropriate word.

5.4.3(a) *Mechanical Advantage (MA)*

The concept of MA is used to quantify the benefit of using machines in Mechanical Systems. The concept of MA was elaborated through the use of simulation, demonstration and calculations by the Technology teacher as the usefulness of engaging simple machines as oppose to human efforts. MA was used to determine the ratio between the output and the input of a simple machine. MA did not have a vocabulary in Sign Language and did not have a single simple sign. Through the comprehension of the concept, the words 'Mechanical' and 'Advantage' were signed separately to capture the meaning of 'MA'. As indicated, there was no single sign from SASL to unpack MA, but the signs in Figures 5.59 and 5.60 emanated from finger signing and the negotiated endeavours of the participants in a non-hearing environment.

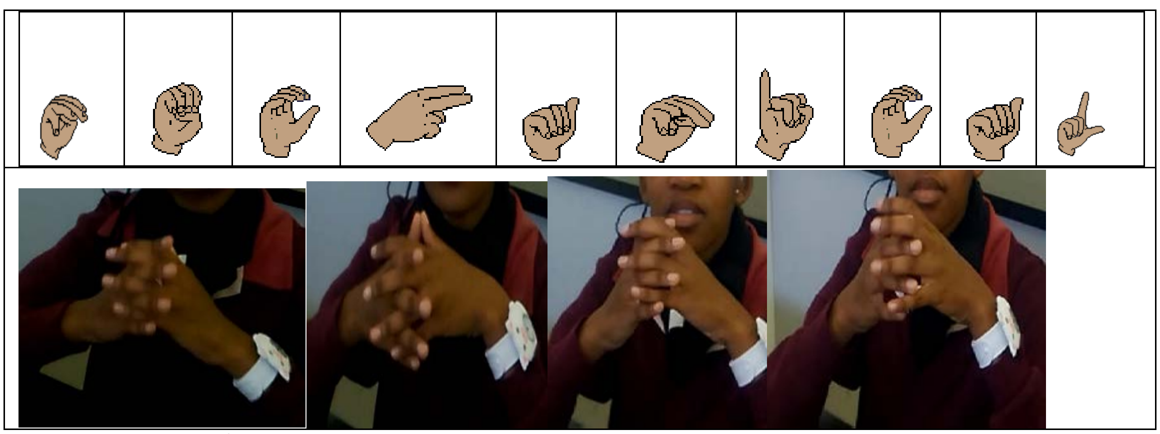


Figure 5.59: Illustration of the word 'mechanical' though Sign Language.

Nosipho is demonstrating the word ‘Mechanical’ as shown in Figure 5.39, by shaking hands as shown in the pictures. The finger spelling enhances the conceptual understanding of the word.

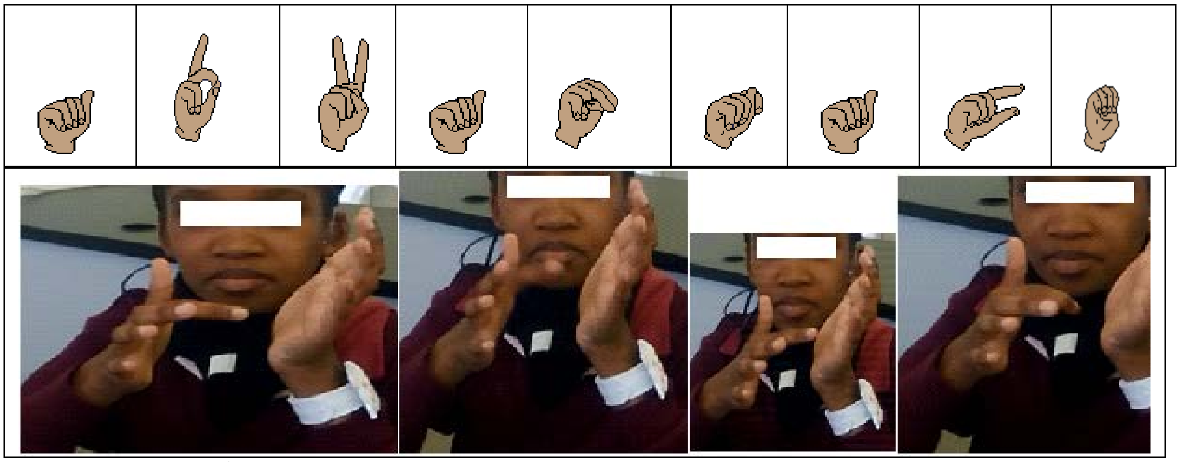


Figure 5.60: Illustration of the word ‘Advantage’ though Sign Language.

The word Advantage is used concurrently and quickly with the word Mechanical. Hence the concept ‘MA’ was provided with finger spelling in this chapter.

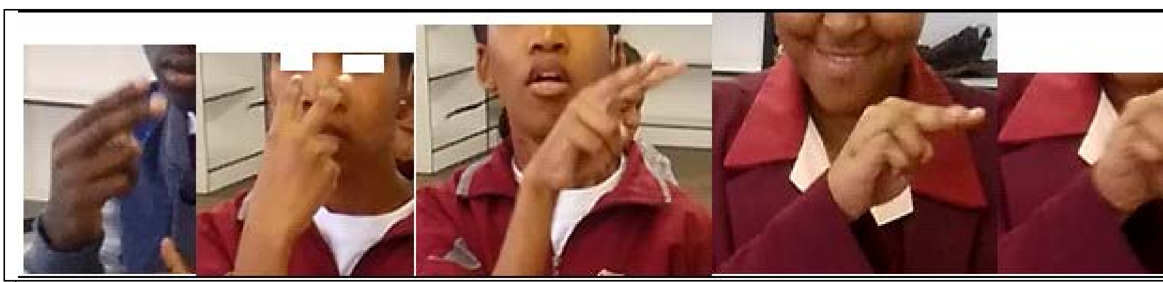
5.4.3(b) ***Related terminologies for MA and work done in Mechanical Systems***

Mechanical Advantage (MA) is a specialised terminology used in Mechanical Systems to qualify the benefits of a machine over human participation. An effective application of MA is grounded on the understanding of the technological process as highlighted in Figure 2.2 and 2.3 where human participation is separated from the performance of a simple machine. In all of the lessons I observed, a foreground was internalising a structure of MA and use of input/effort and output/load for a calculation of MA. The comprehension of the concept of MA contributed to the cognitive proficiency of learners since they were are to calculate MA in different sections of Mechanical Systems. In their cognitive process the participants were able to provide signage of the following terms used in calculating ‘MA’ and ‘work done’.

Sphelele is providing a symbol for 'load', which is a steady upward movement symbolising a lifting endeavour of an object

Figure 5.61: Illustration of the word 'load' though Sign Language.

In Figure 5.61 Sphelele demonstrates an understanding of 'load' as a concept used in the calculation of MA. In this demonstration there is interdisciplinarity between Technology, Science and Sign Language, in the sense that 'load' is a quantitative measure of goods subjected to gravitational force. Sphelele could understand the concept of 'load' as it is used in Mechanical Systems, in the sense that load does not change shape, movement or size but will only be influenced by a person who can lift or push it. Hence he shows his hands moving up with the positioning of his hands indicating a lifting attempt. However, this sign used for representing 'load' misses the Technological connotation that it is a force exacted directly on the surface of an object, leading to movement.



Deaf learners were captured using the division sign in explaining a mathematical approach to calculation of MA. The movement of the two figures start from the nose bridge and point at an opponent or front position

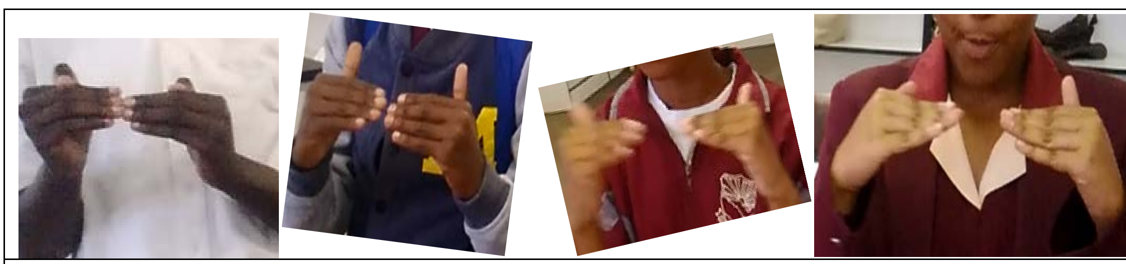
Figure 5.62: Illustration of the word 'divide' though Sign Language.

Figure 5.62 presents participants showing a division sign using Sign Language. The division sign forms a crucial part of binary operations, as discussed in section 2.4.3. Participants display a comprehension of the sign and their gestures (body movement) reviled some comprehension and the internalisation of the concepts.

Mxolisi is placing the left hand flat to be a plane for the right hand. The right hand is in the form of a G clamp. Initially a thumb of the right hand is placed at the left backhand and the hand is moved, maintaining the position of a G clamp

Figure 5.63: Illustration of 'force' though Sign Language.

In Figure 5.63 Mxolisi is demonstrating the word 'force' using Sign Language. Force is a scientific concept related to stimulation of one object by another, leading to movement. Mxolisi seems to have an understanding of the scientific nature of force as a vector quantity that encompasses direction and magnitude. He placed his left hand as a plane and moved his right hand shaped as a grip on top of the left hand (plane). In this action there is forceful movement and a constant direction. Both 'load' and 'force' are signed differently in Figures 5.61 and 5.63 respectively. Gestures from Sphelele depict resistance against gravitational force while Mxolisi's gestures show interaction between his two hands, where his right hand is moving on and against the left hand. Both learners could fathom relative task, movement, and factions contained in the two concepts of 'load' and 'force'.



Sphelele, Mxolosi, Nosipho and Sphesihle are signing 'equal'. This is linking Mathematics language with Sign Language

Figure 5.64: Illustration of the 'equals' sign though Sign Language.

In Figure 5.64 participants are showing an 'equals' sign through sign language. This mathematical symbol falls within the category of binary operations. The function of the ‘equals’ sign is to compare two sides regardless of their composition. The equals sign is used with understanding in the Deaf classroom and is enhanced by gestures.

Nosipho, Sphesihle and Zekhethelo are crossing arms as a symbol for a multiplication sign

Figure 5.65: Illustration of ‘multiplication’ sign through Sign Language.

Figure 5.65 shows Nosipho, Sphesihle and Zekhethelo demonstrating a ‘multiplication’ sign through Sign Language. The multiplication sign is part of the binary operations. Their gestures are the same and the positioning of the hands is similar. This is evidence of learned behaviour and shows comprehension of the concept.

Sphesihle is placing her hands ‘right above left’ and moving the right hand in a circular motion

Figure 5.66: Illustration of ‘area’ through Sign Language.

Sphesihle is demonstrating the sign used to illustrate ‘area’ through Sign Language in Figure 5.66. These pictures show her right hand hovering over the left hand. This action is depicting an understanding of the amount of space within a bounded surface. ‘Area’ is an amount of two-dimensional space taken up by an object. Hence Sphesihle is only hovering her right hand over her left hand. The implication of this concept of ‘area’ to Mechanical

Systems demands the effective understanding and use of formulas in different shapes. For example, rectangle, square, triangle, etc., as highlighted in 2.4.3, in formulas embrace a symbolic expression using numbers to express functional relationships in a single object. An understanding of the concept 'area' in Mechanical Systems enhanced comprehension of Mathematics language relations used in logical calculations of surfaces in different shapes by learners.

The signing teacher is demonstrating a suitable symbol to be used when referring to a heavy object. Gestures are suggesting the need for power as essential in picking up massive things

Figure 5.67: Illustration of the term 'lifting' through Sign Language.

In Figure 5.67 the signing teacher is addressing the ambiguity between 'load' and 'lifting' through Sign Language, and demonstrating the signing symbol used in the term 'lifting'. Any person would expect that Figure 5.41 would be appropriate for 'lifting', but the dynamics of Sign language suggest that the letter L as signed in finger spelling is used with both hands to illustrate picking up of an object. Participants did not have a clear concept of the term 'lifting' as it was confused with the term 'load'; hence the signing teacher is demonstrating the difference to the participants.

The signing teacher is using face, arms and hands to emphasise the concept of heavy. Hands are moved up with a tickling movement

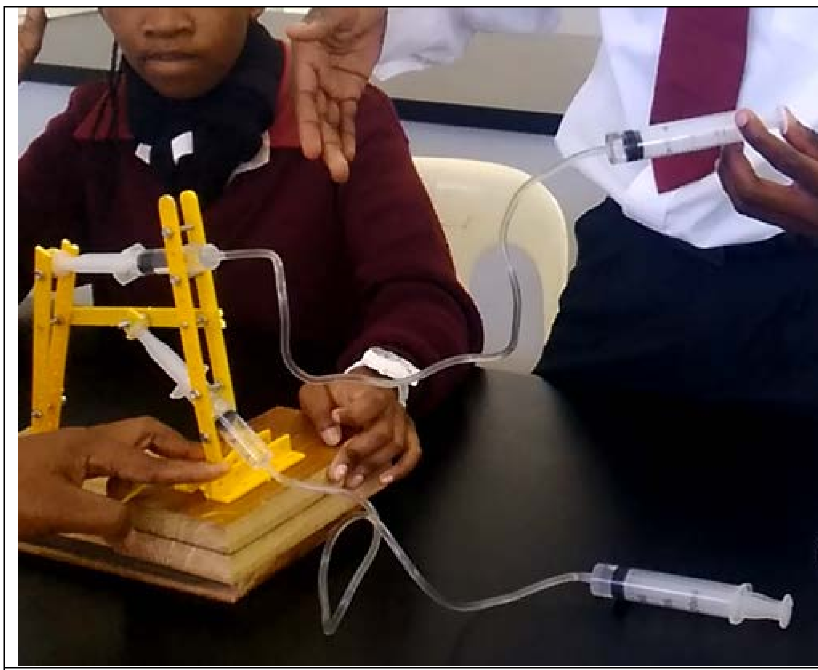
Figure 5.68: Illustration of the term 'heavy' through Sign Language.

In Figure 5.68 the signing teacher is illustrating the term 'heavy' to participants. This is an important term in Mechanical Systems, as it highlights a weight of an object. The challenge is not in the comprehension of the term, but regarding the symbol used for Sign Language. In this symbol the hands are moved up with a tickling movement. participants are able to sign different mathematical operations. These operations are accessible from their schema when questions demand them. Applying Mathematics operations to MA and other concepts in Mechanical Systems effectively is a cognitive process foregrounded on coherent mental presentation envisaged by a sense of purpose, as displayed in Figure 3.2.

5.4.3(c) *Project development and presentation*

Practical lessons extended the scope of discovery to participants from observation of different movements in demonstrations and simulations. Exposure of participants to hands-on experience provided a breakthrough that stimulated the quest for investigation on different objects, processes and techniques involved in all mechanisms. The project in Figure 5.70 was done after the completion of Mechanical System during break-time and free moment when learners were waiting for transport. I was not part of the development but the Technology teacher committed to assist learners in the workshop. In projects they produced for assessment, Nosipho and Mxolisi designed an excavator, where the knowledge used was gained from the simulation lever system in Appendix E and the demonstration of hydraulics systems in Figure 5.6. The roadworks at the gate of their school (Figures 5.69 - 5.71) assisted them to compare the knowledge gained in class to real-life application.

Figure 5.69: Signing on a project though Sign Language.

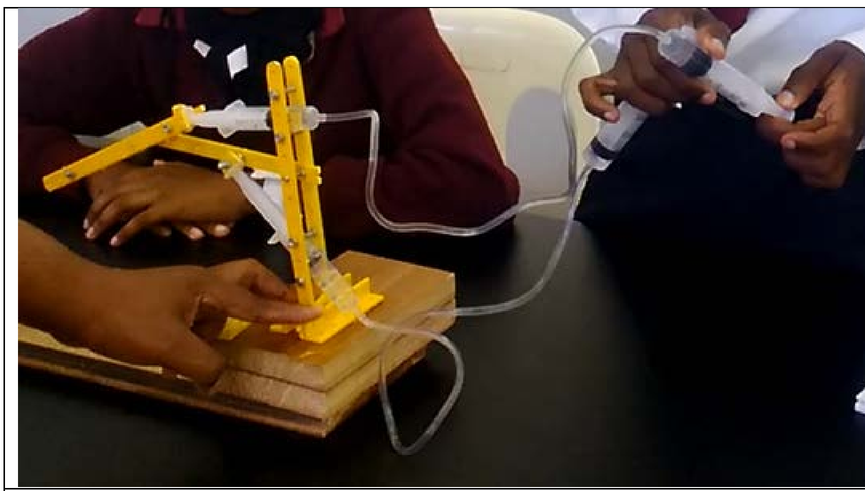


Nosipho and Mxolisi presenting their project and explaining its operation.

Figure 5.70: Demonstration of the project by Nosipho and Mxolisi.

These participants used three sets of levers joined flexibly at three pivots. One lever is fixed on the plane as the base. Two syringes are glued to the fixed lever. The first syringe is forming a triangle with the second lever, while the second syringe is linking the fixed lever and the third lever. Syringes are mounted so that they can control the second lever to move upwards and the third lever to move up horizontally. In the account which Nosipho and Mxolisi gave on the operation of this project, Mxolisi said:

> *… water is locked into two syringes controlled by separate rubber tubes. Force is applied to this syringe* [syringe in hand]. *Pressure is pushing the piston to control third lever straight and back down.*
>
> *… force is applied to another piston and it put pressure on a syringe that control lever two. If you apply force, lever two will move up.*



Mxolisi is operating this project simultaneously. The second lever is able to move from a horizontal position to a vertical position, while the third lever is able to move from the vertical position to a horizontal position

Figure 5.71: Explanation of the operation of the project.

In asking about the originality of the ideas of their project, I discovered that Nosipho and Mxolisi correlated mechanisms to the excavator on the roadworks next to their school, where construction workers were developing the road joining Pinetown and the Kwamashu area. Each time they had a break and when they were waiting for their transport, they would go and observe how the machine was moving. This was during the time that the Technology class was covering hydraulics.

Sphesihle, Sphelele and Zekhethelo partnered on a project of pulley systems using waste materials.

Sphesihle, Sphelele and Zekhethelo developed a project of pulley systems. All the material and equipment used in their project was provided on request.

Figure 5.72: Illustration of the process for completion of the project by *Sphesihle, Sphelele and Zekhethelo.*

5.5 Interviews with participants

Semi-structured interviews were conducted with the participants. Each interview took an average of 30 minutes and all were interviewed. All participants were from the Grade 9 Technology classroom. An interview schedule was prepared to guide the pattern of the interview protocol and to optimise use of time. These interviews were aimed at understanding the experiences and exposure of Deaf learners to daily activities, and this was explained to them before embarking on the interviews. Participants were reminded of the confidentiality and anonymity clauses, and their identities were encoded to ensure this. Questions were probing to gain information on their historical background related to their socialisation and learning of Mechanical Systems.

5.5.1 Interview Question 1

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: Did you attend a preschool?
Nosipho: *Yes.* **Researcher:** Do you remember the name of your preschool? **Nosipho:** *It is here.*
Zekhethelo: *Yes I do.*
Mxolisi: *Yes.*
Sphesihle: *It is here.*
Sphelele: *Yes.…it was a primary next to my home.* **Researcher:** Was it a deaf primary school? **Sphelele:** *No.*

Four out of five participants were privileged to attend preschool education in a Deaf school. The introduction of Deaf children to basic education is challenging because a language foundation is missing where families are conscripted to introduce children to basic language development. However, their early introduction to the Deaf school contributed to relevant academic language development. Only one Deaf learner attended his preschool education in a mainstream school.

5.5.2 Interview question 2

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: How did your family discover that you have to come to the Deaf school?
Nosipho: *The doctor write a letter and the parent bring me to school here.*
Zekhethelo: *The clinic gave the*m a *letter but I don't know why, I remember at home parents send me to school when I was small and this is the school they take me to after that.*
Mxolisi: *The doctor at the hospital tell them to bring me here when I was young.*
Sphesihle: *I was not understanding the ways they were using to learn. I used to see children's playing and the teacher talking but I was not hearing what they were saying. Later on the clinic next to my home gave my mother a letter and they bring me to this school.*

Sphelele: *When I was failing to do what other children are doing and when I was not understanding instructions at home.*

All of the learners were referred to the Deaf school by medical practitioners. I suppose they were diagnosed with a hearing challenge. Their inability to cope with activities on a daily basis may be based on the limited communication ability.

5.5.3 Interview Question 3

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: When did you start learning Sign Language?
Nosipho: *When I was at the preschool they teach me to learn how to use hands to express myself.* **Researcher:** Were you able to express yourself the same way at home as you were doing at the preschool? **Nosipho:** *No.* **Researcher:** What was the difference? **Nosipho:** *At school I was taught to understand teachers and teachers understand me. I end up saying everything I need and teachers are able to give what I was asking. At home nobody understand me, they take me to doctors and clinics and I don't know why.* **Researcher:** How is your communication at home now? **Nosipho:** *We don't talk every time. We talk little when we are on TV and when they want me to do something.*
Zekhethelo: *When I begin my learning year.*
Mxolisi: *From my preschool when my parents bring me here.* **Researcher:** How much time do you spend reading for yourself at home? **Mxolisi:** *Before I go to bed, after coming from the volleyball training.* **Researcher:** It's good that you playing volleyball, but who helps you with your homework at home? **Mxolisi:** *Nobody, I do it myself.* **Researcher:** What if you don't understand something in your homework? **Mxolisi:** *I take it to school the next day, but I try to finish at school while waiting for the bus because I know nobody understands Sign Language at home.*

Sphesihle: *At this school.*
Sphelele: *When I was doing Grade 2 here at school.* **Researcher:** Why did you learn Sign Language at Grade 2? **Sphelele:** *It was hard for me to pass Grade 1 and Grade 2. In my near school I spent 3 and a half years then I came to this school because at home they say I was not hearing and I was not able to understand a person when I don't look at the mouth moving.*

All participants started Sign Language when they were introduced to the Deaf school. They were still accommodated for learning a relevant language required to equip them for a broad range of educational subjects, as highlighted in Hoff et al. (2012). Unfortunately the entire issue of language development was the task of the school. No contribution was made by families as they could not understand Sign Language. Moreover, families did not assist in the education of their children because of the language barrier – for example, reading together, spelling practice, home work and sharing of experiences during the day at school.

5.5.4 Interview question 4

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: What changes would you like to see in the classroom to enhance your understanding in Technology?
Nosipho: *The teacher must give us more projects.*
Zekhethelo: *I need more practicals and more time to work on my exercises. To do practical before a teacher teach us about the section.*
Mxolisi: *The teacher must start with the practical because you see the movement of the project. When we are learning and there is no sign for the word it is difficult to understand it, even if they sign it alphabetically. If I see movements in practicals I get a chance to talk to my classmates about the movement and come up with our understanding.*
Sphesihle: *We must do practicals, we must look at videos, we must work as a group.*
Sphelele: *To start by doing practical and to learn and to write notes.*

It is presumed that the approach used in teaching participants was mainly theoretical. The introduction of simulations and demonstrations changed the state of mind in the participants in the sense that every word learned was enhanced by practical demonstrations. Practical demonstrations and participation gave them the chance to develop mental models and formulate mental patterns for different mechanisms. Hence all participants advocated for practicals in every academic activity done in Mechanical Systems.

5.5.5 Interview question 5

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: Do you agree with the following statements, and why or why not? (a) Most occupations need Maths, Science and Technology skills; (b) Technology is necessary to design things that are safe and useful.
Nosipho: (a) *No. People sweeping the road, cutting grass, making tea do not need Technology.* (b) *Yes. Cell phones, computers and stoves and sometimes motorcars.*
Zekhethelo: (a) *Yes. To increase temperature in the stove you start from zero to six. Speed of a car has got number.* (b) *Yes. Cell phone is useful when I text my friends. A bus is safe and useful when I come to school and go home in the afternoon*
Mxolisi: (a) *Yes. Because cell phone is making easy to communicate. Cars are taking us to schools quickly and fixing that if it is broken forces us to have knowledge of Technology.* (b) *Yes. With my cell phone, I am able to chat with my friends I found from volleyball who do not understand Sign Language.*
Sphesihle: (a) *Yes.* (b) *Yes. Because it easier to communicate with the cell phone. You don't hear any sound, you only see what you are talking about and it's easy to understand what other people are saying.*
Sphelele: (a) *Yes.* (b) *Cell phone is helping me to say my feelings to anybody. School bus is collecting me from home.*

Participants valued Technology on the basis of gadgets they were using. They would talk about cell phones and cars that impacted their lives, but very little significance was placed on the skilfulness behind the gadgets. Zekhethelo indicated gadgets that related to the use of numbers for scaling. She mentioned the temperature of a stove and speedometer on a car, this knowledge being rooted on the exposure she experiences in family activities.

5.5.6 Interview question 6

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: How do you feel about Technology in Grade 9?
Nosipho: *Good.* **Researcher:** Can you explain the reason why? *Grade 9 is the same teacher teaching us as in Grade 8. Grade 9 has practical.* **Researcher:** When did you start feeling this way? **Nosipho:** *When I see our project working.* **Researcher:** Is Mechanical Systems taught differently in Grade 9 compared to other grades? **Nosipho:** *Yes,* **Researcher:** How? **Nosipho:** *There is practical and project.*
Zekhethelo: *It is difficult* **Researcher:** Why is it difficult? **Zekhethelo:** *I need to know different topics and the topics have maths and there is a project. The teacher tells us that we must understand all these topics and know how to count.* **Researcher:** When did you start feeling this way? **Zekhethelo:** *In Grade 8 and 9.* **Researcher:** Is Mechanical Systems taught differently in Grade 9 compared to other grades? **Zekhethelo:** *Yes.* **Researcher:** How can you explain the difference? **Zekhethelo:** *We learn a topic and do a practical. All we are learning is reading and doing practicals.*
Mxolisi: *I am happy.* **Researcher:** How do you feel about Mechanical Systems in Grade 9 and why? **Mxolisi:** *I feel good because our project* is *finished and working. When we are doing practicals I understand better but when the teacher is explaining without practical it is difficult.* **Researcher:** When did you start feeling this way?

Mxolisi: *When we were designing our project it was easy because in our practical lessons we are made to understand how gears are working, how pulleys are working, how hydraulics are working.*

Researcher: Is Mechanical Systems taught differently in Grade 9 compared to other grades?

Mxolisi: *Yes. We have good practicals. In other grades the teachers are using Sign Language only and I don't understand how these things we are learning work.*

Sphesihle: *Good.*

Researcher: Explain more

Sphesihle: *We are not writing only, we are doing practical and we talk.*

Researcher: How do you feel about Mechanical Systems in Grade 9? And why?

Sphesihle: *I enjoy Mechanical Systems because there is practical and you see all movements that the teacher is talking about and calculation is understandable and not too much drawing is wanted.*

Researcher: When did you start feeling this way?

Sphesihle: *When I was getting an opportunity to do practical with my classmates. When we were starting I was afraid to touch anything because I think what will happen if it break.*

Researcher: Is Mechanical Systems different in Grade 9 compared to other grades?

Sphesihle: *Yes.*

Researcher: Can you explain the difference?

Sphesihle: *There is a lot of practical; when we are doing a project we work in the workshop.*

Sphelele: *Is nice.*

Researcher: Why?

Sphelele: *Because we make a project, we get time to stay with our teacher during break doing our project. When we have problems with our projects we talk with classmates and we help each other.*

Researcher: When did you start feeling this way?

Sphelele: *Last year and this year.*

Researcher: Is Technology taught differently in Grade 9 compared to other grades?

Sphelele: *Yes.*

Researcher: How? **Sphelele:** *We learn and do small project and understand what we are learning and the teacher is with us when we are trying our project.*

CAPS requires a project that combines different mechanisms. I presume that all practicals and demonstrations were serving as build-ups to a final project. Blending practical and theory in the learning of Mechanical Systems benefitted participants in ensuring transfer of relevant knowledge from which essential stages of learning were sourced. This process is analysed in section 3.3.3. All of the learners advocated an integrated approach.

5.5.7 Interview question 7

Extract from interviews with in a Grade 9 Technology classroom:

Researcher: Do you prefer to work on your own or as a group?
Nosipho: *As a group.* **Researcher:** Why? **Nosipho:** *If I fear the teacher I ask my friend. If I don't understand my classmates help me.*
Zekhethelo: *Group is good.* **Researcher:** Why? **Zekhethelo:** *If I don't understand an instruction from the teacher from the book, I talk to my classmates asking for their understanding and it becomes easy to go on with my project.*
Mxolisi: *It is good to work as a group because we are able to help each other if I don't understand.*
Sphesihle: *I like a group because we share ideas and boys are active in practical, we can follow them with other girls to see how they completed their practicals.*
Sphelele: *I like group.*

This class was a special class in my experience. Participants were so supportive to each other in their participation in the simulation of pulley systems. They were discussing steps more than consulting the guide. Zekhethelo emphasised that in the case of ambiguous instructions in Technology books and worksheets, she preferred to consult her classmate.

5.5.8 Interview question 8

Extract from interviews with participants in a Grade 9 Technology classroom:

Researcher: How did you feel about Mechanical Systems before the project or practical lesson was introduced?
Nosipho: *Not easy to understand.*
Zekhethelo: *I did not understand words used in different things. It was hard.*
Mxolisi: *It was not good to understand.*
Sphesihle: *It is difficult because I did not understand most of words signed by the signing teacher.*
Sphelele: *It is difficult because the teacher tells us something new and the words are not having signs, the teacher is signing alphabets.*

Participants have a strong feeling that Mechanical Systems introduces words beyond their scope of imagination. Their presence in class was passive because of the limitations in communication. Participants felt marginalised when new words were introduced. Their attitude of perpetual consultation of their peers when they experienced misunderstandings was facilitating essential communication to enable them to better engage in classroom activities within that context. Such consultation is evident in Figures 5.10 and 5.31.

5.5.9 Interview question 9

Extract from interviews with participants in Grade 9 Technology classroom:

Researcher: Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?
Nosipho: *English. Because our teacher is using English and the booking writing is English. A test is English.*
Zekhethelo: *English. I cannot read other languages when my friends send messages on my phone.*
Mxolisi: *English. I am taught Sign Language by teachers who speak English from pre-school.*

Sphesihle: *English. Because we are chatting in English. I don't understand the language they are using at home and I don't feel to be a member in my family. I don't hear them when they speak, they don't understand me clear[ly] when I sign.*
Sphelele: *English because a person who teach me Sign Language was speaking English and when we sms my friends it is easy with English and can't write IsiZulu.*

All learning was mediated in English as a common practice for educational endeavour. Deaf learners are the beneficiaries of "collectivization and schooled literacy", as highlighted in Lantolf (2000). Sign Language is used as a communicative competence while English is used to communicate and mediate lessons in the non-hearing environment. As a result all their communication, including cell phone communication, revolved around English.

5.6 Conclusion

Due to the number of aspects addressed in this chapter, it focused on presentation of data from different sources during the learning of Mechanical Systems in a Grade 9 Technology classroom. Data were generated through learners' responses to different activities. Areas of interest were observation, document analysis and the working of a designed model. Categories in Mechanical Systems for which data were generated were theory on pneumatics, theory and demonstration of hydraulics, and demonstration of a gear train with two or more gears, and simulation of pulleys. Worksheet responses and illustrations of operation of the projects and interviews were also included. In chapter 6, data will be organised into themes in order to analyse this study.

CHAPTER 6

Data analysis

6.1 Introduction

Education is a democratic right rooted in the South African Constitution. It is aimed at enhancing quality teaching and learning that promotes competent learners in South Africa. Within the parameters of democracy, Technology has been prioritised to have a positive impact on economic development through the CAPS policy. This chapter analyses the data that were collected during classroom activities in a non-hearing environment, outlining the trends and patterns in the data presented in Chapter 5. Pertinent observations were presented in Chapter 5 with an intention to explore the 'Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal: An exploration of a learning of Technology in a non-hearing environment'. I revisited the following two questions which guided my research:

1. **What are the experiences of Deaf learners in learning Mechanical Systems?**
2. **What is the role of Sign Language in learning Mechanical Systems?**

The preponderance of ideas which emerged from observations as outlined in Chapter 5 compelled me to categorise these ideas into themes, which are described. Furthermore this chapter will underline the appropriate learning styles that worked effectively in enhancing the competency of Deaf learners in the learning of Mechanical Systems.

Mechanical Systems is one of the compulsory strands in Grade 9 Technology education entrenched in the CAPS document. Although V.N. Naik Deaf School is a special school, it adheres to the mainstream curriculum. The time allocation for Technology is 2 hours per week. It is conscripted that in Technology practical work should be taught concurrently with theory. This school is using a cycle system e.g. day 1 to day 10, but ensures that the time allocated to Technology is precise. Technology theory, demonstrations and simulations are done in a normal classroom, but the seating arrangement demands face-to-face contact and a direct range of interaction, as illustrated in Figure 5.1. The content covered in Mechanical Systems is prescribed by the curriculum to provide activities suitable for effective learning and provide opportunities for learners to practice specific skills which are tailor-made to prepare them for advanced tasks. As suggested in the CAPS curriculum: “the Grade 9 learner has to be able to identify a problem, need or opportunity”; hence the curriculum for Grade 9 is not specific on textbooks to be used but gives liberty to the school to develop ideas that suit the given content within a curriculum context (DoBE, 2011). Deaf learners in this Technology classroom adhere to all requirements entrenched in the CAPS curriculum. Mechanical Systems in this context of a non-hearing environment is taught through Sign Language. Two teachers – the signing teacher and the Technology teacher – facilitate the teaching of Mechanical Systems. The tasks, worksheets and practicals were developed by the Technology teacher to ensure fitness of purpose.

6.2 Themes

Theme 1: Inadequate application of prior knowledge through the lack of previous exposure to everyday concepts

I observed the introductory lesson in the learning of Mechanical Systems, and the initial lesson involved the question and answer method. The concept of pneumatic systems within the strand of Mechanical Systems was introduced. At the beginning of the lesson learners found it difficult to respond and were very cold and uneasy about participating in the lesson. They were listening attentively but very reluctant to provide answers. When participants were answering questions it was evident that they were inexperienced and could not relate the necessary technological concepts to their daily lives. Pneumatic systems was used as an introduction to Mechanical Systems. In order to engage participants, the TT had a challenge and had to ask different questions to search for the threshold understanding of participants. For example:

TT: Where do we use compressed air?

Sphesihle: Plastic pocket

Within the concept of pneumatics, the two learners who attempted to answer questions on compressed air presented different items. It is possible that Sphesihle applied the understanding of compressed air to a plastic pocket that had been blown up with air. Participants kept on providing answers based on their understanding of the situation presented to them. In another example:

TT: Do you put compressed air in a plastic pocket? Think of something that needs a pump.

Mxolisi: Water.

Expected possible answers to the two questions above would be a ball, balloon, bicycle tyre, etc., based on devices that are commonly used by children at the age of Grade 9 learners. The TT kept on probing issues related to compressed air, trying to find a common understanding for their lesson to take off. None of the participants' responses was getting closer to the expected answers. Another example:

TT: Do you know a pump, the one you use when you put air inside the ball? In a bicycle, what in the bicycle needs a pump? What makes the bicycle move?

Mxolisi: You apply pressure on pedals and the bicycle moves.

No one amongst the participants was relating responses to tyres, and it was clear that no significance was placed on the purpose of pumping up tyres. The TT kept on drawing learners closer to the issue of pumping air and tyres, but it was a struggle until they asked the following question:

TT: If bicycle tyres are flat, can it move?

Mxolisi: Yes, if tyres are pumped.

The TT managed to get to a common ground to start their lesson. Participants were able to provide examples of transport modes that use tyres, but with a hazy idea of the purpose of tyres. The TT emphasised a few aspects around pneumatics, e.g. air in a limited space, pump, pressure, etc. Mxolisi and Zekhethelo were better at responding to questions compared to the other learners. Although these two were responding more frequently compared to other learners, their responses were not directed to relevant answers but were highlighting an overall understanding of the concept of pressure in their daily practice.

The Technology teacher had a tendency of relating her subject of the day to daily practice. In introducing the lesson on hydraulics, the TT asked the following question:

TT: to get to higher level of a building, what can you use?

Sphelele: Steps.

This was a sincere answer by Sphelele because the school premises is a cluster buildings which are accessible by steps. Each question needed to be simplified to capture the attention of the Deaf learners, and a prompt follow-up gave a good guide to them. For example:

TT: What about a tall building with a great number of floors, can you use steps?

Mxolisi: A lift.

TT: Good. What do the technicians use to get the lift up and down?

Sphelele: They use compressed air.

In Grade 9 it is expected that participants would bring a wide range of knowledge and skills that inform the way they would receive, process and integrate new information. Although the principles of pneumatics pertinent to their grade are common in the soccer ball, balloon and bicycle, it is indisputable that the concepts of pneumatics were abstract to this group of learners. A concept of using compressed air in relation to mechanisms for lifts was inadequate for the potential response from Sphelele. Even when Sphesihle answered “Plastic pocket” in relation to compressed air, it showed a poor understanding of scenarios around concepts of pneumatics and hydraulics.

When the TT was asking questions on hydraulics, participants kept on referring to concepts of pneumatics. There was no proper sign for hydraulics, so the signing teacher used her fingers to spell the word ‘hydraulics’. This lesson was taught differently from the pneumatics lesson, since it was on demonstration of hydraulic systems. The Technology teacher brought a model of a simple hydraulics system (Figure 5.6), and questions during the development of the lesson were based on the model. Participants were able to identify with the situation and were able to relate to the components of this model, as illustrated in Figure 5.8. It was observed that participants were responding better and with more relevance to the hydraulic systems lesson compared to the pneumatics lesson. When the TT was extending the lesson to outside applications, the participants relied unsatisfactorily on previous knowledge from their previous lessons.

When the TT provided explanations in the learning of Mechanical Systems, they involved the use of devices used for daily practices in family life, peer group interaction, and institutional context. Participants were constrained from participating in family activities such as cleaning, cooking, gardening, etc. Their families could not understand Sign Language adequately. For example, in our interviews with participants on participation and exposure to Sign Language, it was revealed that after participants were introduced to Deaf school all their knowledge development was sourced from school programmes and most of their lives were spent happily at school and joyfully. Their participation in daily practice was not limited. However, when going home they experienced neglect and abandonment. Details of the experiences of the participants are analysed in section 5.2.4.

If a child is prohibited from opening a can using a tin opener, using a wheelbarrow for gardening, or opening the door of a car, the child misses out on picking up fine motor skills and the conceptualisation of the operation of the abovementioned devices. Here are just a few devices that are commonly used in homes on daily basis:

Seesaw	Class 1 lever
Tin opener	Class 2 lever
Broom	Class 3 lever
Wheelbarrow	Class 2 lever
Bush knife	Class 3 lever
Door of a car	Class 2 lever
Axe	Wedge, etc.

The abovementioned devices are considered as simple machines and are dealt with in Mechanical Systems. It is expected that all learners are able to calculate all aspects related to different kinds of simple machines which are used for daily functions in all homes. This study found that participants had a challenge in relating daily used devices to their aspects of operations. All machines that were given demonstration, like hydraulic systems, levers, pulleys and gears, were better understood by the participants. Observation of these demonstrations developed the mental capacity essential to apply relevant concepts to their schemas. As a result Mxolisi and Nosipho designed a model of an excavator using levers and hydraulic systems (Figure 5.70). When these two participants were asked what motivated them to come up with this idea, they stated that they observed the operation of the excavator on the roadworks near their school, and related that to the lesson on hydraulics.

Theme 2: Experience gained through the hands-on work

In the process of developing the hydraulics lesson into a simulation, the operation of this model was demonstrated practically with participants, and questions asked in relation to its mechanism. This demonstration process permitted participants to discuss concepts of hydraulics and ideas involved in hydraulics. Participants were able to own the lesson as active participants; for example, in Figure 5.11 Sphesihle is able to discuss the purpose of a syringe for daily use while referring to the model. In Figure 5.10 Zekhethelo was able to analyse the hydraulics principle looking at the mechanism of this model. This model of hydraulics was a vivid visual aid that stimulated participants' memory for recall and understanding: for example, Mxolisi and Zekhethelo were able to recall the scientific term for water as H_2O.

(a) Simulation project

The third lesson was on the simulation of pulley systems, designed to engage participants. In this simulation of pulley systems participants participants were expected to assemble the model by following instructions provided in the booklet. The model was given in an exploded view. Participants were expected to assemble this model as illustrated in Appendix E. Participants were expected to complete each step of the model before proceeding to the next one.

In this lesson it was a question of who would start engaging in the project, as they were all tentative to initiate a move. Participants were very observant, quick and attentive to any move. As the pieces of the model were presented in different colours and shapes, participants took advantage of attentiveness to these at the expense of the instructions provided. Furthermore, participants were their 'brother's keeper' in monitoring what their fellow learners were doing. For example, when Sphesihle was dismantling pieces incorrectly without following instructions (Figure 5.14), Mxolisi was quick to pick that up and intervened immediately. Their ability to participate in this simulation was diverse, in the sense that Zekhethelo kept on instructing others on what to do, Sphesihle voluntarily took many initiatives, Nosipho took many instructions from Zekhethelo, while Mxolisi and Sphelele formed a good team.

When the model was developing, the female learners worked on one side as a team while the male learners worked on the other side (Figure 5.17). Towards the end of the simulation project participants recognised the importance of following instructions at every step. Participants developed confidence and the project was developed quickly. Communication and participation of learners was at its maximum towards the completion of the model. When the project was finished the participants were excited and did not want to go to their next class, and took some minutes of the following period. The concept of the pulley system was better understood by participants after they interrogated the assembling of a lifting tackle as a model of pulley systems

(b) Learners' comprehension of concepts of Mechanical Systems through mathematical application

In responding to the comprehension of concepts of Mechanical Systems, I looked at participants' responses (provided in Figures 5.36 and 5.37) that were completed in the classroom during the demonstration lesson on gears. Learners were responding to Appendix F, where instructions are provided for the participants. This exercise took place after a theoretical lesson on gears was concluded, and aimed at identifying knowledge and understanding on gears. Learners were expected to respond to a demonstration of the movement of a gear train on an individual basis. Instructions prompted participants to: 1) to identify directions of pertinent gears in relation to a given gear, 2) observe the behaviour of an idler gear in relation to the first and related gear, and 3) use instruments to draw their individual gear trains and identify directions in their choice of initial gear.

Participants were instructed to move an input gear and observe the movement of other gear(s). Each gear for observation was highlighted and participants responded in writing.

Participants were able to interpret the movement of gears in writing and were able to represent the movement of gears graphically, as illustrated in Figure 5.36 to Figure 5.38 although they did not use graphical symbols in Figure 5.38. Learners responded with better comprehension through the enhancement of their responses by the working model, as compared to the introductory lesson on pneumatics. In this model of a gear train participants were able to express their opinions based on what they observed, but their written responses were unsatisfactory when communicating. Overall, all learners responded to all questions in that classroom exercise and their achievement was above average for all questions. An average achievement of 65% was evident for the classroom exercise for gears.

(c) Concepts used with understanding in Mechanical Systems through Sign Language

The following Figures are typical examples of technological concepts used in Mechanical Systems and were frequently used in calculations:

1) Load in Figure 5.61
2) Divide in Figure 5.62
3) Force in Figure 5.63
4) Equal in Figure 5.64
5) Multiplicationg in Figure 5.65
6) Area in Figure 5.66
7) Lifting in Figure 5.67
8) Heavy in Figure 5.68
9) Project in Figure 5.69

Theme 3: Written responses of leaners

I also looked at responses of participants to a worksheet designed for revision after all sections in Mechanical Systems were completed in the second quarter of the year. I purposefully chose Questions 5, 6, 10, and 12 to explore the knowledge comprehension of participants on these sections, and considered consistency in relevant questions that would inform data collection and data analysis. A similar exercise was given (Appendix G) in the form of a worksheet. This worksheet contained different levels of cognitive domains where learners had to show evidence of knowledge and facts, use concepts in Mechanical Systems as well as solve problems through the use of concepts of Mathematics and Mechanical Systems.

. Table 6.1
Av. = Average. The illustration of participants' achievements on question for data collection and data analyses

Questions	**Total marks**	**Av.**	**Nosipho**	**Zekhethelo**	**Mxolisi**	**Ssphesihle**	**Sphelele**	**Class av.**
Q5	1	1	1	1	1	1	1	**1**
Q6A	3	3	3	3	3	3	3	**3**
Q6B	2	2	2	2	1		2	**1,4**
Q10A	5	5	5		4		5	**2,8**
Q12A	2	2	1	1	1	1		**0,8**
Q12B	3	3	3	3	3	3	3	**3**
Q12C	4	4	4		4		4	**2,4**

Questions 5, 6, 10, and 12 were chosen to assess the understanding of learners on related topics. Table 6.1 illustrates the questions selected for data analysis purposes and the achievement of participants on each question. This worksheet was given to participants towards the end of Mechanical Systems as a summary and for the revision of Mechanical Systems in the second term. Their responses to these questions were adequate and depicted sufficient knowledge. Participants were expected to recall formulas for MA, work done and Pascal's law as well as their implications for Mechanical Systems.

(a) Elaboration on Question 5: Calculations on Mechanical Advantage

As shown in Figures 5.39 to 43, participants were expected to unpack the concept of MA. In Figure 5.39 Mxolisi provided his perspective on MA, in words and in a formula representation. The word 'over' used in the concept of load divided by effort was a misconception, since the word 'over' in a sentence may not be mathematically justified. The word 'over' can be interpreted as ended, again and/or remaining in relation to English as a language, but in Mathematics the word 'over' can be used as a division sign for binary operation. All other learners provided a formula for MA in a simple and straightforward way (load divided by effort).

(b) Elaboration on Question 6: Calculations on levers

Table 6.2 summarises the responses of the participants to Question 6, which was on levers.

Table 6.2
Analyses of question 6

Responses to Question 6a	**No. of learners**
Correct identification of formula	5
Correct formula but error in substitution and working	1
Incorrect formula	0
No attempt	0
Did not write formula but provided an answer	0

Question 6 demanded an understanding of MA, which justifies the core business of using devices to make work easy. This question required a procedural application of an MA formula where a general Mathematics rule is expressed using algebraic symbols for division and inequality. In this question all learners were able to use the context-specific rule appropriately, providing the relevant relationship between load and effort through the guidance of the formula, as illustrated from Figure 5.44 to Figure 5.48. Participants were able to recall patterns and relationships between the input force and the output force that would cause movement on the load. They were able to represent these mathematically.

Question 6 was divided into parts a) and b). Responses to 6b were based on the understanding of 6a; 70% of learners were able to provide adequate responses about Question 6a in Question 6b. Sphelele was able to provide the response mathematically, stating $MA \geq 1$. This is an evidence of understanding of inequalities for ratio purposes. Of the participants, 80% were able to identify the relationship between the output and the input, and able to classify these to load and effort respectively. Most participants were able to formulate the relationship into a quotient without a unit of measurement, and the relationship of input and output into a quotient. However, while Zekhethelo was procedurally correct in calculating MA, she failed to represent her answer independent of a unit of measurement, and instead appended ‘kg’. Although MA is calculated in the form of a fraction, it is for the purpose of determining a ratio of output to input. The ratio does not have a notation as a unit of measurement.

(c) *Elaboration on Question 10: Calculations on hydraulics*

Question 10 on hydraulics was used as one of the questions for data collection and analysis. Table 6.3 provides an analysis of the attempts of participants to respond to this question.

Table 6.3
Analyses of question 10

Responses to Question 10	**No. of learners**
Correct identification of formula	2
Correct formula but error in substitution	0
Incorrect formula	0
No attempt	0
Did not write formula but provided an answer	3

All learners attempted Question 10 on hydraulics. Nosipho, Mxolisi, and Sphesihle were able to identify the relevant formula for calculating pressure in relation to $Work_{input}$ = $Work_{outpiut}$ and their approach was mathematically correct. Sphelele and Zekhethelo were procedurally correct in their endeavours to calculate pressure, but they neglected the effectiveness of using a formula. They went straight to the manipulation of formula $P_1 = P_2$ or $F_1/A_1 = F_2/A_2$. They were able to identify the relationship between the force on the input side and the related piston and the force on the output side with a relative piston. Sphelele's approach (Figure 5.53) was correct but it was cluttered with many calculations all over the place. The calculations were not logically written, leading to confusion. In Figure 5.52 Sphesihle calculated two areas without converting centimetres.

The approach of participants to Question 10 was not consistent but depicted a fair understanding of the hydraulics section. Some learners converted centimetres into metres for calculating required areas, while others substituted values as they are given. All participants were able to maintain the correct arithmetic procedure in looking for the force input in Question 10, but there was no evidence of the motive behind calculations in this section, and the learners seemed to be using number crunching in many instances.

(d) Elaboration on Question 12: Calculations on gears

Table 6.4 provides an analysis of Deaf learners' responses to Question 12.

Table 6.4
Analyses of question 12

Responses to Question 12	**No. of learners**
Correct identification of formula	3
Correct formula but error in substitution	1
Incorrect formula	1
No attempt	0
Did not write formula but provided an answer	0

Questions 12a, b and c dealt with a compound gear train. For Questions 12a and b that relied on learners' recall, most of the participants did exceptionally well. They were able to present the function of the idler gear and provided pertinent directions sequentially. Sphelele and Nosipho did not respond to 12a, but all learners responded to 12b and c. In 12c, participants had an adequate numerical approach, but Zekhethelo and Sphesihle confused the gear sequence from gear A to gear C, with their calculations being procedurally correct. Mxolisi provided an answer in the form of a decimal fraction and thereafter in an improper fraction. This approach by Mxolisi demystifies the chronological order of calculating the gear ratio in its simplest form, and there is no evidence of understanding what a gear ratio was.

Table 6.5 illustrates questions selected for mathematical manipulation in Mechanical Systems and the achievement of each learner on these questions.

Table 6.5
Sumary of responses to the worksheet

Questions	**Total**	**Av.**	**NT**	**ZM**	**MM**	**SM**	**SS**	**Class av.**
Q5	1	1	1	1	1	1	1	1
Q6a	3	3	3	3	3	3	3	3
Q6b	2	2	2	2	1		2	1,4

Q10a	5	5	5		4		5	2,8
Q12a	2	2	1	1	1	1		0,8
Q12b	3	3	3	3	3	3	3	3
Q12c	4	4	4		4	0	4	2,4
Total	20	20	10	10	17	18	10	14.4

The achievements of each learner on the identified questions are provided in rows. The identified questions were out of 20 marks. The learner achievement averages 71%. Learners were able to recall the formulas that were expected for each problem. In questions that required a simple substitution, e.g. Question 6a, all learners were able to substitute the given information for them to calculate MA adequately; however, Nosipho extended her answer to 4 kg, deviating from the purpose of calculating MA in a ratio form.

Most learners had a challenge with Question 10, where they had to calculate and provide their solution in a chain form. Here learners were expected to calculate the area in a small piston and a large piston. They understood the procedure of calculating pressure in both pistons as $\frac{F1}{A1} = \frac{F2}{A2}$. However, participants were not consistent in providing basic requirements for calculating area. As a result, two learners (Zekhethelo and Sphesihle) did not calculate areas of piston but substituted the values of radii as they were. Their procedure in following the steps was arithmetically correct. Participants were using the correct procedures in following steps for calculations, but omitted important aspects of calculating pressure.

Theme 4: Participants' engagement in different lessons

There is evidence of team work in each stage of the model. When a stage is cumbersome to some learners, they will refer to peers before they execute. Figure 5.9 illustrated teamwork in assembling relevant pieces cumulatively. Similarly, Figure 5.31 depicted the same confirmatory approach before endorsing the response. When learners encounter ambiguity in any instruction based on either the abstractness of the concept used or the similarity in signing, they would relate their individual understanding to their peers before providing answers to the TT. Through the introduction of teaching aids (pulley system through the lifting tackle, gear train and hydraulics system) they developed an interest in operating the working models. Learners were curious and more focused on how the operation was taking place. After a demonstration or a simulation lesson, learners wanted to do more of the practical work. As the follow-up lesson was introduced at different levels, all participants were attentive and ever willing to participate. Gender issues were not omitted from their practical lessons: females bonded more easily and were able to approach individual challenges in unity, and males were doing the same. Figures 5.16 - 5.17 illustrate co-operation of males and females in assembling similar parts of the lifting tackle. Males were comparatively faster than females in most activities.

The pulley system in Appendix E was selected for a simulation lesson. This pulley system is a model of a lifting tackle with 11 stages. Learners were expected to follow the instructions on the working guide in order to complete the model. Each stage needed to be completed before proceeding to the next stage. Different pieces were given in different colour codes and shapes but were kept in one box. A major challenge for learners was to identify the relevant pieces for each stage, guided by the prototype instructions. Some Deaf learners were freer than others when working with the simulation, while others were fearful to initiate any move. In my continuous interaction with the Technology class, I discovered that Mxolisi was more involved in activities outside the classroom. As a result Mxolisi was also more involved in lessons and more active in simulations and demonstrations. I discovered that Mxolisi was involved in volleyball, amongst other things. As the simulation progressed participants became more active, open and free to participate. In their interviews more participants alluded to the fact that they were not given the freedom to play and participate in any work at home as they wished.

At an elementary stage the female learners were more sceptical about participating in the simulation and demonstration lessons, with the exception of Sphesihle, who wanted to try. Figure 5.14 shows Sphesihle attempting to dismantle pieces that were wrongly assembled; instead of logically dismantling pieces, she wanted to break them. Figure 5.16 provides evidence of female learners ganging up against male learners, but the male learners were quicker at assembling their side. Figure 5.18 shows female learners comparing their work with the males’ work. Participants did not rely on the instructions for simulation but tried to do it themselves by experimenting and consulting their peers. For example, Figures 5.15, 5.17 and Figure 5.19 show participants confirming pieces with one another without consulting instructions from the book. I observed that participants preferred to brainstorm their ideas about steps to be taken instead of using the guide provided.

Theme 5: Peer communication to the learning of Mechanical Systems

(a) *Discursive skills observable*

During the simulation lesson, where learners were expected to assemble a model of a lifting tackle, they were expected to be guided by the instructions stipulated in Appendix F. Team work was at a maximum when learners could not understand one of the steps to be followed. Some of the learners were sceptical to initiate but could instruct other people to execute the duties expected. In Figure 5.13 and Figure 5.15 Nosipho and Zekhethelo are seen telling Sphesihle what to do. The boys' team worked very well while the females worked as another team on the other side. In Figure 5.16 Sphelele was being very accurate and observant in choosing pieces as suggested in the instruction steps. The combination of Sphelele and Mxolisi was effective, as Sphelele provided the necessary material. Figure 5.18 shows the female team versus the male team busy with their tower building, and also shows Sphesihle comparing some stages on the tower with that opposite to theirs. Nosipho was able to identify that they were stacked wrongly, but was not willing to try anything to remedy the situation. In arguments about actions to be initiated in steps, Sphesihle stood firm in what she believes (Figure 5.18).

The learners were able to complete the model with minimum usage of the model guide, trial and error being their first option. In this option learners believed in negotiating their responses before they executed them. Since this was a simulation demanding participation and group work, the learners were able to share ideas, share resources and empower one another. Initially most of the learners were sceptical about participating, but as time went by they gained confidence and relied on one another more than the simulation guide

(b) *Participants' discovery with each other*

Mechanical Systems in Technology is a subject that is language specific and content relevant. It is highly influenced by human activities practised on daily basis. Technology becomes relevant to societies based on the fitness for purpose. The application of mechanical concepts produces a language that directs activities to a required instruction. I observed that participants frequently shared and negotiated their responses before they answered questions from the TT. Hypothetically, participants share their innate thoughts about the evident environment. In this instance participants grasped the unfolding prescriptive Technology language with the emerging Sign Language through their negotiated approach. This situation underlines the importance of including Deaf communities in the development of Technology terminology, in a quest to know whether or not the development of relevant Sign Language may stem from active participation of Deaf learners in different practical involvements.

Deaf communities are the minority of the verbally communicating population that has an influence on curriculum design. When participants were interrogating the mainstream curriculum they were able of negotiating their perceptions of any concept presented that was beyond their Sign Language vocabulary, before giving answers to the TT. Through their negotiations in class participants developed their esteem, which improved their confidence. According to Jambor and Elliott (2005) esteem impacts positively on human cognition, motivation, emotions and behaviour and that correlates with psychological wellbeing. Participants appreciate being members of a signing society that shares a feeling of belonging to a group of 'similar others' while thriving to function in the hearing world.

In the process of learners' discovery with each other, discovery becomes a process of finding a new piece of information that facilitates learning of a new phenomenon. As stated in Antia et al. (2002), participants are able to discover information through various senses merging with pre-existing knowledge. It was observed that participants frequently shared and negotiated their responses before they answered questions from the TT. Hypothetically, participants share their innate thoughts from their environment with an intention to grasp the changing use of prescriptive Technology language with the emerging Sign Language. The Technology curriculum envisages participation of all learners inclusively. However, this process underlines the importance of including Deaf communities in participation in the curriculum and classroom membership for cognitive enhancement. Membership refers to the integration of individuals in education communities that has potential to influence curriculum, highlight structural barriers and provide partnership support (Antia et al., 2002). It is important to include Deaf learners in the development of Technology terminology signing to explore if the development of relevant Sign may come from active participation of Deaf learners in different practical involvements. The concept of inclusion should be identified in terms of membership for both development and participation of Deaf learners in the curriculum.

(c) ***Contribution of peer communication to the learning of Mechanical Systems***

Participants shared grades and learning areas for some years. Grade 9 could be their last grade together and Technology may be their last learning area together, since they had to make different career choices in Grade 10. Their experience in sharing classes had a positive academic influence through establishing bonds and trust with one another. I can allude to the fact that participants were interdependent during their lifelong learning. The discussion that participants had when there was ambiguity and misconceptions about signs for different concepts in Mechanical Systems unleashed their potential to attempt different options for a number of times. Mxolisi and Nosipho were more receptive than other participants, in the sense that most participants would approach them about their misconceptions and misunderstandings. Furthermore these two learners were quick to attempt any challenge to the best of their ability. For that matter they jointly developed a project together. Zekhethelo was very lazy physically, but in terms of attempting to respond she was brilliant.

The learning of participants in the family environment reduces the family purpose because of the lack of adequate ability to communicate with their families; this in turn maximised their availability for learning programmes. For example, the Technology teacher attested to the fact that participants are always on the school premises and were always around her for working on their practical project whenever they were doing nothing and during their breaks. In exploring this further, participants confirmed the fact that school is the place where they enjoyed their communication and use of Sign Language. My observation is that a greater motivation for this group of participants was the feeling of belonging, which was satisfied by the culture, environment and their language of communication. The environment created in their school and classroom was welcoming to participants, but posed the question of identifying an effective approach to competent participants in Mechanical Systems. The TT attested that learners enjoyed being at school mostly because it is where they express themselves in the language they understand.

While it is commonly found in most schools that when learners have completed writing exams, they don't enjoy coming - the direct opposite is seen with participants, who spend every day of their schooling on the school premises. According to the TT most aspects of their project were done after the formal exam was completed; the. TT highlighted that learners wouldn't mind spending the whole day working on their project. Because of the Safety Act that prohibits learners from working alone in the workshop, the TT alternated times to monitor learners in their process of completing their projects.

Theme 6: Role of Sign Language in learning Mechanical Systems

In a Deaf classroom the Deaf community used Sign Language and finger spelling to communicate their learning. I wish to make a distinction between Sign Language and finger spelling as these were used as ingredients for comprehension and competency in the Deaf classroom.

(a) Sign Language

Sign Language is a mode of communication that integrates the use of the hands, face and upper body to express different grammatical structures, concepts and illustrations. The CAPS document advocates for the use of SASL. Sign Language is a form of communication that is not bonded to a particular grammatical rule but can be applied to pragmatic and discourse analysis. For example, in Figure 5.22 participants were displaying their understanding of the motion of different gears within the same gear train. Hand forms, movements, locations, facial expressions and alignments were used in the discourse of direction of different gear trains. Not only that, but the upper torso coupled with miming without speech was used to elaborate their understanding of the gear train demonstration. Sign Language was used by the whole 'classroom community' to produce manual dexterity. For complex concepts used in Mechanical Systems, like pneumatics, hydraulics and levers, the signing teacher used finger spelling.

(b) Finger spelling

Finger spellings are gestures made by shaping the hands and fingers to represent the 26 letters of the alphabet from A-Z and numbers from 0 - 9. Finger spelling is normally used in spelling names of places and people, abstract concepts and words that do not have authentic signs. It is permitted for SASL to use more of finger spelling based on its limited vocabulary in signs as compared to American Sign Language. This is an appropriate technique used in the Deaf classroom to represent an abstract concept, such as Mechanical Systems, in a word equivalent to the written language of communication.

Many concepts and terminologies used in the Deaf classroom did not have proper signage. For example, Appendix J provides a list of some concepts in Mechanical Systems that did not have justifiable Sign Language. For these concepts finger spelling was used with the guidance of the signing teacher. In these cases the Technology teacher uttered concepts and the signing teacher finger spelled the word to enhance the understanding of participants. The language of communication that was used in class was English, maintaining the call in the CAPS document for using English as a medium of instruction. Finger spelling is not a Sign Language, but it provides a balance between the limited vocabulary and the required standard expected for competences in Mechanical Systems. As a result participants were compelled to be adequately skilled in using a language of instruction alphabetically to be able to code switch from Sign Language and finger spelling to written English.

Some Technology concepts and words in Mechanical Systems could be signed adequately while others relied on finger spelling. Those concepts in Mechanical Systems that were signable to participants were better understood, because they already existed in the learners' schemas. Those concepts in Mechanical Systems that could not be signed posed a cognitive challenge to participants. This cognitive challenge was based on limited Technology literacy influenced by previous exposure. In my observation, there were three things foregrounding the learning of Mechanical Systems in the Deaf classroom: previous exposure to everyday concepts, involvement, and participation in daily activities.

(c) The role of the Sign Language interpreter in the lessons

The composition of the Deaf classroom was made up of learners, the Technology teacher and the Sign Language interpreter. Crucial facilitators of the learning of Mechanical Systems in the Deaf classroom were the Technology teacher and the Sign Language interpreter. Participants were initiated into the Deaf school at an early stage of their formal education with no background in either a home language, language of instruction or Sign

Language. Teachers who participated in learners' earlier language development in Sign Language are from the English-speaking population, and their contribution to these learners was dominated by English. As a result their communication is mainly in English. Learners were provided with the questions based on language usage.

The role of an interpreter in supporting the learning of Mechanical Systems in a non-hearing environment was to translate the content of Mechanical Systems from verbal language to Sign Language and vice versa. In cases where participants used signage unsuitable to academic progression, the interpreter would correct such incorrect gestures and confirm an acceptable sign. Participants also had some misconceptions about issues and concepts dealt with in Mechanical Systems, and the interpreter would correct these too. For example, when the Technology teacher was talking about air during the pneumatics topic, Nosipho (Figure 5.2A) responded with the word 'water' instead of 'air'. The interpreter noticed that misconception and she enunciated the difference between 'water' and 'air' using finger spelling (see Figures 5.2B and 5.3).

In many instances where there were no signs, the interpreter used finger spelling and participants would relate their understanding about the signed concepts to what they could remember and craft the answer. The interpreter used to clarify learners' responses during and after their negotiations. In the case where they confused the sign for 'water', Mxolisi resorted to using 'H_2O' as a scientific word for water. In that instance it was the interpreter who disclosed this from the negotiation of Zekhethelo, Mxolisi and Sphelele about H_2O. In the absence of a unit symbol for signing, the teacher is compelled to use the alphabet to constitute the word, e.g. hydrogen and two oxygen to mean water.

6.3 Learning style in the classroom

The prominent learning style in the Deaf classroom was visual learning. Blended learning was not only identified in the Technology classroom for non-hearing leaners based on its mono-nature of encoding knowledge but also based on measurable behavioural change, knowledge evidence and participants' involvement in lessons. Visual learning was blended into formal learning and informal learning within the context of constructivism and social constructivism. BLM is illustrated in Figure 3.1.

6.3.1 Analysis of formal learning

Within the formal learning, work-based learning, problem-based learning and discovery learning were identified as having an impact in enhancing understanding of participants.

(a) Work-based learning

Work-based is the typology of learning through the project. It facilitates learning that integrates theory and practice. The elements of the responsibility, safety and reliability of learners were assured at all levels of Technology design, and were evident in projects that the learners developed. The Technology TT made themselves available when participants were working on their projects. When participants engaged in the simulation (Appendix E), it was provided to them in an exploded view, the aim being to insist on the guided instruction provided. At the initial stages the learners were sceptical about participating in the process because of their experiences of being prohibited from taking part in other activities at home. Participants were tasked with class work to tackle different aspects of gears (Appendix F). The confidence gained during participation in simulations and demonstrations extended to the project (Figure 5.70) as evidence of tacit learning. This project had a combination of levers and hydraulic systems, and Nosipho and Mxolisi had the idea of creating an excavator when they were developing their project, deducing it from the roadworks they observed in a real-life situation. This idea adheres to CAPS, with the two learners providing evidence of competency in their design. In their explanation of operations, the principles of systems, knowledge of the performance of hydraulic systems and the way in which levers operate reinforced the understanding of processes described in individual topics (levers and hydraulic systems). The enhanced understanding of Mechanical Systems led learners to use their previous knowledge gained in their theoretical lessons and active involvement in class in the development of a model and as a simulation of an excavator. I concur with Myers (2016) that project-based learning requires some level of consultation and a level of research, as the TT did not have time on their part but kept on assisting learners in the processes of their projects (Lelliott et al., 2009).

(b) Problem-based learning

According to Hung, Jonassen, and Liu (2008) problem-based learning occurs when learners solve their daily problems. As shown in Appendix E, learners were tasked to assemble the exploded view of the lifting tackle. Learners were able to work collaboratively in assembling the tackle. Because they were enthusiastic to contribute towards completion of the model, they combined into two groups. The learners were compelled to follow instructions, as each step led to the next. Participants in this Technology class have been together for more than 6 years, sharing subjects and grades. They enjoyed social interaction that has the potential of leading to good partnerships in learning situations. Individual learners were watchful of what the next person was doing, and they wanted to confirm and consult their peers before presenting their responses.

The innate need to belong was an initiator for cooperation and interactive exploration. It is suggested that belonging is as compelling as the need for food, and that human nature is conditioned to seek it (Gregory, 2016). For this reason participants had no risk of losing face or appearing incompetent in front of others based on their sense of belonging to the Deaf class. Collaboration offers participants a chance to be appreciated and to feel important, influential and powerful among peers. In these exercises done in class, participants were not ashamed to share their knowledge and to participate in any activity. Problem-based learning is an element of design that is informed by ratio and proportion (Allen, Donham, & Bernhardt, 2011), and based on the quest for calculated solutions. In the case of Mechanical Systems it is foregrounded on MA, where knowledge of ratio and proportion is a major ingredient. When learners are presented with a problem that integrates logic, theory and practice, problem-based learning fosters a deep understanding of concepts and content development. As seen in Appendix G, Question 6, participants were tasked to calculate MA and specify the existence of MA, and 88% of participants managed to respond to the question correctly. Only 12% struggled with the correlation between MA and understanding of the concept when MA ≥ 1.

(c) Discovery learning

Discovery learning is a type of enquiry that is grounded on the findings of learners themselves during problem-solving exercises (Da Nóbrega, Cerri, & Sallantin, 2003). In a Deaf classroom learners are at the disadvantage of depending only on their eyes as an encoding mode of their learning: thus depending on only what they could see. Discovery learning was compensating for the absence of other senses that could contribute to their effective learning. During simulations and demonstrations, participants were in a position to deduce their understanding from the manual operation of the simulation and demonstration. Simulation gives an individual learner a chance to build their mental models about the process and the operations of the systems in the project through the development of mental cognitive skills, deeper understanding and a high level of learner engagement.

In the simulation of gear trains (Appendix F) learners were able to identify the direction of each gear in the gear train and the function of the idler gear and represent the gear train graphically. As evidence of comprehension of the gear train, participants were able to attempt Question 12 (Appendix G). Participants were hands-on in assembling simulations and demonstrations. They were able to master the process of operation and were encouraged to apply their understanding to similar situations. One typical practice that was common to learners is that they would discuss their ideas before responding to the question. An advantage of discovery learning for participants is that they were able to remember concepts and knowledge discovered in their active learning.

Through the discovery of participants, they were able to relate their observations to fragmented terminologies and crafted that knowledge into unit understanding of concepts. For example, as shown in Figure 5.31 the Deaf classroom was able to give interpretations to the words ‘anti’, ‘clock’ and ‘wise’ to inform the concept of anticlockwise direction. A similar approach is seen in Figures 5.29 and Figure 5.30. Because of the insufficient signage in Mechanical Systems, for concepts like MA learners were compelled to come up with relative signs justified by their observation, as illustrated in Figures 5.59 (‘Mechanical’) and 5.60 (‘Advantage’).

6.3.2 Analyses of informal learning

(a) Learning as social activity

Moving from teacher-centred to learner-centred education, classroom interaction goes hand in hand with the theoretical shift that emphasises the active role of the individual in meaning making and knowledge construction. I concur with Kumpulainen and Wray (2002) that in this learning style classroom interaction emphasises the collective negotiation of responses. Participants were interdependent in their learning and very watchful of what the other persons were doing. Each time a question is posed to them, they always want to act within the principle of collective argument (Kumpulainen & Wray, 2002). In this process participants explain their ideas to one another, justify their reasoning about their responses, and come to agreement before responding to the TT. I also concur with Pritchard and Woollard (2010) that social interaction contributes to a full development of cognitive development and plays a fundamental role in activating perception about the phenomenon beyond the concepts. This process is a true reflection of communicative knowledge gained through informal interaction. Learning as a social activity supports the work of Vygotsky (1978) in Pritchard and Woollard (2010) that learning in the Deaf classroom occurred at a interpsychological level when they negotiated responses to different questions. When participants respond to questions in a written form, they yield to the intrapsychological as their responses are coming from the logical memory through the formation of concepts.

(b) Active learning

Active learning is a process whereby a person eagerly develops an interest in testing a new hypothesis as part of a continuing interactive learning process. Interactive learning develops a line of enquiry within a series of experiments that helps a child to draw efficient conclusions. Active learning is sometimes called query learning (Grabinger & Dunlap, 1995). The effect of active learning in the Deaf classroom was evident in the development of final projects in this group. Participants were able to develop a simulation of an excavator, linking what they learnt in the classroom to what they see in society. Learners were able to use proper measurements and proper scaling in designing parts of their project. Participants were not fully exposed to real-life situations that made knowledge gained relevant; instead, they were asked to solve problems that caused them to wonder why they needed to know some piece of arithmetic information. For example, when participants were working on Question 12 (Appendix G) they were procedurally correct in calculating gear ratios but logically incompetent in arranging the gear train for effective calculations. During my observation less emphasis was placed on the numerical science of Mechanical Systems. As a result, aspects of Mechanical Systems were dealt with separately to the arithmetic processes of Mechanical Systems. It is evidence of proper scaling to measure the quantity of liquid in a syringe that will allow the combination of levers to stretch without breaking and rise up without breaking, and that emanated from the simulations done in class. Active learning leads to increases in performance as evidence of understanding (Freeman et al., 2014).

(c) Experience learning

Experience learning is a relatively new initiative targeted at transforming educational goals. In Technology experience learning enhances the development of participants and educational experiences by providing more opportunities for hands-on learning. This approach was foregrounded on participants' engagement that encapsulates increasing knowledge, acquisition of lifelong learning and problem-solving skills that are embedded in the value of education. I allude to the fact that learning through experience is the process whereby knowledge is created through transformation of experience (Kolb, 1984). As stated in Gibson (2009), experience learning added much to the experience of participants involved in Mechanical Systems. This learning process recognises the prior knowledge that learners bring into the process of learning; their intellect, feeling, senses and personalities are directly involved and learners are personally engaged. I concur with Hansen (2000) that practical competency is the combination of thoughtless behaviours and habits inculcated through practised skill. Participants acknowledge the significance of instruction through their engagement in the simulation (Appendix E). In Figure 5.13 - 5.15 participants were struggling with identifying relevant pieces in their assembling based on their neglect of the instructions. They concentrated on colours and similarities but neglected logical steps involved in the simulation. A struggle was observed in the initial stages when participants wanted to work on a common simulation through individual efforts. Until they discovered the essence of honouring instruction through collective effort, their endeavour was a futile exercise.

6.4 Conclusion

The learners' responses emanating from the data collection process during Mechanical Systems lessons were analysed in Chapter 6. Data collection was carried out through observation of different topics (pneumatics and hydraulics, pulleys and gears), and document analysis that included simulation responses as well as responses to a worksheet with selected questions. Ultimately interviews were conducted with all participants.

Chapter 7 will discuss the findings and provide the recommendations of the study foregrounded on knowledge, skills and competency as entrenched in the CAPS document.

CHAPTER 7

Findings

7.1 Introduction

The previous chapter discussed themes that were revealed by this study. This study began by observing the experiences that learners bring to the Technology classroom and the influence of these experiences on the learning of Mechanical Systems. The endeavour was undertaken to address the concept of the '**Learning of Mechanical Systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal'.** In undertaking this research project learners in the Grade 9 Technology classroom were observed during the learning of Mechanical Systems in the second quarter of the year. The classroom included three female learners, two male learners, the Technology teacher and the Sign Language interpreter. Learning in non-hearng classroom was observed and video recorded and interviews were done over the period allocated for Mechanical Systems.

7.2 Findings

While the Department of Basic Education adopted Technology as a school subject alongside Mathematics for critical and creative thinking, communities continued to view Technology as an instrument for equipping disabled learners with hands-on skills for living. This meant that Deaf schools used the mainstream Technology curriculum to mediate teaching and learning in Technology as opposed to assuming this school to be a specialised institution for disabled learners.

This study was challenging but significant in assessing the undertaking of the Technology curriculum by participants. Findings were notable in relation to the actual participation of learners in the mainstream Technology curriculum. It was evident from the data collected that all aspect of Mechanical Systems were mediated as prescribed by the Technology curriculum in Grade 9, and the time allocated was honoured. Within the boundaries of this study, findings were reached in relation to the following critical questions:

1. What are the experiences of Deaf learners in learning Mechanical Systems?

2. What is the role of Sign Language in learning Mechanical Systems?

These findings are outlined in the sections that follow.

7.3 What are the experiences of participants in learning Mechanical Systems?

The first question dealt with identifying all experiences that are essential for the effective learning of children in schools where participants brought into the Technology classroom. The experiences of these learners encapsulate socialisation, the schooling system, the impact of interdisciplinarity, and knowledge application in the Deaf classroom, and advanced learning as well as information retention.

7.3.1 Socialisation

Deaf learners are socialised differently because knowledge is usually learned from the mother's basic skills in language. However learners learn communication at school. Proper Sign Language development starts when learners enroll into the Deaf school. For that matter, social development of participants did not support their academic development, since concepts dealt with in Mechanical Systems are closely related to aspects of family activities. Pertaining to this study, socialisation of these learners entailed mixing activities in the learning process from social structures to craft an acceptable behaviour that fulfills a particular culture. People live in the world of norms and values where families inherit what is done in societies. According to Baferani (2015), families and parents are the core of education in the development of children. Moreover families embrace what the average person considers as norms. Participants picked up Sign Language at school. It is hypothetical that socialisation of children entails social skills, self-esteem and social adaptation of a child rooted in human life as the social origins of the development of a child. Conversely, participants experienced an alternative social process that limits transmission of their values, norms and social customs. Participants did not benefit from the intimate relationship vital for establishing their social balance associated with the play learning and adaptation required to prepare a child for communication. Desirable growth of Deaf children was not encouraged in terms of social dimensions of their communities and their direct families. This means many participants missed out on these linking activities.

The study showed that participants communicated very little at home. Presumably their communication was around fundamental things using signs used in the home, for example, food, eat, sleep, pee, etc. It was revealed that participants seldom participated in daily activities in their homes. For example, Nosipho attested to the fact that her family does not allow her to do some work because she breaks things.

Participants missed out on a lot of activities that are experienced by children in their growth. When the teaching team was asking them about their understanding of compressed air, participants could not make sense of it because they had no experience of games and play related to compressed air. To the specific question 'Where do we use compressed air?' Sphesihle answered '*plastic pocket*'. Sphesihle had an idea of a blown-up plastic pocket, maybe because she has never been exposed to a soccer ball or a balloon. This limitation affected participants in different ways, as the pneumatics lesson was presented theoretically based on questions and answers.

Participants remembered all events that had a direct impact on their lives. When a model of hydraulics systems was shown to them, their facial expression resembled pain. When participants were asked to share their understanding and experiences about the model of hydraulics systems in Figure 5.6, they all sat up straight, attentively looking at the teaching team. Nosipho's eyes were wide open as she sat in silence, as shown in Figure 5.7. Occurrences related to syringes had left an impression that the syringe is designed to inflict pain. All participants pointed at different parts of their body where injections had inflicted pain. For example, Sphesihle started by illustrating the penetration of the needle using both her hands, as shown in Figure 5.7. Her facial expression is emphasising a painful penetration. Ultimately she directed all of that process to her rear, as shown in Figure 5.8.

Participants were able to relate to lessons on hydraulics since the gargets used in this section resembled painful occurrences which they had personally encountered in their lives. Throughout the development of lessons in hydraulics, Deaf learners shared experiences (Figure 5.9) and responded to questions from the teaching team. Emanating from their experiences of injections, Zekhethelo explained the operation of the hydraulics systems vividly in Figure 5.10, and the whole class had something to say during discussions with understanding, as shown in Figure 5.11. Although some terms used in hydraulics systems did not have signs, the combination of experiences related to injections and their observations of operations enabled them to analyse the processes.

7.3.2 Schooling system

Education for this group (Deaf learners) was discriminatory because they were advocated for mainstream education on the basis of inclusion, yet no specific intervention was put in place to address communication challenges to their participation. This study revealed that the education system for Deaf learners was regulated by CAPS under the domain of mainstream and inclusive education entrenched in Chapter 29 of the Constitution of South Africa on education: 'Right to basic education'. This group was at the exit point of the GET band, preparing for the FET band. The Technology subject was adopted in 1998, but the language of communication to Deaf learners was formally adopted only in 2015, leaving the question of Sign Language as an official language. For generations school has been considered the extension of a home, where the social development of a child at home has to be co-related to academic achievement. Participants experienced contradictory procedures: their communities and families did not contribute adequately to their language skills, as their (Deaf children's) conscripted language was alien to their societies. 'Parent talk' was not core to basic education facilitation of Deaf children, yet educative learning advocates for reflective behaviour centered on families for problem solving in learning.

The Deaf school provided radical support to participants that ensured a required adaptive behaviour to their learning. Of Deaf learners' in this class, 80% began their schooling career at the Deaf school; the other 20% joined the Deaf school after Grade 2. In the academic engagement, participants were introduced to a schooling system that facilitated required skills to accumulate their vocabulary, mainly in Sign Language. Participants were able to adapt to the basics of Sign Language for adaptive behaviour in their learning. For that matter, participants interrogated Mechanical Systems through Sign language. However, their learning opportunities were reduced as they could not pick up lessons from the activities going on around them. Their incidental learning was coupled with exposure to phenomena.

This study showed that participants experienced the significance of interdisciplinarity, where concepts from Mathematics were used to inform the effectiveness of Mechanical Systems. Participants were separating aspects in their learning from those of daily practices at home, as if learning in different contexts requires different approaches and different terminologies (Blatto-Vallee, Kelly, Gaustad, Porter, & Fonzi, 2007). For example, Mxolisi referred to water as H_2O when it was used in the hydraulics systems demonstration, but for water used at home for washing, cooking and bathing he had a different understanding.

Participants enjoy being at school, where their communication and interaction with teachers and their peers was purely in Sign Language. The Technology teacher alluded to the fact that participants were never absent from school unnecessarily, and participants themselves attested to the fact that they preferred to be at school since their peers communicated in the same language. Their school was entrusted with the role of empowering participants for the world of work and a sustainable lifestyle through a viable education system. They also enjoyed school because of the Sign Language that enabled them to communicate

7.3.3 The impact of interdisciplinarity and knowledge application in the Technology classroom

In this study it was evident that the Department of Education appointed the Technology teacher on the basis of education training without specific training in Deaf education. Participants' experience was to work with the 'hearing' teacher who had knowledge of the Technology content and a hearing teacher with Sign Language interpretation skills. Participants experienced different levels of 'content understanding' within the classroom. Mechanical Systems content was delivered by the Technology teacher to the Sign Language interpreter, and from the interpreter to participants. Facilitation of learning in the Technology classroom was actualised through the 'hearing' teaching team. Teaching and learning in the Deaf classroom was made effective through vision as the only encoding mode.

The Technology classroom interrogated Mechanical Systems content through Sign Language. Participants' vision cognition was enhanced as their learning development was reliant on Sign Language. The visual special skills for participants were adequate and appropriate for Technology safety. Participants were compelled to consider interdisciplinarity of Mechanical Systems with Mathematics and Sign Language. For example, the integration of Mechanical Systems and Mathematics required participants to acknowledge their (Mechanical Systems and Mathematics) appropriate languages as well as the associated principles guiding the usefulness of Technology. MA was a prominent concept in Mechanical Systems.

Mediating the language of Mathematics needed specific skills and specific Sign Language interpretation. When participants were calculating MA in section 5.4.2(a) different approaches were observed. Some participants used binary operations (÷) while others used interpretation of binary operations in Mathematics. They used Mathematics language to address abstract ideas of MA. In their calculation of MA it was a merely Mathematics calculation with the observation of Mathematics principles and language. This study showed that participants were able to represent binary operations through Sign Language. For example, in Figures 5.52, 5.54 and 5.55 participants were presenting the division sign, multiplication sign and equals sign respectively using Sign Language.

Mathematics language provided a major pedagogical tool that made the invisible aspects of Mechanical Systems visible. For example, comparing the speed of input and output a machine, it is always cumbersome when they are not quantified. When participants used a concept of MA they were able to comprehend this concept of MA beyond its numerical science. MA provided preciseness of motion, as observed in simulations and demonstrations. Therefore numerical science changed the nature of Sphelele's experience in algorithmic handling in Figure 5.48 by relating MA ≥ 1 to the application of practical activities that were appropriate to societal needs. Sphelele not only looked at 4 as a numerical answer but extended his elaboration to the meaning of 4 in relation to load and effort as a ratio. In question 10 Nosipho (Figure 5.39), Mxolisi (5.41) and Sphesihle (5.42) chose to calculate areas of pistons in a hydraulics system machine using πr^2. They experienced the application of the logic of the 'BODMAS rule' in their calculations and further substituted these answers in the law of simple machines ($W_{in} = W_{out}$). The actual application of the 'law of simple machine' contributed a multidimensional contribution of numbers in providing appropriateness in Mechanical Systems for design and a ratio of resistance where load and effort were used in section 5.4.2. For example, Nosipho and Mxolisi were able to design a simulation of an excavator using the concept of hydraulics in Figure 5.70.

Participants deserved a chance to be physically involved in activities and to be appreciated for their good work on the basis of inclusion. The new knowledge gained and practised expertise during theoretical and simulation learning enabled participants to venture into 'advanced learning skills' in section 2.4, and could predict what they would do with the acquired knowledge, as stated in Wicklein and Schell (1995). For that matter their projections on further education were changed, yielding to the self-esteem and social adaptation gained therefrom.

7.3.4 Cumulative nature of Mechanical Systems

Mechanical Systems is 'cumulative' in nature as concepts are building up on each other. Participants struggled to deal with integrated aspects of concepts from Mathematics and the previous knowledge of Mechanical Systems that were concealed in the theory lessons. Participants learned to retain the previous knowledge gained through observations and demonstrations. Furthermore, participants honoured instructions from teachers and were able to identify relevant opportunities for use. For example, when participants were tasked to calculate number 6, Appendix G, Zekhethelo provided the unit of measurement (kg), claiming that "*I was told to put units in all my answers for correct. I used N in load and effort now I used kg because N cancelled each other …*"

It was revealed that participants were prohibited from participating in family activities, yet such activities are the origins of cognition and social development. Participants experienced the integrated approach to Mechanical Systems and Mathematics knowledge was applied to concepts of Mechanical Systems. For example, in question number 10 in Appendix G participants were acquainted with converting centimetres (cm) into metres (m), and calculating areas covered by the given pistons using the knowledge of calculating the area of a circle. The study showed that some learners were able to advance their approach in their calculations. For example, in Figure 5.41 Mxolisi calculated areas of pistons without converting to metres, claiming that "… *two pistons are using centimetres. When I am calculating force, centimetres will cancel because they are equal to centimetres…*" Although some knowledge application by participants was inadequate, their procedures were correct and their reasoning was in line with principles of Mathematics.

In different sections of Mechanical Systems MA was a concern to qualify the use of pertinent machines as opposed to human effort. In theoretical lessons participants took time to ponder the previous knowledge, but in lessons that integrated theory, demonstrations and, simulations their learning enhanced knowledge and skills as important learning domains in Mechanical Systems. Their active participation embraced two major aspects of Mechanical Systems: 1) doing, and 2) thinking about mechanisms of machines which the Deaf learners designed. These two aspects facilitated the morphisms of participants on the basis of Sign Language into Mathematics language and relevant Technology terminology.

7.4 What is the role of Sign Language in learning Mechanical Systems?

Sign Language is a mode of communication that allow messages to pass to another person through gestures, as explained in 1.8.5. Knowledge that was commonly disseminated in verbal: written language was disseminated in visual: written language. Sign Language has been adequately used for personal communication in the Technology class, but participants experienced communication of knowledge of Mechanical Systems in a pragmatic way through Sign Language. Sign Language was not translating thoughts but was rather changing a discourse of a spoken language into a visual language, without compromising the meaning of the concepts of Mechanical Systems.

In the classroom Sign Language maintained the meaning of concepts through the use of ligaments and developed a vocabulary through comprehension. Sign Language facilitated the learning of related concepts within the interdisciplinarity of Mechanical Systems and Mathematics. Sign Language translated the content of Mechanical Systems without compromising the context in which related knowledge will be used for design. Sign

Language requires more content comprehension for knowledge to be translated from English as a medium of instruction to Sign Language over and above finger spelling.

In the case where there was no appropriate signage, the Sign Language interpreter used finger spelling to present the word and the Deaf community in the classroom discussed the context at which the word is used. For example, in Figure 5.2A Deaf learners are explaining the concept of Pneumatics according to their understanding, but the Sign Language interpreter picked up that they are missing a full grasp of the concept. In Figure 5.21 the teaching team are explaining the concept of gears in terms of sizes and directions, and in Figure 5.22 participants are interpreting the situation using Sign Language.

For Mathematics, binary operations were signed (÷, × and +) adequately by participants (see, for example, Figures 5.52 and 5.55).

Participants and the teaching team adapted regular Sign Language to the specific context of Mechanical systems. Participants were able to provide a signage for ‘load’ (Figure 5.51), ‘force’ (Figure 5.53) and ‘area’ (Figure 5.56). The Sign Language interpreter assisted with ‘lifting’ (Figure 5.57) as well as ‘heavy’ (Figure 5.58), as they were providing ambiguity with ‘load (Figure 5.51). Participants were able to craft the concept of MA (Figures 5.49 and 5.50) through comprehension of the concepts. For signs that were not available in the Mechanical Systems vocabulary, the Sign Language interpreter used finger spelling to compensate for the absence of proper signs. For example, for words like ‘pneumatics’ (Figure 5.4) and ‘hydraulics’ (Figure 5.12) finger spelling was used to expose participants to required cognition about related concepts.

7.5 Conclusion

Five learners, the Technology teacher and the Sign Language interpreter formed part of the Technology class and participated in this study. Data were collected from their participation in classroom activities through observation, video recordings and interviews. Data collected from the teaching team was used to triangulate research findings on how Mechanical Systems was mediated in the non-hearing environment.

The next chapter will provide the conclusion and recommendations of the study. It will further identify research opportunities in the light of understanding Deaf learners and improved approaches in providing effective teaching and learning in a non-hearing environment.

CHAPTER 8

Conclusion and recommendations

8.1 Introduction

In the previous chapter we presented data gathered in the non-hearing environment during the learning of Mechanical Systems. This chapter provides concluding comments in the form of unique features as they emanated from the data and makes recommendations of the study. In focusing on the data analysis I began with specific observations and measures, starting with the raw data that we collected. Thereafter, patterns and regularities in the data were identified which led to the formulation of some tentative hypotheses that were explored. Finally some general conclusions were developed, as advocated in Bertram and Christiansen (2015, p.117). Hence it is clear that this study followed inductive methods in exploring the way in which Deaf learners learn Mechanical Systems.

8.2 Analysis of unique features of this study

All lessons observed in this study were carefully chosen to explore participants' conceptual understanding in the learning of Mechanical Systems in Technology. The lessons were guided by CAPS in engaging participants in Mechanical Systems in a meaningful way in all activities conscripted for the Grade 9 Technology class. CAPS is rooted in specific aims that emphasise learners' ability to "develop and apply specific design skills to solve technological problems; understand concepts and knowledge used in Technology education and use them responsibly and purposefully; and appreciate the interaction between people's values and attitudes, Technology, society and the environment" (DoBE, 2011, p.8). All three specific aims are targeted at ensuring technological literacy among all learners which aims for learners to acquire an insight into how engineers apply scientific principles to practical problems.

The findings of this study presents another perspectives from a non-hearing population in Mechanical Systems in Technology, in relation to how Technology should be taught in different environments. Technology is learned through a theoretical and practical approach. It involves the integration of learning areas by considering their common concepts in solving practical problems. In my discussion of unique features, I will refer to knowledge and skills that I observed in participants in relation to the technological literacy that CAPS envisages.

8.2.1 Analysis of how working collaboratively with others influenced the learning of Mechanical Systems in a Deaf classroom

The learning of Mechanical Systems was mediated through Sign Language that exposed participants to opportunities of practising Sign Language for social and practical purposes within the classroom context. Sign Language was taught in an integrated way where the signing teacher was stretching the scope of the participants' vocabulary in Sign Language on Mechanical Systems. For example, in the case of the misconception where participants were confusing the sign 'air' with 'water', the signing teacher was able to pick up this misconception and finger spelled the word 'air'. In cases where participants were unsure of the answer, they trusted each other so much that they communicated their understanding with each other before responding to the TT. For example, in Figure 5.9 Sphesihle is seen teasing Nosipho to negotiate her ideas around the question on hydraulics systems, while in Figure 5.31 Nosipho is shown teasing Zekhethelo to communicate her understanding about the concept of gears during the classroom exercise. It was common e for participants to discuss their responses before responding to the TT. Their interdependency bonded them and integrated their effectiveness in Technology participation and learning.

8.2.2 Analysis of using a variety of life skills in an authentic context for decision making, problem solving, critical and creative thinking that influenced the learning of Mechanical Systems in a Deaf classroom

The purpose of Technology education is to produce technologically literate citizens that are able to think innovatively, creatively and critically in producing engineers, technicians and artisans for social change (DoBE, 2011). Literacy in Technology in the Deaf classroom was highly influenced by interdisciplinarity between the gateway subjects (Mathematics, Science and Technology) and Sign Language. However, specific outcomes in Mathematics, Science and Technology is emphasising the importance of knowledge, skills and purposeful application. Mechanical Systems is learned through a theoretical and practical approach. It integrates learning areas by considering their principles in solving practical problems. In my discussion I will share observations on knowledge and skills in the Technology class in relation to the technologically literate learner that is envisaged by CAPS.

(a) Knowledge

Knowledge is integrated information that is given meaning by human agencies. It is intended to be distributed across social groups with purposeful application vested in human interests (Fleck, 1997). There were two major components that influenced the teaching and learning of Mechanical Systems, namely Mechanical Advantage (MA) and Work done (W). The calculation of MA needed comprehension of a specific knowledge on ratio and proportion and the adequate use of the language of Mathematics. For example, in Figure 5.39 Mxolisi provided a response for a formula used for calculating MA as 'MA is equal to load over effort', while in Figure 5.44 Zekhethelo provided the unit of measurement 'kg' when presenting MA in the form of a ratio. Both learners fulfilled a chain of actions related to the calculation of MA based on the aim of the activity. In justifying their responses, participants referred to their teachers as the source of their knowledge, and the teachers emphasised that it is important to put a unit of measurement when you are calculating a technological or scientific problem. Participants understood the concept of MA but missed out the essence of calculating ratio of output to input/load to effort in MA.

Work done (W) is a scientific concept that justifies motions in Mechanical Systems. Comprehension of W requires specific knowledge of forces and distances that is made appropriate through multiplication (X) as a binary operation. In all sections taught in Mechanical Systems, participants had fragmented knowledge owing to the background essential for effective comprehension. Participants have a limited exposure to social participation, leading to them owning limited classroom knowledge separated from human experiences. Their technical knowledge was limited to adequate Sign Language as they belong to a limited Deaf community. As a result, their practical knowledge was limited to the scope of what was taught in their schooling. Participants are isolated to their communities where the content of local technologies is exchanged as a major element of their learning process and a resource for their cognition. The introduction of demonstrations and simulations in the form of manipulatives played an important role in mediating concepts in Mechanical Systems. Demonstrations and simulations foregrounded practical work that awarded participants a chance to get ‘hands-on’ experiences.

Participants alluded to the fact that they are prohibited from participating in daily activities at home as a result of a mono-encoding instrument and a lack of understanding from their communities. Demonstrations and simulations provided directly related activities in the sense that the learning of participants underlined the important aspects of what they were doing in theory and related this to practical application. Participants were able to observe motions of different machines that are theorised in textbooks in a safer environment. I concur with Millar (2004) that this process involves hands and minds in an active manner. Their learning was cumulative. Practical involvement of participants unpacked formal procedures that reflected truthful conditions in Mechanical Systems. Reasoning within the parameters of theory and practicals contracted a combined mental model that ensured procedural knowledge leading to content-appropriate inferences.

(b) Skills

Skill refers to the proficiency with which activities are executed (Bleed, 2008, p.156). Cognitive learning advocates for learning from concrete to abstract that moves away from teacher-centeredness. Skills ensure that learning emphasises effective use of general forms of solutions to problems in solving other problems. For example, in different simple machines, e.g. levers, pulleys, gears, hydraulics and pneumatics, participants were able to identify input and output and qualify them into effort and load respectively. The context of cognition was evident when participants were able to work with the aspect of MA in levers, gears, pulleys, hydraulics, etc., in order to master knowledge and skills that will introduce them to full participation in the sociocultural practices of communities.

Furthermore, participants were able to sign different concepts in Mechanical Systems, including binary operations in Mathematics, e.g. MA (Figures 5.59 and 5.60), load (Figure 5.61), force (Figure 5.63), area (Figure 5.66), division (Figure 5.62), and the equals sign (Figure 5.64). This study operates within communicative and tacit knowledge where participants are manipulating concrete comprehension with competent abilities for a craft. A skill is acquired in the process of learning discrete information and involves practical mastery. Skill is a special kind of technical knowledge and practical engagement that draws from cognitive and motor activities through rapid practice with objects, and this is assimilative learning.

8.2.3 Analysis of how the use of and the engagement with knowledge in a purposeful way influenced the learning of Mechanical Systems in a Deaf classroom

In the learning of hydraulics, pulleys and gears participants were awarded a chance to work on simulations and demonstrations in a practical manner. Practical involvement of participants in simulations and demonstrations unpacked formal procedures in simple machines, providing truthful insights into their mechanisms. Reasoning within the parameters of theory and practical through demonstrations and simulations constructed a combined mental model that ensured procedural knowledge, leading to content-appropriate inferences. This is an important part of cognitive learning, which advocates learning from concrete to the abstract that contributes to meaning making for learner-centeredness. For example, in Figure 5.29 Nosipho operates a model of a gear train related to a classroom exercise on gears while Sphesihle is practising the same exercise of comparing a model of a gear train with the question on a worksheet. This helped Nosipho to calculate a gear ratio (Figure 5.54). Although Sphesihle did not carry out the calculation on gears properly (Figure 5.57), she was procedurally correct. Skills developed from cognition ensure learning transfer that highlights effective use of a general form of solution that is applicable to another problem of a similar nature. Skilful learners are able to recognise that a presented problem requires an application of knowledge already mastered. The concept of MA in all simple machines dealt with demands a related response in line with the input to output and effort to load respectively, and the participants were able to identify loads and efforts for calculating MA.

8.2.4 Analysis of how the linking of abstract concepts to concrete understanding influenced the learning of Mechanical Systems in a classroom

Mathematics is a language that uses symbols and notations to describe numerical and graphical relationships found in human activities that require mental processes for logical and critical thinking for accurate problem solving (DoBE, 2011). Knowledge of

Mathematics is a measure of mental brilliance with which there is no possibility of argument.

In Question 10 on the worksheet, participants maintained the 'law of simple machine' ($F_1/A_1 = F_2/A_2$) but omitted knowledge of the unit of measurement in Pascal's law (N/m^2) that confirmed the approach in the calculation of pressure. Nosipho and Zekhethelo substituted the given data without converting them into metres in Figures 5.49 and 5.50, while Mxolisi remembered that he has to calculate areas of hydraulics pistons but did not convert them to metres in Figure 5.51, and said: "*because cm will cancel in both sides, it will make no difference to the answer. We have to be fast for examination*".

Mathematics has the potential to become the quintessential scientific field in education. The concepts of a 'notation system' brings together cognitive subject matter and a Technological perspective (Lave, 1998). Simulations and demonstrations provided a model of learning that assisted participants to concretise the abstract formulae and symbols encompassing design in Mechanical Systems. Mathematics develops theories on signs that form into symbols based on thinking patterns. Every thought is a sign that aligns a person to the external signs. For that matter language is the total sum of a person that links the thoughts of man to the external signs and facilitates interaction between human beings.

In social and cognitive process of Mathematics, Libertus and Needham (2014) attests to the fact that concepts from different sciences and contexts are put into perspectives and relations to create a manipulatable manifestation of an abstract phenomenon that contributes to a powerful sense-making intervention. The potential of Technology in Mathematics lies in the prospect of being able to create innovative notation systems that support an inquisitive community through collaborative content that addresses aspect of learning. It encourages manipulation of the normal movement in a way that helps participants to view the mathematical presentation of theory. Algebra represents something like a mathematical language. The binary operations create concrete relations and the concrete treatment of objects directly in a symbolic way. Language is understood as a translation of objects from the reality of operation into Mathematics content that explains how abstract concepts relate to their concrete content. This contributes to a better understanding of the reasons that impacts cognitive unconsciousness, with an alternative mode of thinking from concept definition to mental model.

8.2.5 My reflection on participants' growth leading to an increased confidence levels

At the beginning of Mechanical Systems lessons, participants were reluctant to participate, and they were skeptical about engaging in demonstrations and simulations. As lessons unfolded participants gained confidence and became interested in Technology (Sakamoto, Nishimura, & Kato, 2015). For example, in Figure 5.10 Zekhethelo was voluntarily able to explain the operation of hydraulics systems based on the observations of the demonstration. Knowledge accumulated and skills acquired during lessons, particularly in hydraulics systems, enabled Mxolosi and Nosipho to de-school the content of hydraulics by designing a model of an excavator after they observed roadworks outside their school gate. Figures 5.59 and 5.60 depicted how the concept of MA should be signed using Sign Language. It was difficult to have a single sign embracing both words 'Mechanical' and 'Advantage'; however, the enhanced understanding of the concepts of Mechanical Systems enabled participants to come up with relevant signs. The same experience was evident in Figures 5.61–5.66 where participants were able to adapt to the requirements of related concepts. There was a challenge in Figures 5.61, 5.67 and 5.68, where participants experienced ambiguity in the concepts of 'load', 'lifting' and 'heavy'. Participants were missing the ontological medium of communication required to facilitate the content knowledge for their learning. It is crucial for participants to acquire an understanding of the content so that they can contribute in the generation of Sign Language relevant to technological concepts. For that matter, it was easy for the teaching team to pick up ambiguities as participants were engaging confidently to lessons

8.2.6 Summery of the overall engagement of participants in the learning of Mechanical Systems in a Deaf classroom

In the Technology class, the aim of the curriculum was encourage critical and creative thinking among participants. Concepts and knowledge used in Mechanical Systems in the non-hearing class integrated the purposefulness of Technology and Mathematics, adhering to the curriculum goals of integrating Technology and other sciences to expand the standard of Technology that include social and pedagogical context. For example, in Question 6 (Appendix G):

a) What will be the MA if the load = 1200N and the effort = 300N?

b) What does this tell us about the machine?

This problem embraces both pedagogical and social occurrences, where a solution should be used to interpret the nature of a machine related to its fitness of purpose. Mathematics was the cornerstone in the non-hearing class practice, integrated with quantity of knowledge and adaptive reasoning in Technology learning.

Mechanical Systems was not functionally neutral but encapsulated an intertextual approach which was the shaping of the meaning of Technology text by Mathematics text (Mwakapenda & Dhlamini, 2010). This process created an interrelationship between the Technology and Mathematics texts and generated understanding in their separate works. Arithmetic problems in Technology involved the language of Mathematics and arithmetic skills. For example, in Question 10 (Appendix G):

The pistons of a hydraulic press have radii of 2 cm and 12 cm.

(a) What force must be applied to the smaller piston to exert a force of 5000N on the larger piston?

(b) What is the pressure on each piston?

Within the Mechanical Systems context the formula for calculating pressure in hydraulics systems was used to systematise the pattern of words into a ‘symbolic expression’. The emphasis on the manipulation of tools in Technology compared the relationship between the input and the output in the form of a relation for accuracy and safety purposes. The input and output phenomenon justified mechanisms in tools through the practical use of numbers. The relationships used in input to output/effort and load were generalised in algebra, where participants operated at a high level of abstraction. Aspects of Mathematics related to Technology were semantically used to underpin patterns of operation in social practice (e.g. $Work_{input} = Work_{output} \approx F_{in} \times S_{in} = F_{out} \times S_{out}$). The patterns of operation presented logical consequences, and sets of rules and principles within formulas, as defined in section 2.4.3 and 2.4.4.

Conceptual understanding developed an integrated corpus of knowledge essential for skills, procedures and abilities to formulate measurable ideas for problem solving. Mathematics language provided clarity and simplicity when participants were reading verbal problems. For example, Question 10 presented a statement in words with an intention to determine the force required in a small piston. Participants were able to identify the appropriate formula used in Pascal's law, follow procedures for assimilating area as required in Mathematics terms and substitute values in the formula adequately. Therefore arithmetic notation provided proof of logical arguments on abstract patterns in simple machines, e.g. pressure in = pressure out ≈ $P_{in} = P_{out}$.

In Mechanical Systems, number science involved more than routine calculation where problem solving arranged patterns of 'place value' behaviour into formula representation. Hence different formulas were used to address semantic content of Technology, as highlighted in section 2.4.3. Technology advocated interdisciplinarity, where specialised skills from a borrowed vocabulary were used to unpack theoretical explanations. For example, in addressing the mechanism process the MA formula was used to calculate ratio, and this ratio was able to determine the usefulness of engaging a machine when doing work. Advanced learning in Mechanical Systems enhanced a high level of Technological literacy, as illustrated in Figure 2.1. For example participants were able to design an escavator judging from knowledge and skills accumulated hydraulics section taught as a raw subject matter. Ultimately, participants were able to contract the meaning of "equal pressure of liquid at any point on a closed system" when they were interpreting and manipulating information in response to design problem where they were requested to combine more than one system in the design of a machine.

Mathematics integrated a different body of knowledge into interdisciplinary curricula where various components of Mechanical Systems Technology and Mathematics were contextualised. Knowledge in Mechanical Systems was situated in activities and Mathematics organised knowledge into a coherent whole. The connection between concepts revealed that participants were able to recognise the need to use Mathematics in their calculations of MA. Showing how Mathematics concepts were useful in calculating Mechanical Systems' problems, participants were able to provide a formula for pressure in a cylinder. Within the same formula, participants were able to convert ‘centimeters (cm)’ to ‘meters (m)’ as a prerequisite for calculating pressure. Moreover, from the law of a simple machine ($W_{in} = W_{out}$) participants were able to identify accurate performance of appropriate procedures required in $P_{in} = P_{out}$.

Interdisciplinarity translates curriculum expectations into practical projections required to be integrated across Mechanical Systems and Mathematics over and above their curriculum disciplines. Participants were able to pick up formulas for different aspects in Technology and justified the Mathematical aspects that were inherent in the unit learned. However, participants’ approach to Mechanical Systems’ calculations depended more on formulas and manipulations. Participants did not recognise the integrated approach of Mathematics in MA where Mathematics concepts were linked to Technology concepts. For example, when Zekhethelo was calculating MA in Figure 5.44, she could not relate her answer to a ratio but only to an answer to a question; she insisted that the teacher warned her not to give an answer without the unit of measurement. Furthermore, all participants left their calculations in fraction form; none represented their answers in ratio form, even though their calculations provided accurate performance of appropriate procedures.

The learning of Mechanical Systems in the non-hearing environment was highly influenced by the integrated languages in informing the perceptions of participants. The interpretation of specialized subject languages (English and Mathematics) into Sign Language made participants multilingual as they mastered all languages included in their learning. English maintained coherence in communication and standardized required knowledge and skills for reading writing. Mathematics language enunciated the significance of prescriptive language that provides accuracy in Mechanical Systems. It assisted the cognitive processes of participants that enhanced logical and critical thinking, accuracy and problem solving essential for decision making. Sign Language interpreted knowledge and skills that facilitated participants’ perspectives during the learning process of Mechanical Systems. It foregrounded the systems of communication through visual gestures, body posture, facial expression and symbols for personal expression. Although the learning of Mechanical Systems was engraved in the comprehension of different languages (English, Mathematics language and Sign Language), language learning was occurring under restricted intake (vision only)where participants took advantage of shared communication between the Technology teacher and the Sign Language interpreter to integrate cognitive strategies and comprehension into tasks completion.

8.3 Usefulness of theoretical framework in data analysis

Development of the education system provided innovation in curriculum to redress the past inequalities. Every child is considered for education on the basis of human dignity. The learning of Technology in Deaf communities is of concern in this study. The contribution of this study is that it will identify effective ways in which to engage participants in constructive learning that enhances human dignity for all. In this diverse approach to learning BLM categorized knowledge systems observed in the Deaf classroom, with an impact on appropriately informing the learning of participants under constructivism and social constructivism, as shown in Figure 3.1. The BLM assisted in data analysis, providing a simplified version of the theoretical framework under the influence of constructivism and social constructivism. After all observations of lessons in the Technology class I discovered that theoretical and practical approaches to the learning of Mechanical Systems had a particular influence on the achievement on participants. The learning in the Technology class was influenced by both constructivism and social constructivism. In the development of some lessons, participants exhibited elements of social constructivism theory where learning was enhanced by social interaction and active participation in simulations and demonstrations. Social interaction supported cognitive development of participants. Terminologies in Mechanical Systems through Sign Language were developed during the interaction between the TT and participants. For example, the signing teacher provided clarity between the words 'load', 'heavy' and 'lift' through Sign Language and these words were then better understood in calculations. Some lessons exhibited constructivism theory, where participants negotiated information that enhanced their understanding based on their background knowledge. The active involvement of participants in the learning endeavors encouraged them to bring their own ideas, based on how they observed activities in their environment. For example, the design of an excavator was evidence of transformative learning, as explained in section 3.3.3.

8.4 Challenges

As in every research study, this study also had challenges. Some challenges were associated with the disjuncture between the participants' impoverished social experiences at home which did not provide a practical background or insight from which they could explore the design features of technology. Other challenges were that the participants were shy and needed much encouragement before they opened up and shared their thoughts. Furthermore most of their communication was mediated by the sign language interpreter which could have led to some misinterpretations of the data. Ideally it would have been preferable for the learners to have been interviewed directly by a researcher who was fluent in their sign language, however this was not possible,

8.5 Recommendations and conclusion

A classroom with a diverse population of learners encapsulates a great diversity of learning styles that need to be acknowledged, to assist curriculum designers in acknowledging the potential conflict that may weaken the learning in participants. The way in which learners process information and the way in which they retain knowledge is directly linked to the learning style of an individual learner. As education planners we need to match the individual learner with the appropriate learning style that has potential to stretch the capabilities of participants.

It is hoped that this study will increase the awareness that curriculum preparations need to be tailor-made for learenrs with particular disabilities to ensure effective learning, and to further produce creative and practical approaches for ensuring access to further educational opportunities. Because participants have a right to learn, they must gain knowledge and demonstrate knowledge for their survival and economic sustainability.

For knowledge to be gained by Deaf learners, I recommend that ~~Deaf~~ schools for deaf learners should make use of overhead projectors (OHP) for two purposes: 1) face-to-face contact, and 2) lip reading and gestures during learning. If a teacher is not grounded in Sign Language, the school should provide the subject teacher with training in Sign Language. When questions and/or statements are given to learners, there should be allowance made for a repetition, and the TT should allow learners to negotiate the meaning during the class.

Since Technology is a safety-orientated subject, visual warning systems for workshop emergencies should be at the disposal of leaners in a non-hearing environment. Video captions should be encouraged in most lessons to bring the real world into a non-hearing class and stretch the minds of Deaf learners to the expected level of comprehension of concepts of Mechanical Systems. Multimedia and video presentations play a vital role in bringing outside experiences into the non-hearing class. This endeavour emphasises the nature of Technology by drilling its language-specific, appropriate SI units and interdisciplinarity without compromising the purpose and usefulness of Technology in communities.

In conclusion, I concur with Rogowsky, Calhoun, and Tallal (2014) that those with a visual learning style prefer to read the e-text. Deaf learners yield more to the visual learning style as they have sight as their most prominent encoding mode. Most deaf learners have finely attuned visualisation skills and are quick with their sight and very attentive to movements.

It is understood that this study was not aimed at exploring assessments in Mechanical Systems, but different exercises were provided to identify the way in which Deaf learners learn Mechanical Systems within the bounded system of CAPS. The findings will have a substantial influence on curriculum delivery for Deaf learners, in stretching them to the minimum requirements of CAPS encompassing all three specific outcomes. I contend that it is imperative to give Deaf learners much expertise with written material to assist them accumulate the required adequacy regarding their preferred individual learning style (Rogowsky et al., 2014).

8.6 Further research opportunities

It is paramount to safely introduce Deaf learners to the purposes of Technology. Considering technological literacy, further research needs to address the other two ‘specific aims’ (develop and apply specific design skills to solve technological problems and appreciate the interaction between people’s values and attitudes, technology, society, and the environment) in order to enhance a high level of technological literacy in Deaf learners, without compromising the standard of education.

REFERENCES

Aarkrog, V. (2005). Learning in the workplace and the significance of school-based education: a study of learning in a Danish vocational education and training programme. *International Journal of lifelong education*, *24*(2), 137 - 147.

Alexis, M. R. (2010). *Mathematics of Language*. Wayne State Univesirity: John Benjamins Publishing Company.

Allen, D. E., Donham, R. S., & Bernhardt, S. A. (2011). Problem-based learning. *New Directions for Teaching and Learning*, *2011*(128), 21 - 29.

Ankiewicz, P. (1995). The planning of Technology education for South African Schools. *International Journal of Technology and Design Education*, *5*(1), 245 - 254.

Antia, S. D., Stinson, M. S., & Gaustad, M. G. (2002). Developing Membership in the Education of Deaf and Hard-of-Hearing Students in Inclusive Settings. *Journal of Deaf Studies and Deaf Education*, *7*(3), 214 - 229.

Awofala, A., Awofala, A., Nneji, L. M., & Fataji, A. (2012). The Relation between Language and Science, Technology and Mathematics in Nigerian Schools. *International Journal of Mathematics Trends and Technology*, *3*(3), 118 - 124.

Babbie, E., Mouton, J., Vorster, P., & Prozesky, B. (2010). *The practice of social research in South Africa*. Cape Town: Oxford University Press.

Baker, C. (1990). *Key issues in bilingualism and bilingual education*. Clevedon: Short Run Press Ltd.

Barr, R. B., & John, T. (1995). From teaching learning a new paradigm for undergraduate education. *Change*, *27*(6), 13 - 25.

Bateman, J. A. (1997). Enabling technology for multilingual natural language generation: the KPML development environment. *Natural Language Engineering*, *3*(01), 15 - 55.

Batten, G., Oakes, P. M., & Alexander, T. (2014). Factors associated with social interactions between deaf children and their hearing peers: A systematic literature review. *Journal of Deaf Studies and Deaf Education*, *19*(3), 285 - 302.

Baferani, M. H. (2015). The Role of the Family in the Socialization of Children. *Mediterranean Journal of Social Sciences, 6*(6), 417 - 423.

Bennett, A., & George, A. (1997). *Research design tasks in case study methods.* Cambridge, Mass.: MIT Press.

Bertram, C., & Christiansen, I. (2015). *Understanding Research. An Introduction to Reading Research*. Pretoria: Van Schaik Publishers.

Blatto-Vallee, G., Kelly, R. R., Gaustad, M. G., Porter, J., & Fonzi, J. (2007). Visual spatial representation in mathematical problem solving by deaf and hearing students. *Journal of Deaf Studies and Deaf Education, 12*(4), 432 - 448.

Brooks, D. W. (1994). *The nature of conceptual learning and thinking* (Unpublished Master's thesis). University of Durban-Westville, Durban.

Bull, R., Blatto-Vallee, G., & Fabich, M. (2006). Subitizing Magnitude Representation And Magnitude Retrieval In Deaf And Hearing Adults *Journal Of Deaf Studies And Deaf Education, 11*(3), 289 - 302.

Burgess, G. (1985). *Issues in Educational Research: Qualitative Methods*. London Falmer Press.

Cenoz, J., & Genesee, F. (1998). *Beyond bilingualism: Multilingualism and multilingual education* (Vol. 110). Multilingual Matters.

Chapman, G. A. (2002). Design analysis of the Grade 9 technology curriculum in South Africa. (Master's thesis). University of KwaZulu-Natal. http://hdl.handle.net/10413/1782.

Chettiparamb, A. (2007). *Interdisciplinarity: A literature review*. Southampton: University of Southampton: Interdisciplinary Teaching and Learning Group, Centre for Languages, Linguistics and Area Studies.

Childress, V. W. (1996). Does integrating Technology, Science, and Mathematics improve Technological problem solving? *Journal of Technology Education, 8*(1), 1 - 10.

Clarkson, P. C., & Galbraith, P. (1992). Bilingualism and mathematics learning: Another perspective. *Journal for Research in Mathematics Education*, 34 - 44.

Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. London: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2011). *Research Methods in Education* (7th ed.). New York: Routledge.

Cohen, L., Manion, L., & Morrison, K. (2013). *Research methods in education* (7 ed.). New York: Routledge.

Cowan, H. J. (1991). *Handbook of Architectural Technology*. New York: Van Nostrand Reinhold.

Creswell, J. W. (2003). *Research design: qualitative, quantitative, and mixed methods approaches* (2 ed.). Thousand Oaks: Sage.

Creswell, J. W. (2007). *Qualitative Inquiry and Research Design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2008). *Research Design, Qualitative and Quantitative Approaches* (3rd ed.) Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2014). *Research Design: Qualitative, Quantitative and Mixed Method Approach* (4 ed.). Thousand Oaks, CA: Sage Publications.

Da Nóbrega, G. M., Cerri, S. A., & Sallantin, J. (2003). *A contradiction-driven approach of learning in discovery learning environments.* Paper presented at the Anais do Simpósio Brasileiro de Informática na Educação.

Dalvi, R. (2012). *The Case Study of the Constitution of School Mathematics For The Deaf in Three Primary Schools Classrooms* (Master's thesis). University of Cape Town, Cape Town.

Dautray, R., & Lions, J. L. (1993). *Mathematical analysis and numerical methods for science and technology*. New York: Springer-Verlag.

De Jager, M. L. E. (2012). *Teachers' understanding and implementation of the design process as it relates to teaching Technology Education in the intermediate and senior phases (Grades 4-9) in the General Education and Training Band in KwaZulu-Natal.* (Master's thesis) DUT.

De Meulder, M. (2016). The power of language policy: the legal recognition of sign languages and the aspirations of deaf communities. *Jyväskylä studies in humanities 301*.

Department of Basic Education (2011). *National Curriculum Statement: Curriculum and Assessment Policy Statement. Senior Phase Grades 7-9*. Pretoria: Department of Basic Education.

Department of Basic Education (2014). *South African Sign Home Language. Seiner Phase Grade 7 – 9. Curriculum and Assessment Policy Statement (CAPS).* Pretoria: Department of Basic Education.

Department of Education. (2003). *Revised National Curriculum Statement Grade* 9. Cape Town: Department of Education.

Devlin, K. J. (2000). *The Language of Mathematics: Making the Invisible Visible*. Palo Alto, CA: Holt, Henry & Company, Inc.

Devlin, K. J. (2001). *The Math Gene: How Mathematical Thinking Evolved and Why Numbers Are Like Gossip*. California: Basic Books.

Djenic, S., Krneta, R., & Mitic, J. (2011). Blended learning of programming in the internet age. *IEEE Transactions on Education, 54*(2), 247 - 254.

Dolan, S., Neil, H., & Quadling, D. (2008). *Further Mathematics For The IB Diploma: Standard level*. New York: Cambridge University Press.

Easterbrooks, S. R., & Stephenson, B. (2006). An Examination of Twenty Literacy, Science, and Mathematics Practices Used to Educate Students Who Are Deaf or Hard of Hearing. *American Annals of the Deaf, 151*(4), 385 - 397.

Eckert, R. C. (2010). Toward a theory of deaf ethnos: Deafnicity≈ D/deaf (hómaemon• homóglosson• homóthreskon). *Journal of Deaf Studies and Deaf Education, 15*(4), 317 - 333.

Engelbrecht, P. (2006). The implementation of inclusive education in South Africa after ten years of democracy. *European Journal of Psychology of Education, XXL*(3), 253 - 264.

Erekson, T. (1992). Technology Education from the Academic Rationalist Theoretical Perspective. *Journal of Technology Education, 3*(2), 6 - 14.

Ernest, P. (1989). *Social constructivism as a philosophy of Mathematics*. New York: Albany University.

Evans, K., Speed, B., & Gordon, K. (2001). *Foundation Mathematics For GCSE: A Complete Course for the Foundation Tier. Thousand Oaks*: Collins Publishers Ltd.

Fleck, J. (1997). Contingent knowledge and technology development. *Technology Analysis & Strategic Management, 9*(4), 383 - 398.

Flick, U. (2009). *An introduction to qualitative research* (4 ed.). London: Sage Publications.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, 111*(23), 8410 - 8415.

Gall, M. D., Borg, W. R., & Gall, J. P. (1996). Educational research: An introduction. In N. Y. W. Plains (Ed.), (6 ed.). USA: Longman Publishers.

Ganiso, M. N. (2012). *Sign Language in South Africa: Language Planning and Policy Challenges*. (Masters thesis), Rhodes University, Rhodes University.

Gans, J. H. (1999). Participant observation in the era of "ethnography". *Journal of Contemporary Ethnography, 28*(5), 540 - 548.

Gay, L. R., & Airasian, P. (2003). *Educational research: competencies for analysis and applications*. New Jersey: Merrill/Prentice Hall.

Gibson, K. (2009). Technology and Design, at Key Stage 3, within the Northern Ireland curriculum: Teachers' perceptions. *International Journal of Technology and Design Education, 19*(1), 37 - 54.

Gila Hanna, M. d. V. (Ed.). (2007). *Proof and Proving in Mathematics Education: The 19th ICMI Study*. New York: Spring.

Gill, J., & Johnson, P. (2002). *Research Methods for Managers* (3rd ed.). London: Sage.

Gestwicki, C. (2013). *Developmentally appropriate practice: Curriculum and development in early education*. United States: Cengage Learning Inc.

Giezen, M. R., Baker, A. E., & Escudero, P. (2014). Relationships Between Spoken Word And Sign Processing In Children With Cochlear Implants *Journal of Deaf Studies and Deaf Education, 19*(1), 107 - 125.

Gonasillan, A. S., Bornman, J., & Harty, M. (2013). Vocabulary used by ethno-linguistically diverse South African toddlers: A parent report using the Language Development Survey. *South African Journal of Communication Disorders, 60*(1), 10 - 15.

Grabinger, R. S., & Dunlap, J. C. (1995). Rich environments for active learning: A definition. *Research in Learning Technology, 3*(2), 5 - 34.

Gredler, M. E. (1997). *Leaning and instruction: Theory into practice* (3 ed.). Upper Saddle River: NJ: Prentice-Hall.

Gregory, G. H. (2016). *Teacher as Activator of Learning*. Thousand Hills, CA: Sage.

Gregory, S. (1998). Mathematics and deaf children. In S. Gregory, P. Knight, W. McCracken, S. Powers & L. Watson (Eds.), *Issues in deaf education* (pp. 119 - 126). London: Fulton.

Hadjerrouit, S. (2008). Towards a Blended Learning Model for teaching and learning Computer Programming: A Case Study. *Information in Education, 7*(2), 181 - 210.

Hansen, R. E. (2000). The role and experience in learning: giving meaning and authenticity to the learning process in schools. *Journal of Technology Education, 11*(2), 329 - 348.

Hazewinkel, M. (1987). *Encyclopaedia of Mathematics* (Vol. 1). London: Kluwer Academic Publishers.

Henning, E., Van Rensburg, W., & Smit, B. (2007). *Finding Your Way in Qualitative Research*. Pretoria: Van Schaik Publishers.

Hildreth, P. M., & Kimble, C. (2004). *Knowledge networks: Innovation through communities of practice*. Thousand Oaks: IGI Global.

Hoff, E., Core, C., Place, S., Rumiche, R., Señor, M., & Parra, M. (2012). Dual language exposure and early bilingual development. *Journal of Child Language, 39*(01), 1 - 27.

Houston, K. (2009). *How To Think Like A Mathematician: A Companion To Undergraduate Mathematics*. New York: Cambridge University Press.

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. *Handbook of Research on Educational Communications and Technology, 3*(1), 485 - 506.

Illeris, K. (2009). A comprehensive understanding of human learning. In K. Illeris (Ed.), *Contemporary theories of learning. Learning theorists* . . . *In their own words* (pp. 7 - 21). New York: Routledge.

Jakobson, R. (2007). *Encyclopedia of Semiotics: Jakobson's model of linguistic communication*. New York: Oxford University Press.

Jambor, E., & Elliott, M. (2005). Self-esteem and Coping Strategies among Deaf Students. *Journal of Deaf Studies and Deaf Education, 10*(1), 63 - 81.

Jamison, R. E. (2000). Learning the language of mathematics. *Language and Learning Across the Disciplines, 4*(1), 45 - 54.

Jegede, O. (1998). The Knowledge Base for Learning in Science and Technology Education. In M. S. Prem Naidoo (Ed.), *African Science and Technology Education into the New Millenium: Pactice, Policy and Priorities*. Cape Town, South Africa: Juta.

Jorgensen, D. (1989). *Participant Observation*. Newbury Park: CA: Sage Publications.

Kavanagh, B. F. (2009). *Surveying: Principles and applications* (8th ed.). Upper Saddle River, NJ: Pearson/Prentice Hall.

Kemp, C. (2009). Defining multilingualism. *The Exploration of Multilingualism: Development of Research On L3, Multilingualism and Multiple Language Acquisition, 6*, 11.

Kim, B. (2001). *Social constructivism. In M. Orey (Ed.), Emerging perspectives on learning, teaching, and technology*. Retrived on 21 July 2016 from http://www.coe.uga.edu/epltt/SocialConstructivism.htm.

Kim, J. S. (2005). The effects of a constructivist teaching approach on student academic achievement self-concept and learning strategies. *Asia Pacific Education Review, 6*(1), 7 - 19.

Kitto, S. C., Chesters, J., & Grbich, C. (2008). Quality in qualitative research. *Medical Journal of Australia, 188*(4), 243 - 246.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development*. Englewood Cliffs: Prentice Hall.

Knoors, H., & Marschark, M. (2012). Language planning for the 21st century: Revisiting bilingual language policy for deaf children. *Journal of Deaf Studies and Deaf Education, 17*(3), 291 - 305.

Kumar, R., & Singh, H. K. (2014). Multilingualism and Education. *Graphics & Typeset, 2*(2), 1 - 77.

Kumpulainen, K., & Wray, D. (2002). *Classroom Interactions and Social Learning: From Theory to Practice*. New York: Routledge Falmer.

Landorf, H., & Nevin, A. (2007). Inclusive global education: implications for social justice. *Journal of Educational Administration, 45*(6), 711 - 723.

Lane, H. L. (2002). Do deaf people have a disability? *Sign Language Studies, 2*(4), 356 - 379.

Lave, J. (1998). *Cognition in Practice.* Cambridge: Cambridge University Press.

Lelliott, A., Mwakapenda, W., Meg Doidge, J. d. P., Mhlolo, M., Msimanga, A., Fhatuwani Mundalamo, . . . Bowie, L. (2009). Issues of Teaching & Learning in South Africa: A disjunction between curriculum policy and implementation. *African Journal of Research in MST Education* (Special Issue), 47 - 64.

Libertus, K., & Needham, A. (2014). Face preference in infancy and its relation to motor activity. *International Journal of Behavioral Development, 38*(6), 529 - 538.

Lincoln, S. Y., & Guba, G. E. (1985). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Luckner, J. L., Sebald, A. M., Cooney, J., Young, J., & Muir, S. G. (2005). An examination of the evidence-based literacy research in deaf education. *American Annals of the Deaf, 150*(5), 443 - 456.

Lyall, C., Bruce, A., Tait, J., & Meagher, L. (2011). *Interdisciplinary research journeys: Practical strategies for capturing creativity.* Bloomsbury Publishing.

Mace, K. (2005). Vygotskys Social Development Theory. In Hoffman B (Ed.) *Encyclopedia Of Educational Technology*. Retrieved from http://coe.sdsu.edu/eet/articles/sdtheory//start.htm.

Macauley, M. (2016). Morphisms and order ideals of toric posets. *Mathematics, 4*(2), 39.

Marshall, K. P. (1999). Has technology introduced new ethical problems? *Journal of Business Ethics*, *19*(1), 81 - 90.

Matlosa, L. (2010). Language policy and literacy among deaf people in Lesotho. *South African Journal of African Languages, 30*(1), 257 - 2117.

Mawson, B. (2003). Beyong 'The Design': An Altenative Pedargogy for Technology Education. *International Journal of Disability, Development and Education*, *13*(2), 117 - 128.

McCade, J. (2006). Is Design a Right-Brain or Left-Brain Activity? *Journal of Technology Education 17*(2), 72 - 75.

McMillan, J. H., & Schumacher, S. (2006). *Research in education: Evidence-Based Inquiry* (6 ed.). Pearson.

Meadows, N. B., Neel, R. S., Scott, C. M., & Parker, G. (1994). Academic performance, social competence, and mainstream accommodations: A look at mainstreamed and nonmainstreamed students with serious behavioral disorders. *Behavioral Disorders*, 170 - 180.

Merriam, S. B. (1998). *Qualitative Research and Case Study Applications in Education.* San Francisco: Jossey Bass Publishers.

Mertens, D. M. (1998). *Research Methods Education and Psychology Integrating. Diversity with Quantitative and Qualitative Approaches*. Thousand Oaks, CA: Sage Publications.

Miller, E. M., Lederberg, A. R., & Easterbrooks, O. R. (2013). Phonological Awareness: Explicit instruction for young deaf and hard-of-hearing children. *Journal of Deaf Studies and Deaf Education, 18*(2), 206 - 227.

Millar, R. (2004). The role of practical work in the teaching and learning of science. *High school science laboratories: Role and vision*.

Mkonto, P. N. (2010). *The development and evaluation of a learning styles assessment tool for the South African higher education context.* PhD thesis. University of the Western Cape.

Morrison, K. (2006). *Cambridge International Examinations: IGCSE: Mathematics*. New York: Cambridge University Press.

Mulder, M., Weigel, T., & Collins, K. (2007). The concept of competence in the development of vocational education and training in selected EU member states: a critical analysis. *Journal of Vocational Education & Training, 59*(1), 67 - 88.

Mwakapenda, W., & Dhlamini, J. (2010). Integrating mathematics and other learning areas: Emerging tensions from a study involving four classroom teachers. *Pythagoras, 2010*(71), 22 - 29.

Myers, L. P. (2016). Knowledge Structures and Their Relevance for Teaching and Learning in Introductory Financial Accounting. *South African Journal of Accounting Research, 30*(1), 79 - 95.

National Research Council. 1999. Transforming undergraduate education in science, mathematics, engineering, and technology. National Academies Press. United State of America.

Nel, J. A., Valchev, V. H., Rothmann, S., van de Vijver, F. J. R., Meiring, D., & de Bruin, G. P. (2012). Exploring the Personality Structure in the 11 Languages of South Africa. *Journal of Personality, 80*(4), 915-948.

Nyaumwe, L. J. (2006). Learning Mathematics concepts in a traditional Socio-cultural Economic Environment in Zimbabwe *Indilinga - African Journal of Indigenous Knowledge Systems, 5*(1), 50 - 61.

Odom, S. L., Brantlinger, E., Gersten, R., Horner, R. H., Thompson, B., & Harris, K. R. (2005). Research in special education: Scientific methods and evidence-based practices. *Exceptional Children, 71*(2), 137 - 148.

Ogilvy-Foreman, D., Penn, C., & Reagan, T. (1994). Selected syntactic features of South African Sign Language: A preliminary analysis. *South African Journal of Linguistics, 12*, 118 - 123.

Olivier, A. (1989). *Handling pupils' misconceptions.* Paper presented at the Pythagoras.

Onwuegbuzie, A. J., Dickinson, W. B., Leech, N. L., & Zoran, A. G. (2009). A Qualitative Framework for Collecting and Analyzing: Data in Focus Group Research *International Journal of Qualitative Methods, 8*(3), 1 - 21.

Parkin, M., Kohler, M., Lakay, L., Rhodes, B., Saayman, A., Schöer, V., . . . Thompson, K. (2010). *Economics: Global and Southern African Perspectives*. Cape Town: Pearson.

Penn, C., & Reagan, T. (1994). The properties of South African Sign Language: Lexical diversity and syntactic unity. *Sign Language Studies, 85*, 319 - 327.

Pfeiffer, D. (2002). The philosophical foundations of disability studies. *Disability Studies Quarterly, 22*(2).

Piaget, J. (1970). *Genetic Epistemology*. New York: Columbia University Press.

Piaget, J. (2014). *The Language and thought of the Child* (3rd ed.). New York: Routledge Taylor and Francis Group.

Prinz, W. (1990). *A common coding approach to perception and action*. Berlin: Heidelberg: Springer.

Pritchard, A., & Woollard, J. (2010). *Psychology for the Classroom: Constructivism and Social Learning*. New York: Routledge.

Qi, S., & Mitchell, R. E. (2012). Large-Scale Academic Achievement Testing of Deaf and Hard-of-Hearing Students: Past, Present, and Future *Journal of Deaf Studies and Deaf Education, 17*(1), 1 - 18.

Ram, A (2010). *Speaking hands and silent voice. Exploring the identities of d/Deaf teachers through narratives in motion.* (PhD thesis): University of KwaZulu-Natal.

Ray, E. (2001). Discovering mathematics: The challenges that deaf/hearing-mpaired children encounter. *ACE Papers, 11*(6), 62 - 75.

Reagan, T. (2008). South African Sign Language and language-in-education policy in South Africa. *Stellenbosch Papers in Linguistics, 38*, 165 - 190.

Rinaldi, P., Caselli, M. C., Renzo, A. D., Gulli, T., & Volterra, V. (2014). Sign Vocabulary in Deaf Toddlers Exposed to Sign Language Since Birth. *Journal of Deaf Studies and Deaf Education, 19*(3), 303 - 318.

Rogowsky, B. A., Calhoun, B. M., & Tallal, P. (2014). Matching learning style to instructional method effects on comprehension. *Journal of Education Psychology, 205*(1), 64 - 78.

Sakamoto, T., Nishimura, Y., & Kato, T. (2015). Tuning of morphology and polymorphs of carbonate/polymer hybrids using photoreactive polymer templates. *CrystEngComm, 17*(36), 6947 - 6954.

Samuels, M. L., Akach, P., Morgan, R., Glaser, M., Dlamini, J. G., Magongwa, L., . . . Swepu, C. (2013). *The Development of the South African Sign Language Curriculum for Grades R-12. Report*. Pretoria: Department of Basic Education.

Singh, P. (2002). Pedagogising Knowledge: Bernstein's Theory of the Pedagogic Device. *British Journal of Sociology of Education, 23*(4), 571 - 582.

Slavin, R. E. (1997). *Educational Psychology: Theory and Practice* (5 ed.). USA: Allyn & Bacon.

Smith, L. (1993). *Necessary knowledge: Piagetian perspectives on constructivism.* Psychology Press.

Smits, R. (2000). The multiple meanings of technological practice in technology education in New Zealand. IN: Kimbell, R. (ed.). Design and Technology International Millennium Conference. Wellesbourne: The D&T Association, pp. 176 - 189.

Snelbecker, G. E. (1974). *Learning Theory, Instructional Theory and Psychoeducational Design*. New York: McGraw-Hill Book Company.

Southwood, F., & Van Dulm, O. (2015). The challenge of linguistic and cultural diversity: Does length of experience affect South African speech-language therapists' management of children with language impairment? *South African Journal of Communication Disorders 62*(1), Art. #71, 14 pages. http://dx.doi.org/10.4102/sajcd.v62i1.71.

Squires, J. (2005). Is mainstreaming transformative? Theorizing mainstreaming in the context of diversity and deliberation. *Social Politics: International Studies in Gender, State and Society, 12*(3), 366 - 388.

Stake, R. E. (Ed.). (2005). *The Sage Handbook of Qualitative Research* (3rd ed.). London: Sage Publications.

Stake, R. E. (2010). *Qualitative Research. Studying How Things Work* New York: The Guilford Press.

Stander, M., & Mcllroy, G. (2017). Language and Culture in the Deaf Community: A Case Study in a Special School. *A Journal for Language Learning*, *33*(1), 87 - 99.

Tennyson, R. D., & Rasch, M. (1998). Linking cognitive learning theory to instructional prescriptions. *Instructional Science, 17*(1), 365 - 385.

Thabethe, B. M. (2012). *An exploration of the utilisation of Mathematics skills by Technology Education pre-service teachers to enhance conceptual understanding of electronic systems* (Master's thesis). University of KwaZulu-Natal, Durban.

Thompson, B. (2004). *Exploratory and Confirmatory Factor Analysis: Understanding Concepts and Applications*. Newbury Park, CA: Sage.

Van Niekerk, M. E. (2002). *Can a non-additional approach to music develop a learning Potential of Primary School Learners?* Pretoria: University of Pretoria.

Van Rooyen, B., & Le Grange, L. (2003). Interpretive discourses in South Africa\'s Education White Paper No. 6: Special Needs Education. *South African journal of education, 23*(2), 152 - 156.

Van Sertima, I. (1999). The Lost Science of Africa. In M. W. Makgoba (Ed.), *African Renaissance: The New Struggle* (1 ed., pp. 305 - 329). Cape Town: Mafube Publishing (Proprietary) Limited Tafelberg Publishers Limited.

Von Glasersfeld, E. (1984). An introduction to radical constructivism. In P. Watzlawick (Ed.), *The invented reality*. New York: Norton.

Wicklein, R. C., & Schell, J. W. (1995). Case studies of multidisciplinary approaches to integrating Mathematics, Science and Technology education. *Journal of Technology Education, 6*(2), 1 - 12.

Wolcott, H. F. (Ed.). (2001). *Writing up Qualitative Research* (2 ed.). Thousand Oaks: Sage Publications.

Wrenn, J., & Wrenn, B. (2009). Enhancing Learning by Integrating Theory and Practice *International Journal of Teaching and Learning in Higher Education, 21*(2), 258 - 265.

Yim, S. (2009). *The Challenges of Culture based learning. Indian Students Experiences*. New York: University Press of America INC.

Vygotsky, L. S. (1978). *Mind in society*. Boston: Harvard University Press.

Zaslavsky, C. (1973). *Africa Counts: Number and Pattern in African Culture*. Prindle, Weber & Schmidt, Inc.

APPENDICES

APPENDICES A1 and A2 LETTERS OF AUTHORITY

APPENDIX A1: ETHICAL CLEARANCE CERTIFICATE

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

26 February 2016

Mr Bhekisisa M Thabethe 206525561
School of Education
Edgewood Campus

Dear Mr Thabethe

Protocol reference number: HSS/0236/015D
New Project Title: Learning of mechanical systems in Grade 9 Technology classroom by Deaf learners in Kwazulu-Natal: An exploration of a learning of Technology in a non-hearing environment

Full Approval – Full Committee Reviewed Protocol

In response to your application received 11 March 2015, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

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

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

Yours faithfully

....

Dr Shenuka Singh (Chair)
Humanitities & Social Scinces Research Ethics Committee

/pm

Cc Supervisor: Professor Sarah Bansilal & Professor Deonarain Brijlall
Cc Academic Leader Research: Professor HG Kamwendo
Cc School Administrator: Ms Tyzer Khumalo

Humanities & Social Sciences Research Ethics Committee
Dr Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

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APPENDIX A2: LETTER FROM THE DEPARTMENT OF EDUCATION

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Nomangisi Ngubane	Tel: 033 392 1004	Ref.:2/4/8/218

Mr B M Thabethe
P 519 Umlazi
P O Umlazi
Mabopha Avenue
4031

Dear Mr Thabethe

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"Learning of mechanical systems in Grade 9 Technology classroom by Deaf learners in KwaZulu-Natal: An exploration of the application of Mathematics into Technology in a non-hearing environment"**, in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 01 August 2014 to 30 June 2015.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Mr. Alwar at the contact numbers below.
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Director-Resources Planning, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education. (See attached List)

Nkosinathi S.P. Sishi, PhD
Head of Department: Education
Date: 15 August 2014

KWAZULU-NATAL DEPARTMENT OF EDUCATION

POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa ...dedicated to service and performance
PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004 Fax: 033 392 1203
EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za; CALL CENTRE: 0860 596 363;
WEBSITE: WWW.kzneducation.gov.za

education

Department:
Education
PROVINCE OF KWAZULU-NATAL

Enquiries: Phindile Duma   Tel: 033 392 1004   Ref.:2/4/8/745

Mr BM Thabethe
P.519 Umlazi
P.O. Box
Mabopha Avenue
4031

Dear Mr Thabethe

PERMISSION TO CONDUCT RESEARCH IN THE KZN DoE INSTITUTIONS

Your application to conduct research entitled: **"LEARNING OF MECHANICAL SYSTEMS IN GRADE 9 TECHNOLOGY CLASSROOM BY DEAF LEARNERS IN KWAZULU-NATAL: AN EXPLORATION OF THE APPLICATION OF MATHEMATICS INTO TECHNOLOGY IN A NON-HEARING ENVIRONMENT",** in the KwaZulu-Natal Department of Education Institutions has been approved. The conditions of the approval are as follows:

1. The researcher will make all the arrangements concerning the research and interviews.
2. The researcher must ensure that Educator and learning programmes are not interrupted.
3. Interviews are not conducted during the time of writing examinations in schools.
4. Learners, Educators, Schools and Institutions are not identifiable in any way from the results of the research.
5. A copy of this letter is submitted to District Managers, Principals and Heads of Institutions where the Intended research and interviews are to be conducted.
6. The period of investigation is limited to the period from 18 March 2016 to 30 June 2017.
7. Your research and interviews will be limited to the schools you have proposed and approved by the Head of Department. Please note that Principals, Educators, Departmental Officials and Learners are under no obligation to participate or assist you in your investigation.
8. Should you wish to extend the period of your survey at the school(s), please contact Miss Connie Kehologile at the contact numbers below
9. Upon completion of the research, a brief summary of the findings, recommendations or a full report / dissertation / thesis must be submitted to the research office of the Department. Please address it to The Office of the HOD, Private Bag X9137, Pietermaritzburg, 3200.
10. Please note that your research and interviews will be limited to schools and institutions in KwaZulu-Natal Department of Education.

V.N Naik Deaf School

Nkosinathi S.P. Sishi, PhD
Head of Department: Education
Date: 18 March 2016

KWAZULU-NATAL DEPARTMENT OF EDUCATION

POSTAL: Private Bag X 9137, Pietermaritzburg, 3200, KwaZulu-Natal, Republic of South Africa ...dedicated to service and performance
PHYSICAL: 247 Burger Street, Anton Lembede House, Pietermaritzburg, 3201. Tel. 033 392 1004 **beyond the call of duty**
EMAIL ADDRESS: kehologile.connie@kzndoe.gov.za / Phindile.Duma@kzndoe.gov.za
CALL CENTRE: 0860 596 363; Fax: 033 392 1203 WEBSITE: WWW.kzneducation.gov.za

APPENDIX B1: LETTER TO THE SCHOOL

P 519 Umlazi
P. O Umlazi
4031
bhethamax@yahoo,com

VN Naik School for the Deaf
1201 Inanda Road
Newlands
4037

Dear Sir

Application for Conducting Research at VN Naik School for the Deaf

On behalf of myself, **Prof Sarah Bansilal and Prof Deonarain Brijlall,** I wish to apply for permission to conduct research in your school. This project will be done through the **Faculty of Education at the University of KwaZulu-Natal** under the supervision of **Professor Sarah Bansilal and Professor Deonarain Brijlall.** This study seeks to explore the **Learning of Mechanical systems in grade 9 Technology classroom by Deaf learners in KwaZulu-Natal.** Although the outcome has the potential to assist in the development of support programmes for special schools, data from your schools shall be professionally handled by the University of KwaZulu-Natal and after a certain period of time it will be destroyed completely.
In documents, your school will be kept unknown and learners will be allocated a code to ensure anonymity and confidentiality. As a researcher and a main character of the project, I will receive ongoing education and monitoring to ensure compliance with well-established ethical and regulatory requirements, through a partnership with the University of KwaZulu-Natal.

Confidentiality is of the utmost importance to us and we will make every effort to protect the privacy of study participants. We have multiple procedures in place to safeguard the personal information we collect. We will:

- label your data with a unique identification number before, during and after it is collected

- store your data and other study materials separately from all personal identifying information (like your name, address, and social security administration codes)
- limit access to any identifying information to authorized study personnel only
- keep study documents in a locked, limited access research storage room
- Not share results with family or other third parties and we will keep your records private to the extent allowed by law, particularly the Constitution of South Africa, Chapter 2, Section 12, Freedom and security of a person.

Furthermore we request permission to work with some staff members in distributing questionnaires among learners, conduct interviews with learners and other developments of a research project.

Thank you for your assistance

Yours sincerely
Mr B. M. Thabethe ……………………….

APPENDIX B2: LETTER FROM THE SCHOOL

VN Naik School for the Deaf
1201 Inanda Road
Newlands
4037

Dear Sir

On behalf of the school community, I would like to confirm a research project conducted by Mr Bhekisisa Maxwell Thabethe from the University of KwaZuli-Natal under the supervision of **Prof Sarah Bansilal and Prof Deonarain Brijlall.**

Since the topic he is exploring is **"Learning of mechanical systems in grade 9 Technology classroom by Deaf learners in KwaZulu-Natal"** he will work closely with Technology Department and will follow the obligation given by the Department of Basic Education. He has shown us the permission from the Department of Basic Education and has a full authority to pursue the interest of Technology.

Yours sincerely

PRINCIPAL
V. N. NAIK SCHOOL FOR
THE DEAF

APPENDICES C1 AND C2: CONSENT LETTERS

APPENDIX C1: LETTER TO PARENTS

I……………………………….,the Parent/Guardian of, ………………………………, have been informed about the study entitled "**Learning of mechanical systems in grade 9 Technology classroom by Deaf learners in KwaZulu-Natal"** by Bhekisisa Maxwell Thabethe.

I understand the purpose and procedures of the study. I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that the participation of my child in this study is entirely voluntary and that he/she may withdraw at any time without affecting any of the benefits that he/she usually entitled to.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at Tel: 27 31 2604557 - Fax: 27 31 2604609,
email: HSSREC@ukzn.ac.za.

If I have any questions or concerns about rights of my child as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

I hereby provide consent to:

Audio-record my interview / focus group discussion	YES / NO
Video-record my interview / focus group discussion	YES / NO
Use of my photographs for research purposes	YES / NO

______________________________ ________________________

Signature of Parent/guardian **Date**

APPENDIX C2: LETTER TO THE TEACHER

To: Participant (Technology Teacher)

My name is Bhekisisa Maxwell Thabethe from the **School of Education in Technology Education at the University of KwaZulu-Natal** under the supervision of **Professor Sarah Bansilal and Professor Deonarain Brijlall**. You are being invited to consider participating in a study that involves research in your school in the Technology Department.

The purpose of this research is to explore the "**Learning of mechanical systems in grade 9 Technology classroom by Deaf learners in KwaZulu-Natal".** The study is expected to enroll grade 9 Technology class. It will involve the following procedures: observation of classroom learning and practical lessons, interviews and written work. The period of your participation if you choose to enroll and remain in the study is expected to be the duration of Mechanical systems in Technology and this study is not funded.

This study does not have a potential of any risk as it is conducted during the tuition time. This study has been ethically reviewed and approved by the UKZN Humanities and Social Sciences Research Ethics Committee (Protocol reference number HSS/0236/015D).

In the event of any problems or concerns/questions, you may contact the researcher at (provide contact details) or the UKZN Humanities & Social Sciences Research Ethics Committee, contact details as follows:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
Research Office, Westville Campus
Govan Mbeki Building
Private Bag X54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557- Fax: 27 31 2604609

Email: HSSREC@ukzn.ac.za

Participation in this research is voluntary and you may withdraw your participation at any point. Moreover in event of refusal/withdrawal of participation, you will not incur penalty or loss of academic benefit to which you are normally entitled. Consequences of withdrawing from this study may compromise the quality of the study thus omitting important aspects of Technology in non-hearing schools. There are no costs to be incurred as a result of your participation in the study since the study will be conducted during Technology period. There are no incentives/reimbursements for participation in the study as well.

To ensure confidentiality, all participants will be noted on transcripts and data collections by a *pseudonym* (i.e. fictitious name). The identities of the interviewees will be kept strictly confidential and data will be stored in a secure password protected server for a minimum period of five years where authentication will be required to access such data.

I …………………………………………………………., have been informed about the study entitled "**Learning of mechanical systems in grade 9 Technology classroom by Deaf learners in KwaZulu-Natal"** by Bhekisisa Maxwell Thabethe.

I understand the purpose and procedures of the study. I have been given an opportunity to answer questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher at Tel: 27 31 2604557 - Fax: 27 31 2604609,
email: HSSREC@ukzn.ac.za.

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION
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Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604557 - Fax: 27 31 2604609
Email: HSSREC@ukzn.ac.za

I hereby provide consent to:

Audio-record my interview / focus group discussion YES / NO
Video-record my interview / focus group discussion YES / NO
Use of my photographs for research purposes YES / NO

____________________ ____________________
Signature of Participant **Date**

____________________ ____________________
Signature of Witness **Date**
(Where applicable)

____________________ ____________________
Signature of Translator **Date**
(Where applicable)

APPEMDICES D1 AND D2: SCHEDULES

APPEMDIX D1: RESEARCH DESIGN SCHEDULE

Question 1

- **What are the experiences of deaf learners in learning Technology?**

Phase1	Guiding question	Data source	Instrument
1	How are the concepts of Mechanical Systems mediated with Deaf learners?	Grade 9 Technology class	Classroom observation
2	To what extent do learners comprehend the concepts of Mechanical Systems?	Grade 9 Technology class	Observation of video recordings
3	What approach is used in the introduction of Mechanical Systems?	Grade 9 Technology class	Observation of video recordings
4	How do learners' prior experiences affect their understanding of concepts in Mechanical Systems?	Participant from class	Modelling and simulation
5	How is communication in the deaf classroom for deaf learners to learn Mechanical Systems?	Grade 9 classroom/ observation	Classroom observation
6	Which manual skills are observable?	Participation from simulations	Modelling and simulation

Question 2

- **What is the role of Sign Language in learning Technology?**

Phase 2	**Guiding question**	**Data source**	**Instrument**
1	To what extent are the Deaf learners able to comprehend instruction for problem solving?	Simulation instructions	Observation
2	What is the ability of Deaf learners to recognise and manipulate related concepts (fraction, ratio, inequality) in Mechanical Systems?	Analysis from the worksheet	Document analyses. Worksheet
3	When learners communicate, which language do they use?	Learners	Open-ended interview
4	Represent the following concepts using Sign Language: Clockwise Anticlockwise Load Effort	Grade 9 Technology class	Observation
5	Represent MA in a formula form	Grade 9 Technology class	Observation
6	Provide a definition for the following concepts using sign language: • MA • Effort • Load • $MA \geq 1$	Grade 9 Technology class	Observation

APPENDIX D2: INTERVIEW SCHEDULE FOR GRADE 9 TECHNOLOGY CLASS

1. Did you attend a pre-school?

Do you remember the name of your pre-school?

2. How did your family discover that you have to come to the Deaf School?

3. When did you start learning Sign Language?

4. Before you begin primary school did anyone in your home do the following to you: (a) Tell Stories

(b) Say counting rhymes

(c) Play games involving shapes

(d) Write numbers

5. How much time do you spend reading for yourself at home?
How do you do homework?

6. How many books are there in your home?

7. How many children's books are there in your home?

8. How many digitals information devices are there in your home?

9. Do you agree with the following statements?
(a) Most occupations needs maths, science and Technology skills

Why?

(b) Technology is necessary to design things that are safe and useful.

Why?

10. How do you feel about Technology in Grade 9?

Can you explain the reason why?

11. When did you start feeling this way?

12. Is Mechanical Systems taught differently in Grade 9 compared to other grades?

How?

13. Do you prefer to work on your own or as a group?

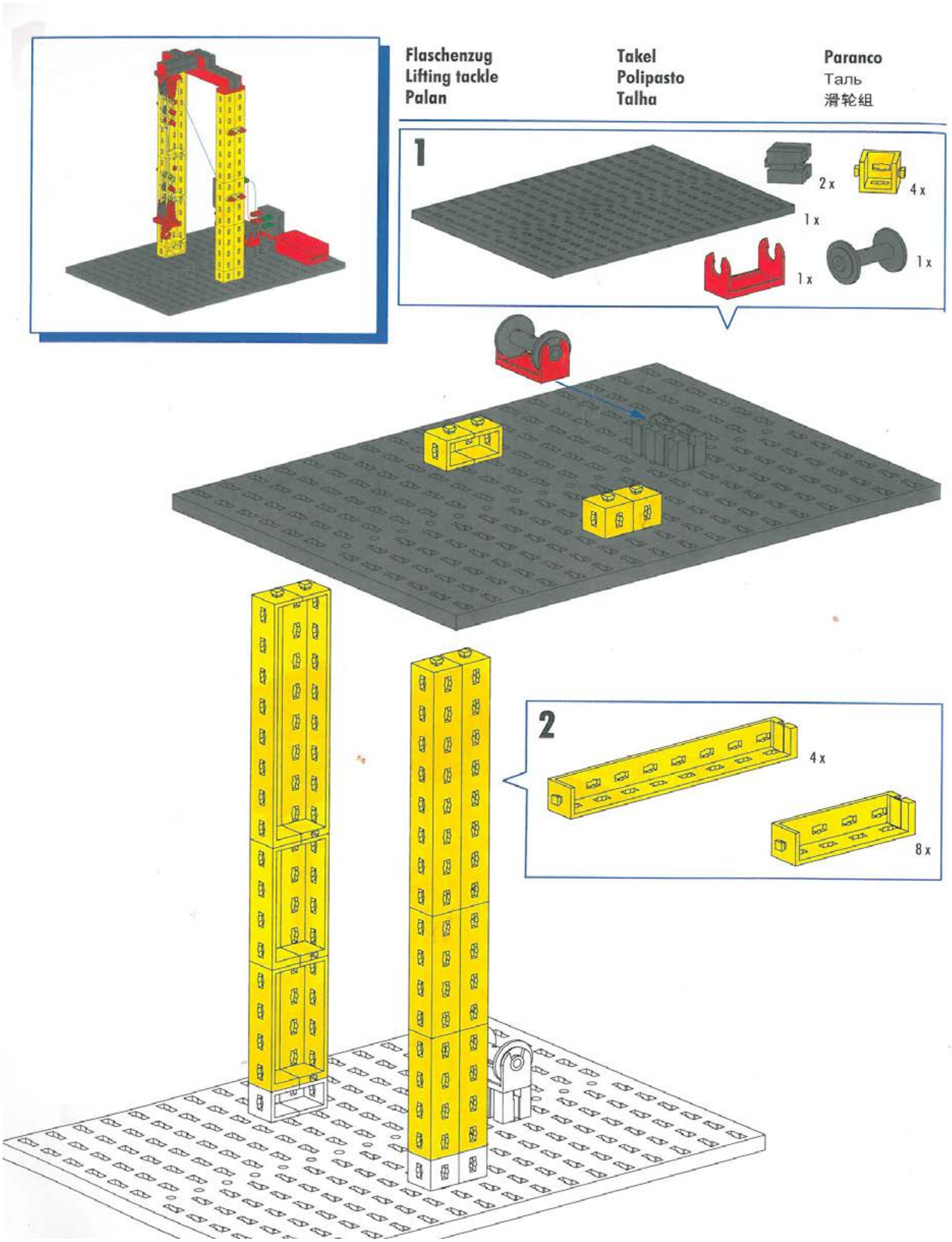
Why?

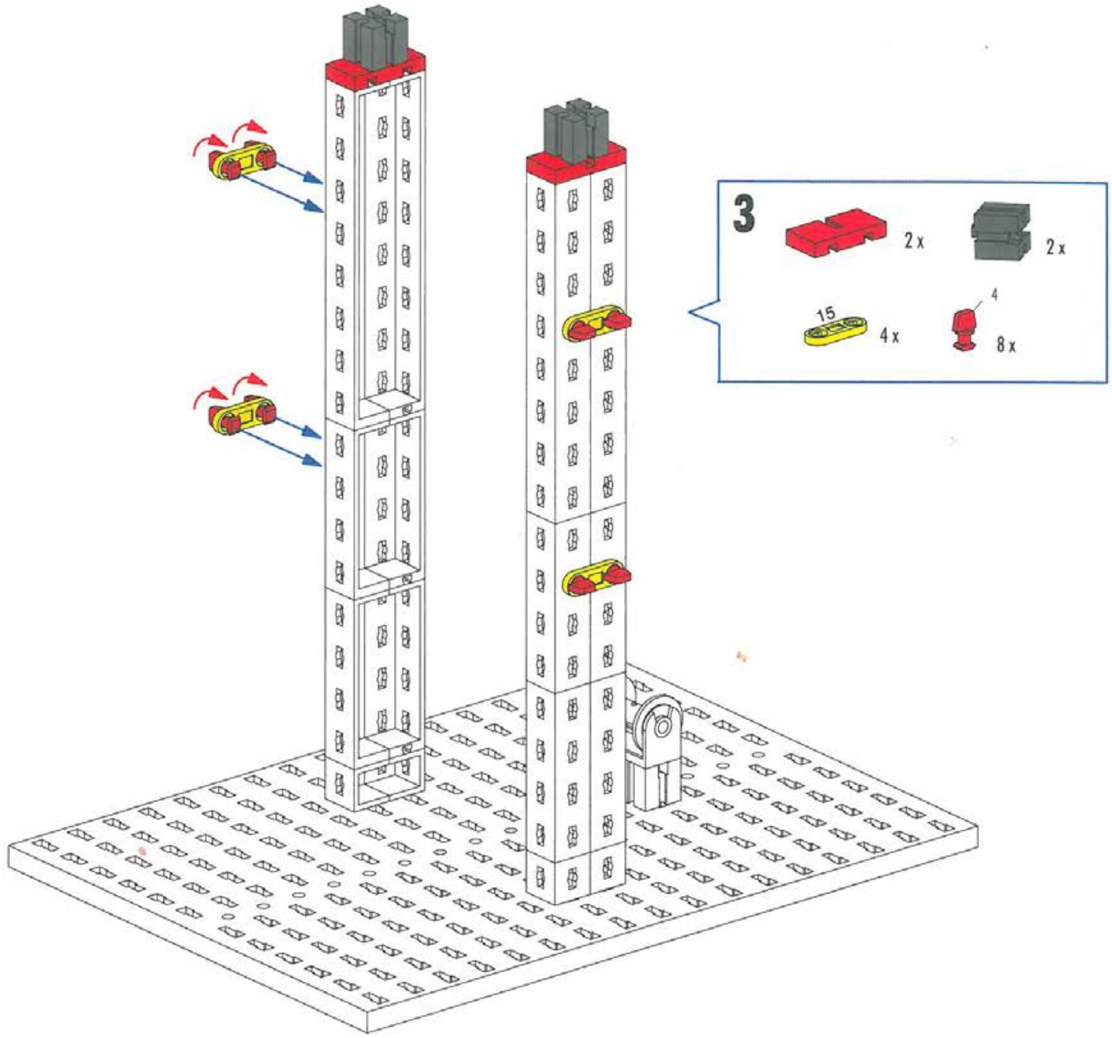
14. What changes would you like to see in the classroom to enhance your understanding in Technology?

15. How did you feel about Technology before project or practical lesson was introduced?

16. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?

APPENDIX E: EXPLODED VIEW OF THE PULLEY SIMULATION

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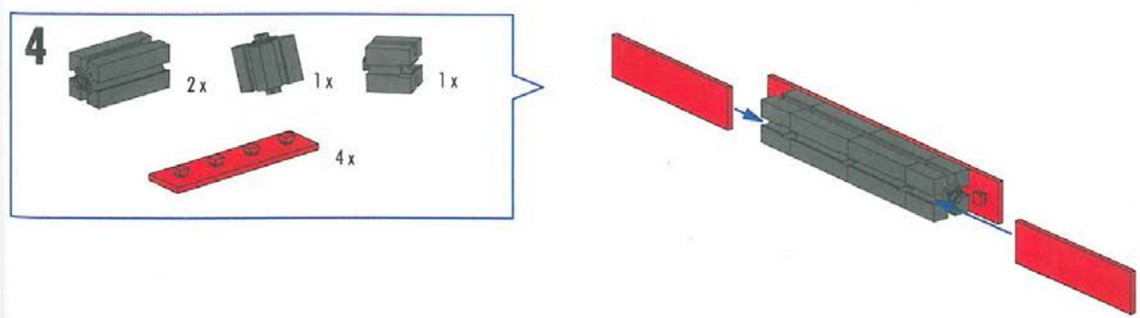
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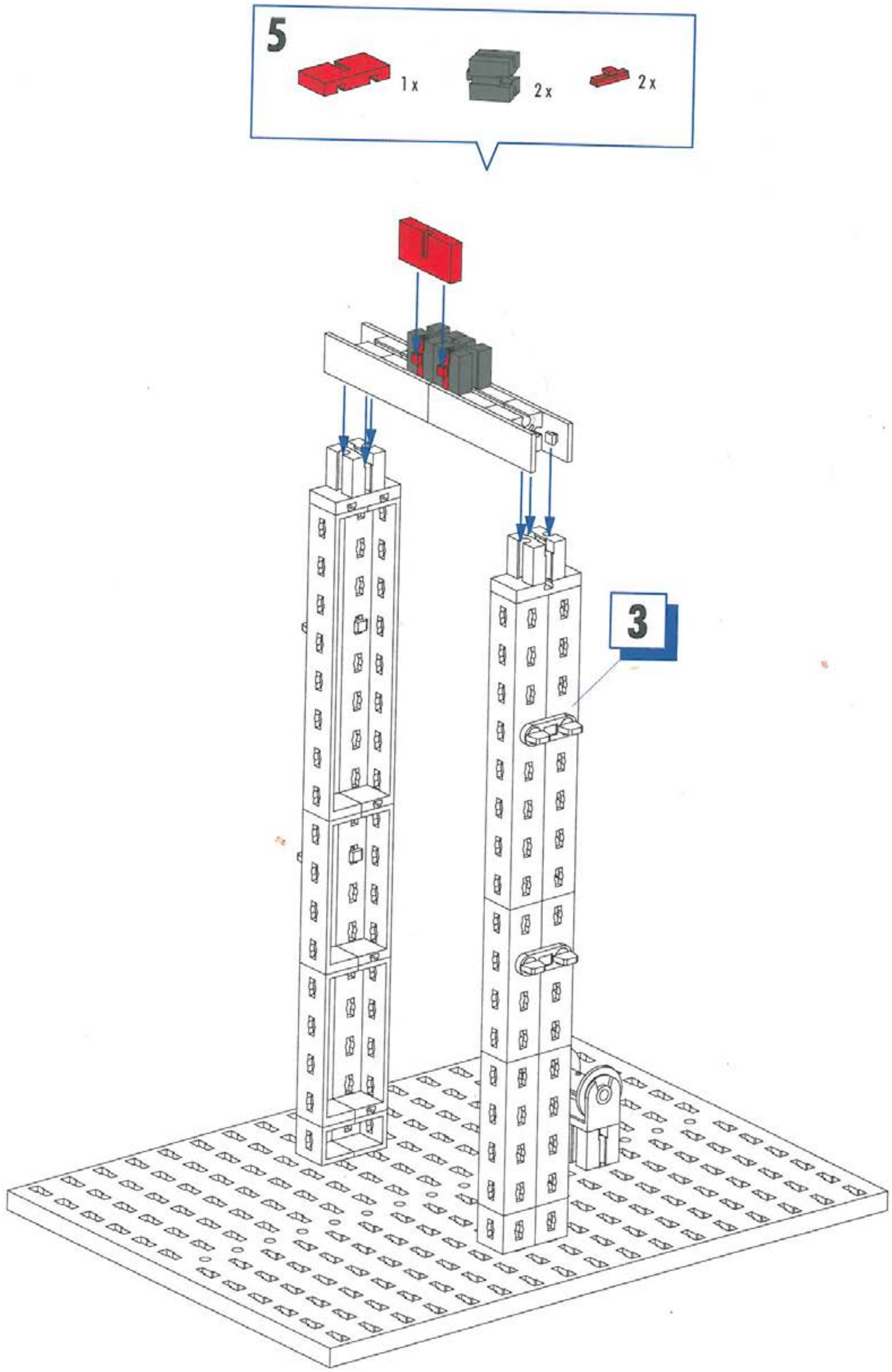
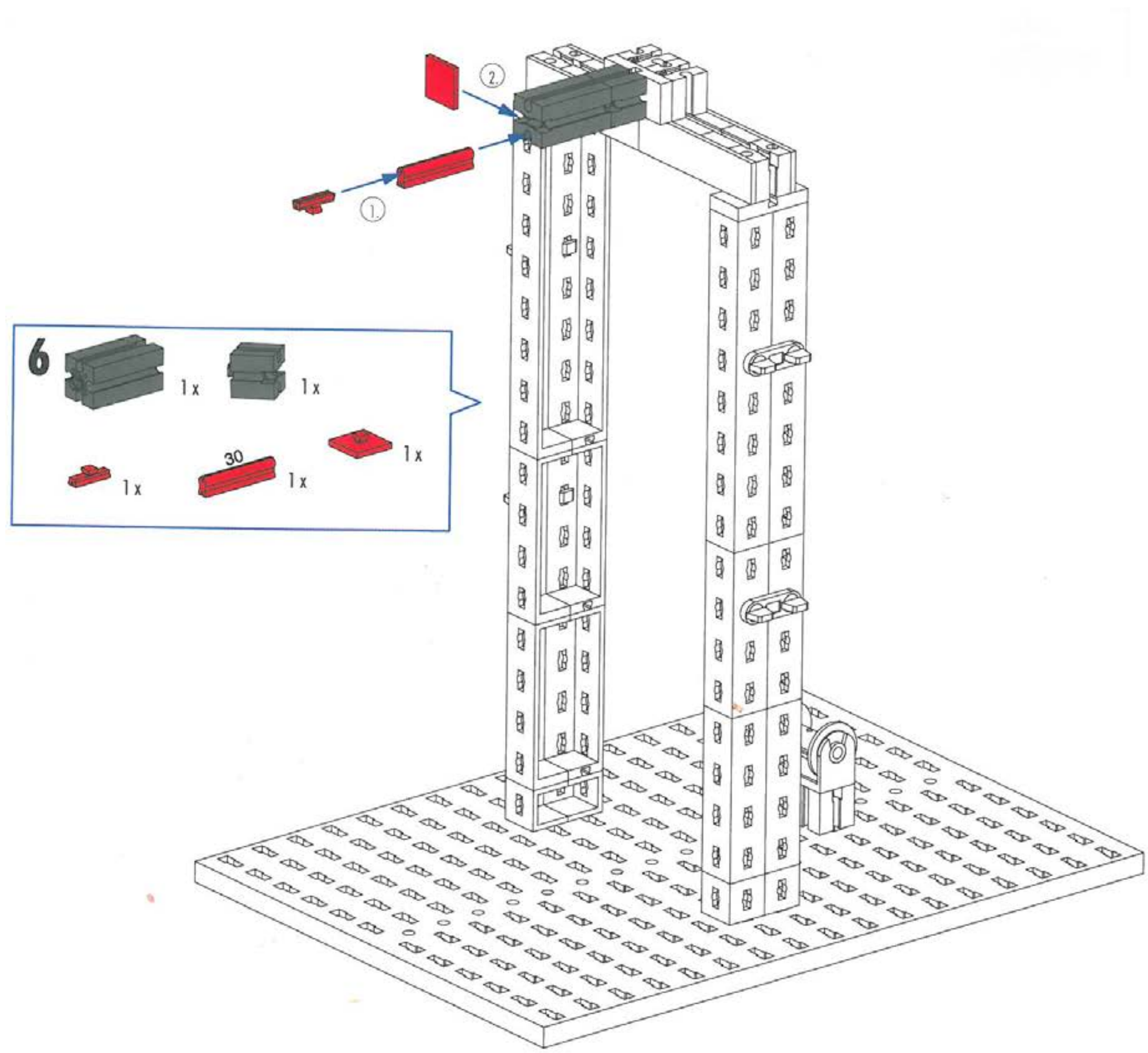
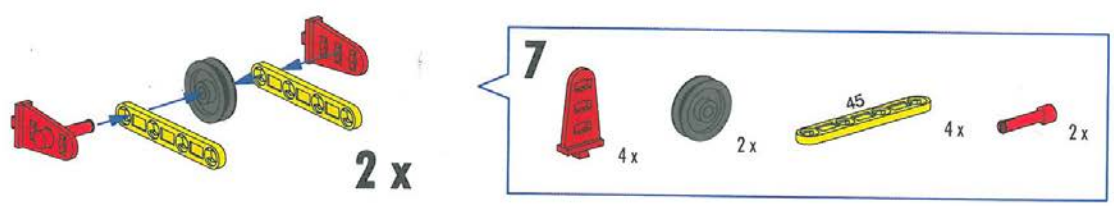
1 x
4 x

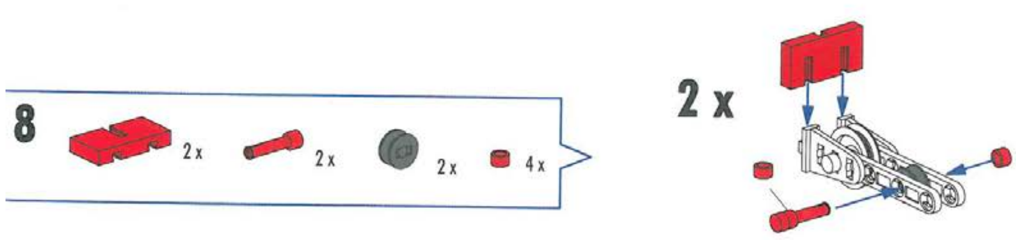

5
1x
2x
2x
3



2.
1.
6
1 x
1 x
1 x
30
1 x
1 x

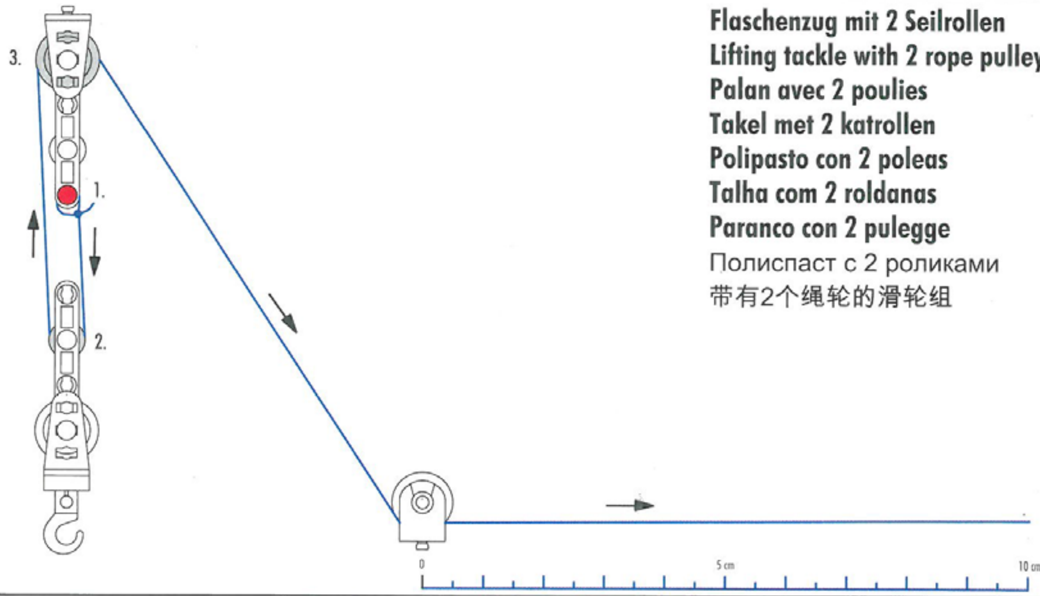


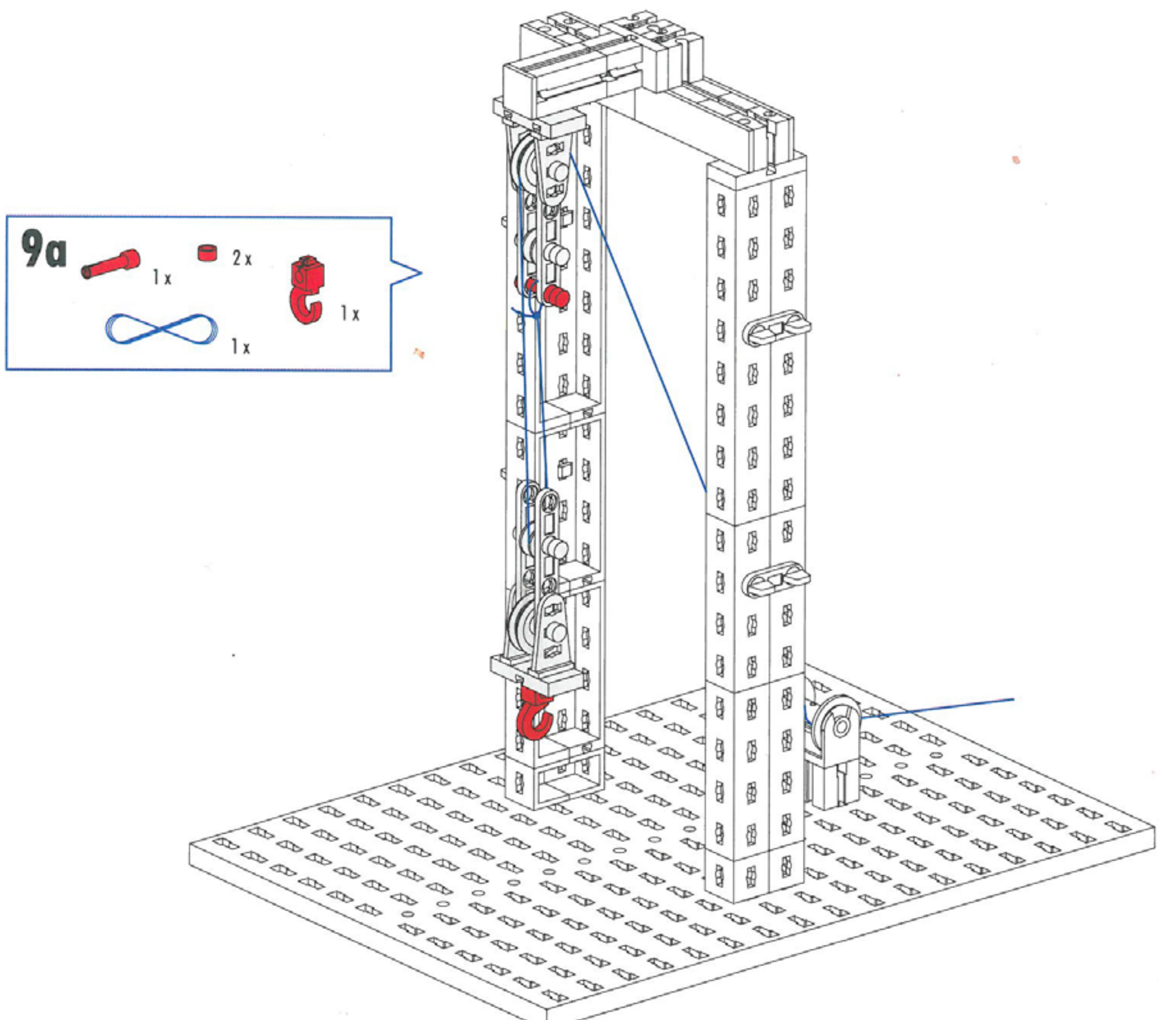
2 x
7
4 x
2 x
45
4 x
2 x

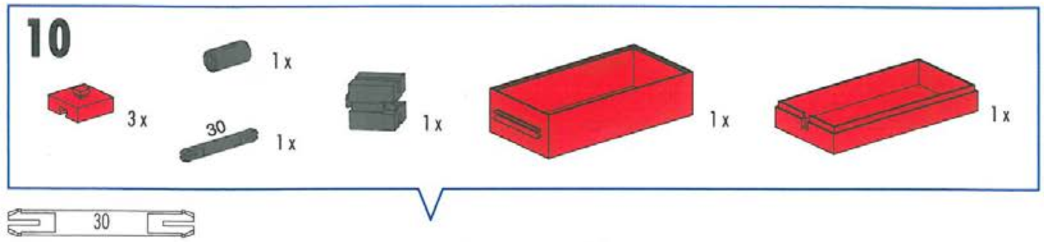


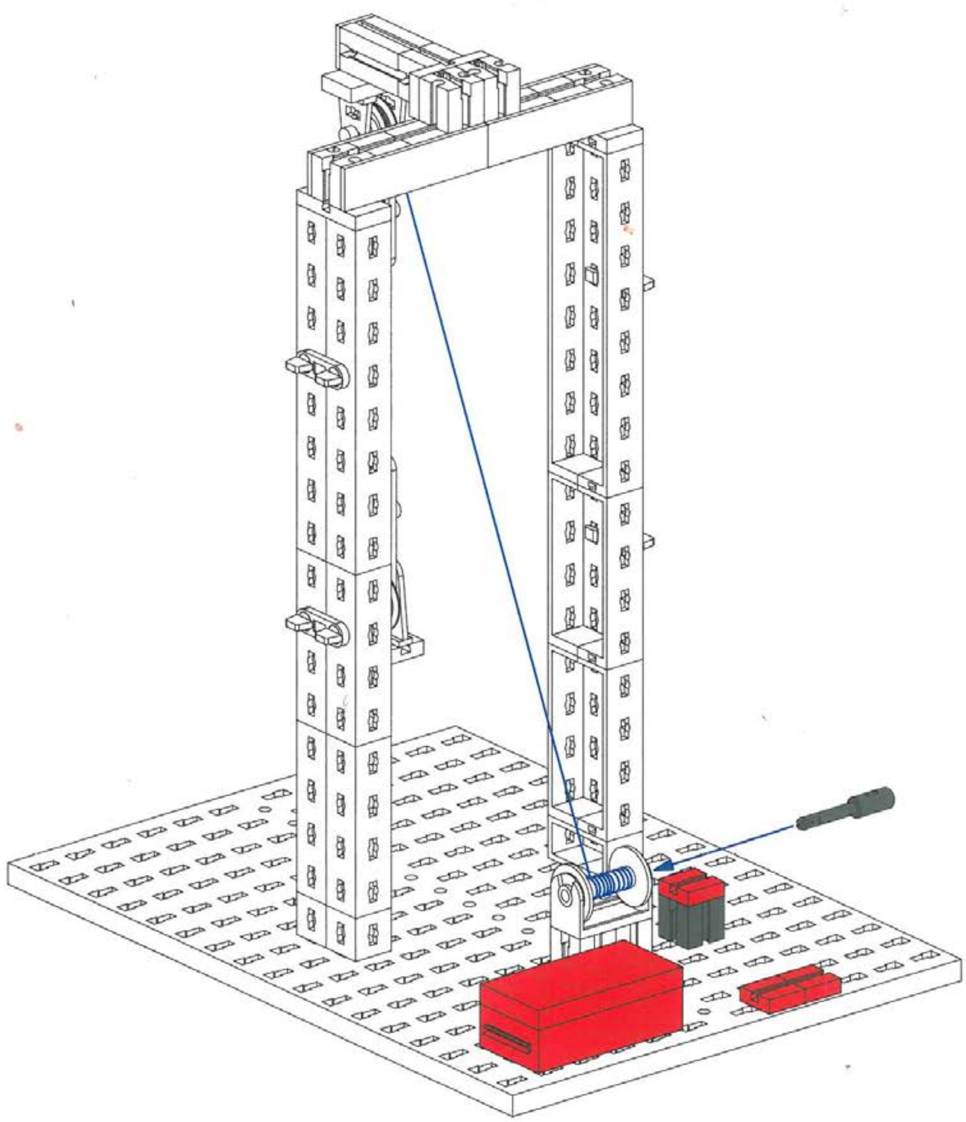
8
2 x
2 x
2 x
4 x
2 x

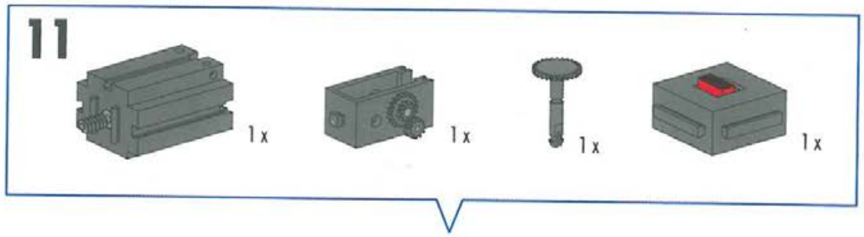
Flaschenzug mit 2 Seilrollen
Lifting tackle with 2 rope pulleys
Palan avec 2 poulies
Takel met 2 katrollen
Polipasto con 2 poleas
Talha com 2 roldanas
Paranco con 2 pulegge
Полиспаст с 2 роликами
带有2个绳轮的滑轮组

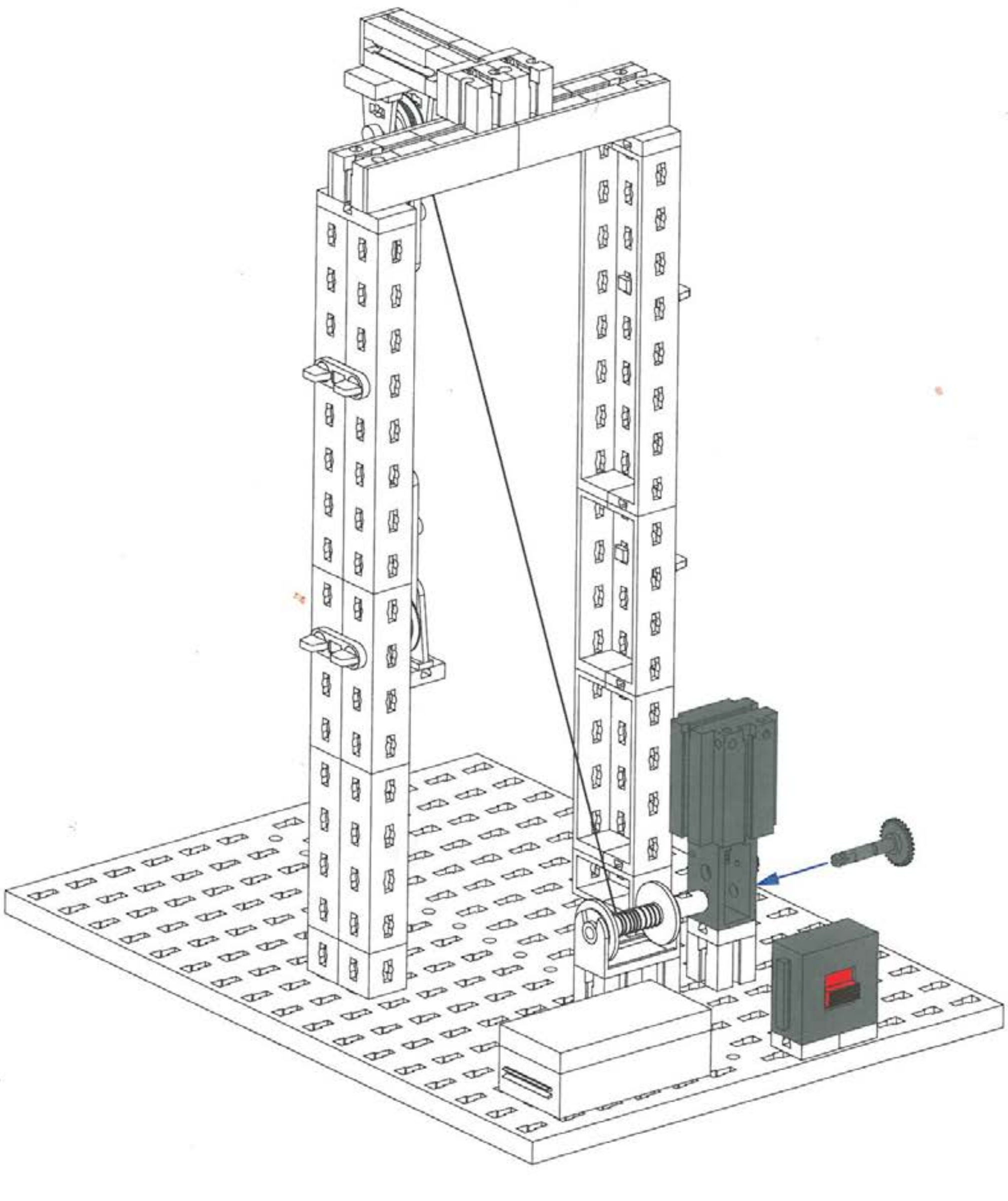


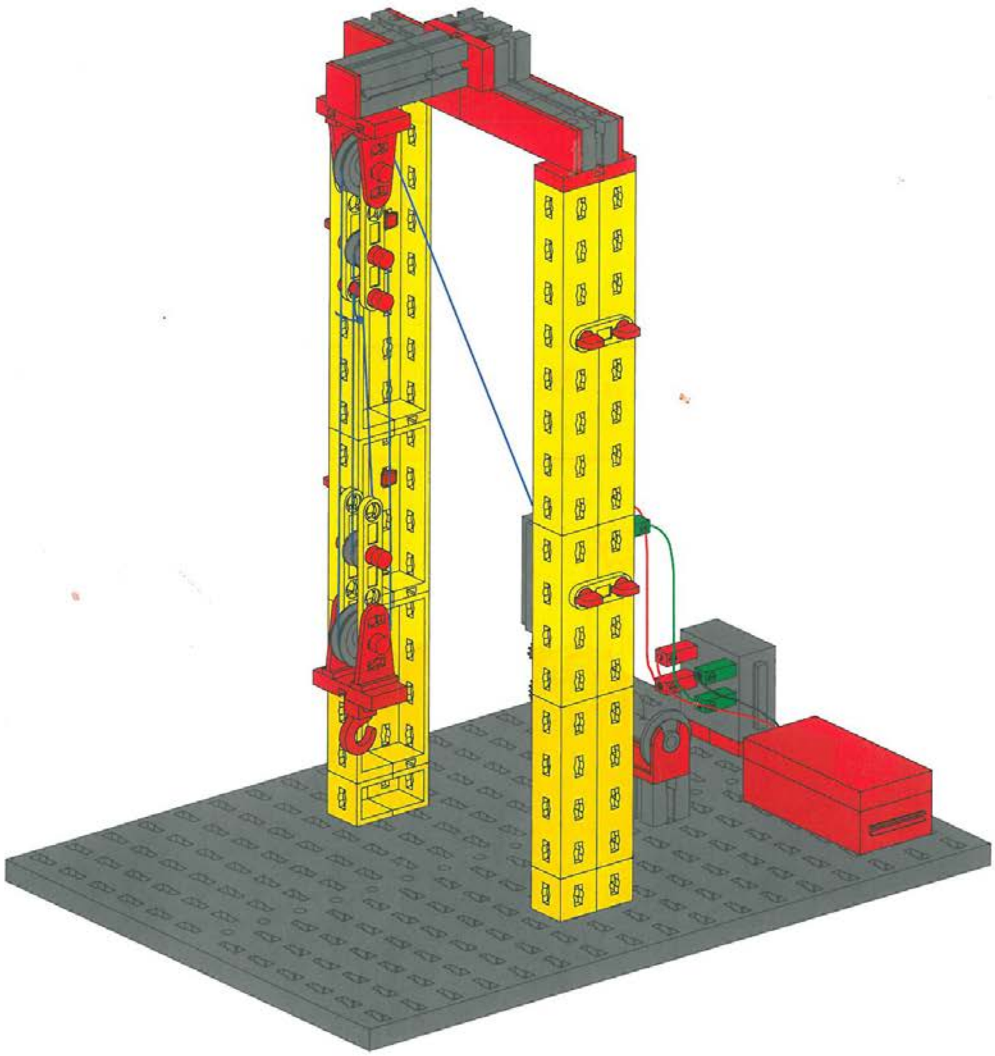


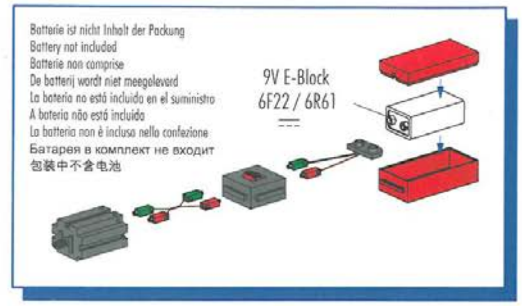

10
1 x
3 x
30
1 x
1 x
1 x
1 x
30




11
1x
1x
1x
1x






Batterie ist nicht Inhalt der Packung
Battery not included
Batterie non comprise
De batterij wordt niet meegeleverd
La batería no está incluida en el suministro
A bateria não está incluida
La batteria non è inclusa nella confezione
Батарея в комплект не входит
包装中不含电池
9V E-Block
6F22 / 6R61

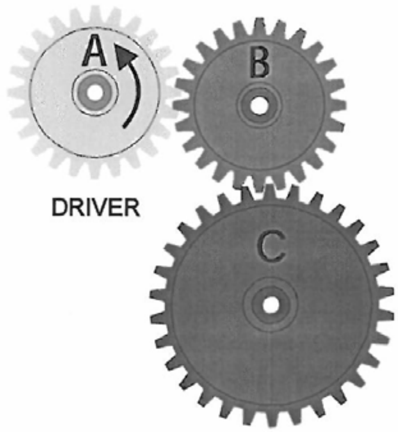
APPENDIX F: WORKSHEET FOR CLASS WORK ON GEARS

Technology **Grade 9**

Gears

Name ………………………………………………

This is a good example of a 'gear train'. A gear train is usually made up of two or more gears. The driver in this example is gear 'A'. If a motor turns gear 'A' in an anticlockwise direction:



1. Which direction does gear 'B' turn ?

____

2. Which direction does gear 'C" turn ?

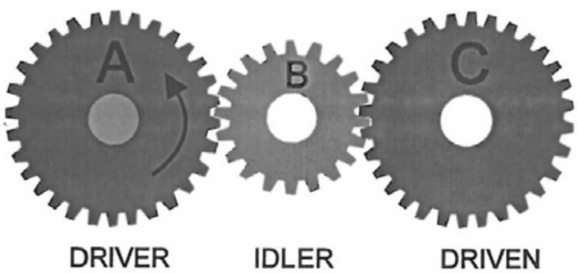
____

3. Does gear 'C' revolve faster or slower than gear 'A ? Explain your answer.'

____

____

____



4. The gear train seen opposite is composed of three gear wheels. What is the purpose of the IDLER gear?

____

____

____

5. Gear 'A' rotates in an anticlockwise direction. What is the direction of rotation of the IDLER and the DRIVEN gears?

IDLER: ______________________ DRIVEN: ______________________

6. In the space below draw the gear train seen in question 4 as a simple drawing, using a compass (no need to draw each tooth).

APPENDIX G: WORKSHEET ON MECHANICAL SYSTEMS IN GRADE 9 TECHNOLOGY CLASSROOM

Technology worksheet **Grade 9**
Mechanical Systems
Name: …………………………………………….

Instructions

- Answer all questions
- Show all calculations
- Provide all drawings clearly and label them accurately

1. Definition of a system

____

____

____

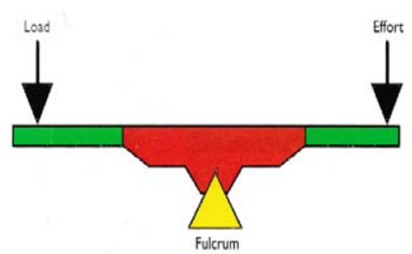
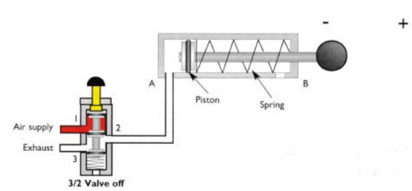
2. What is a machine?

____

____

____

3. Identify the type of Machine and provide the function on the table below

<table>
<tr><td>Pectoral drawing</td><td>Mechanism</td><td>What does it do</td></tr>
<tr><td>
</td><td></td><td>__________
____
____
____
__________</td></tr>
<tr><td>
</td><td></td><td>__________
____
____
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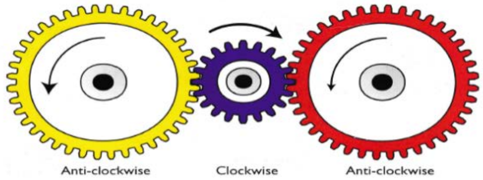
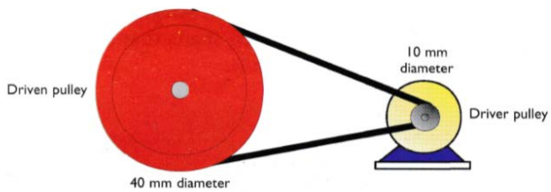
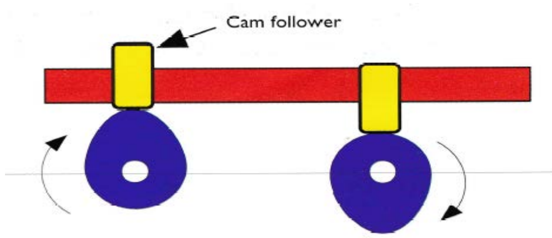
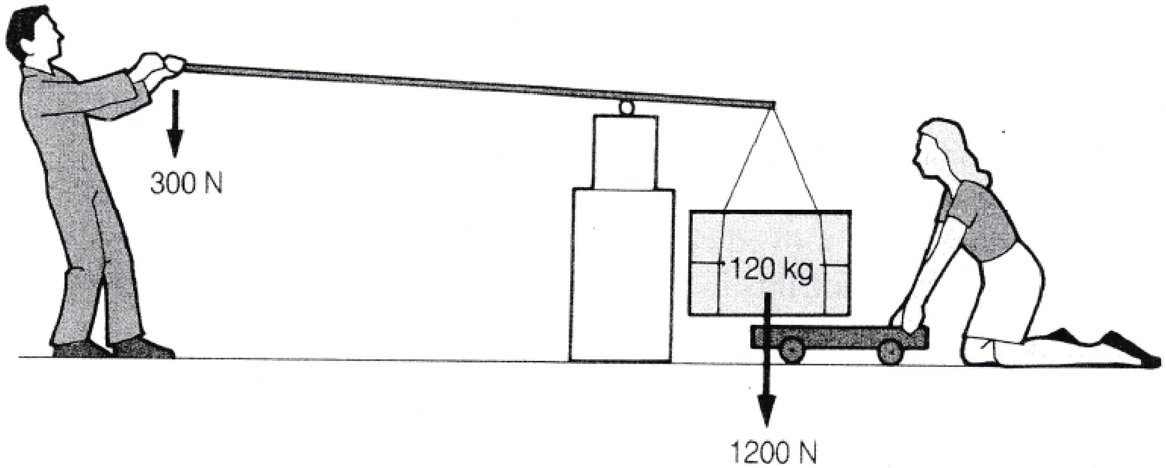
__________</td></tr>
<tr><td></td><td></td><td>__________</td></tr>
</table>

4. What is a LEVER?

5. What is a formula used to calculate MA?

6. Calculate the Mechanical Advantage.



a) What will be the mechanical advantage if the load = 1200N and the effort = 300N.

b) What does this tell us about the machine?

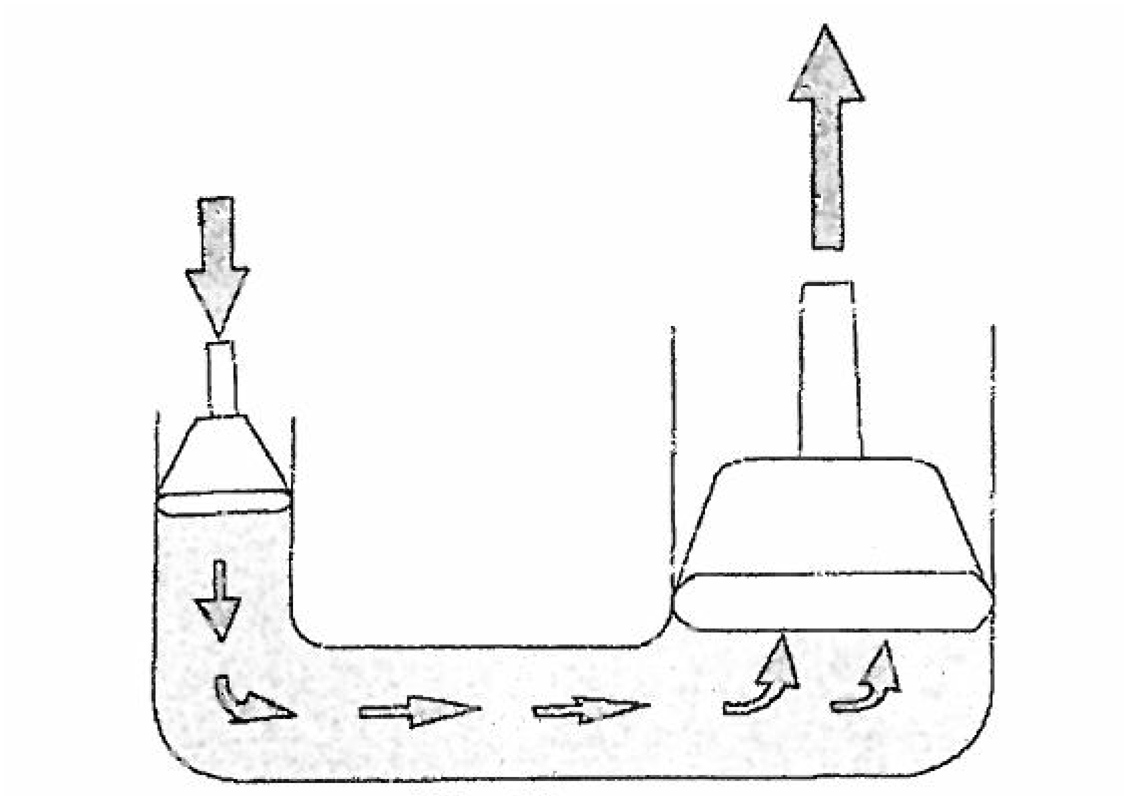
c) State the law of simple machines

d) State Pascal's law

e) State whether the following is true or false?

- Liquids cannot be compressed.

10 The pistons of a hydraulic press have radii of 2 cm and 12 cm.

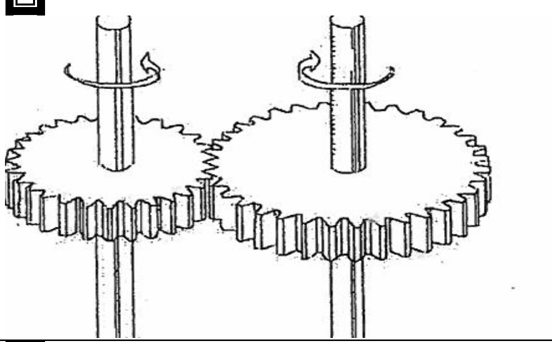
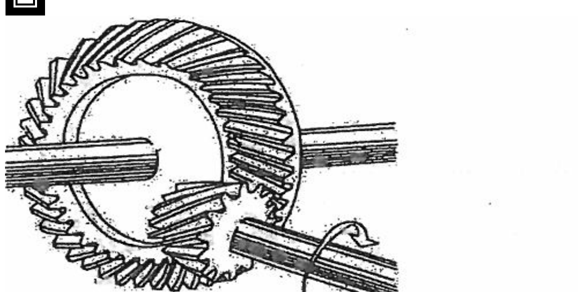


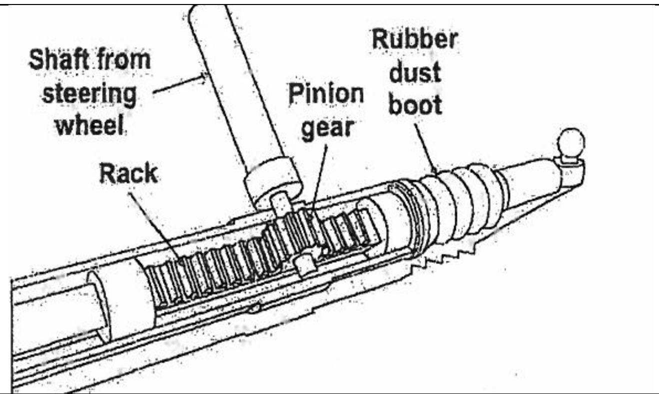
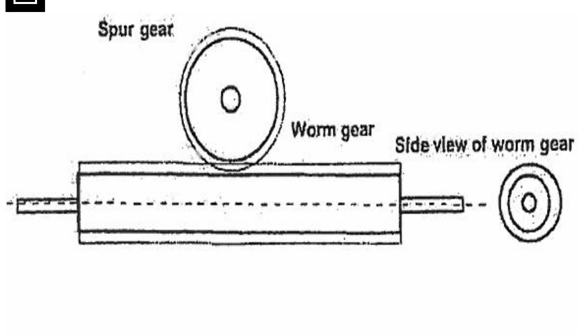
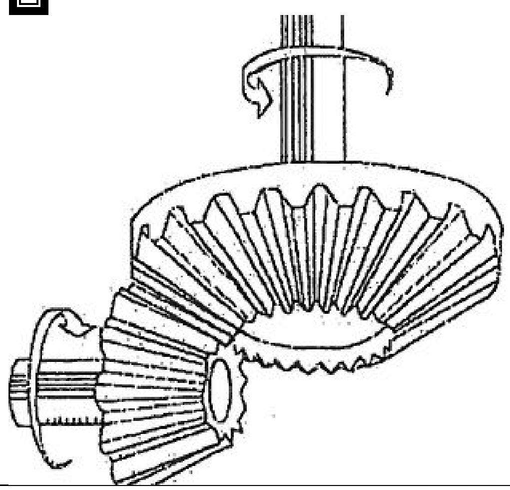
(a). What force must be applied to the smaller piston to exert a force of 5000N on the larger piston?

(b). What is the pressure on each piston?

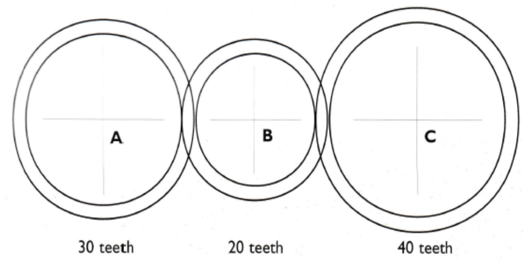
(c). What is the actual Mechanical Advantage?

11.

Pictorial drawing of gear	Name of the gear
1 	
2 	
3	

 Shaft from steering wheel Rubber dust boot Pinion gear Rack	
4  Spur gear Worm gear Side view of worm gear	
5 	

12. The diagram below shows the sketch of a simple gear train, where A matches with B and B matches with C.



A. State the function of the idler gear.

____

____

____

B. Identify the direction of each gear and indicate the direction using arrows on the diagram and write in words on the lines below.

____

____

____

C. Calculate the gear ratio of the gear train

____

____

____

____

____

____

____

____

____

____

APPENDIX H: PROJECT PROTOTYPE

Design a compound lifting machine

Up to this stage, you have investigated mechanical, electrical, hydraulic and pneumatic systems. You are also familiar with the fact that machines are not only made up of a single system. Sometimes a combination of systems provides the effectiveness required from a machine.

Scenario

Moving SA, a new moving company that moves industrial equipment and household objects, needs your help. Mr Ngcobo, the owner of a very valuable Egyptian artifact, lives in the Nelson Mandela Building in Cape Town. Mr Ngcobo is moving into a new apartment within his building, from the ground floor. He owns a priceless ancient dog-headed Egyptian water clock. However, due to the delicate nature of the water clock, no human hands may touch the artifact (ancient timepiece). The owner is very concerned about how this item will be moved and has given specific instructions to the moving company as to how the water clock is to be moved. Some of his instructions include no human hands may briefly move the object to a moving device or transportation method.

Furthermore, the elevator in the building has been acting strangely recently, with the sprinkler system going off unnecessarily, so the stairwell must be used instead. Moving SA wants to hire you to design a machine to do the job.

The practical task

Integrated systems are systems where mechanical, electrical, hydraulic and pneumatic systems are combined. A machine combining at least two subsystems can be effective in giving a mechanical advantage to make work easier. The mechanical element may consist of one or more of the following mechanisms:

: Levers

: linked levers

: Wheel

: Camps

: Pulleys and/or gears.

: Hydraulics and/or pneumatics

You will work in groups or teams to compile this task. Each group member must have a particular role and responsibilities. Although each group member has their own duties with the group, all members are responsible for contributing to the overall effort of the group.

Investigate

The technological process involves solving technological problems and certifying needs and wants.

Investigate the situation so that an appropriate machine can be designed to solve the problem, need or want given in the scenario. Investigate the possible mechanisms and controls to be used together to make the machine. Consider the existing machines as a starting point. Write down your own specifications for your own solutions. Your specification should include your thoughts on the following:

What problem, need or want do you expect to solve.

Which mechanism and controls will you use together to make your machine.

How will your machine work?

How will you achieve mechanical advantage?

Have you given consideration to ergonomics?

What other aspects do you need to consider?

Design brief

Write your suggestion for the design giving the specifications and constraints.

The specifications are those rules for design and making, and include the following:

Who is it for?

What is it for?

How it will do the job?

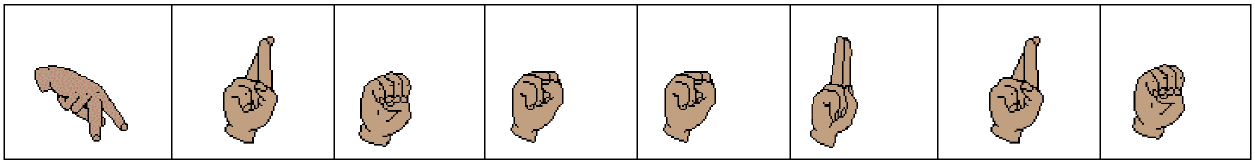
What it should be made of?

Sketches

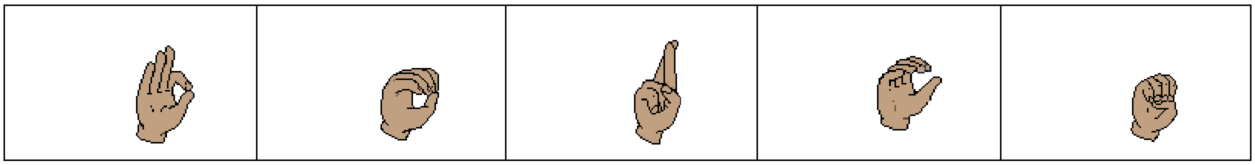
Draw two simple sketches of possible designs which you think are workable and practical.

APPENDIX I: CHALLENGING WORDS IN SIGN LANGUAGE

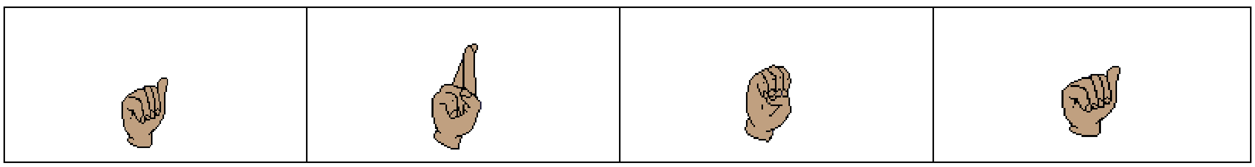
Pressure



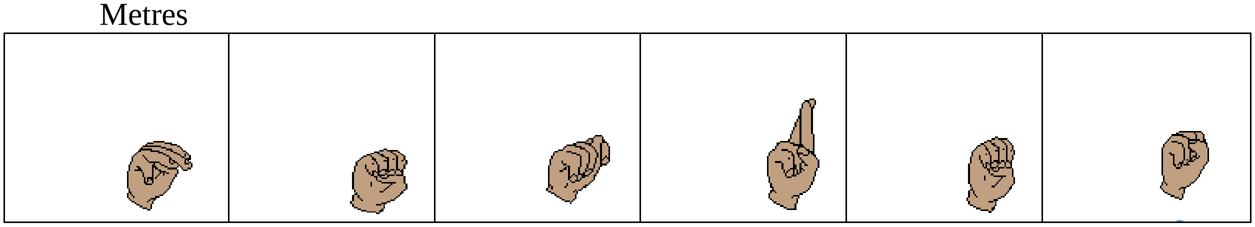
Force



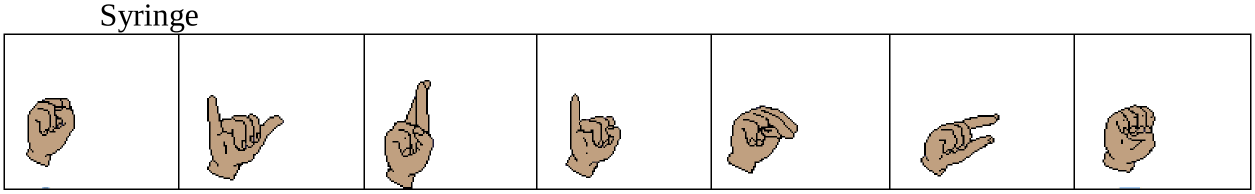
Area



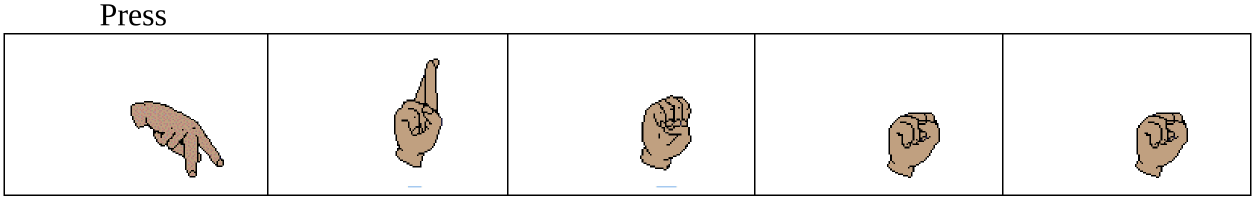
Metres



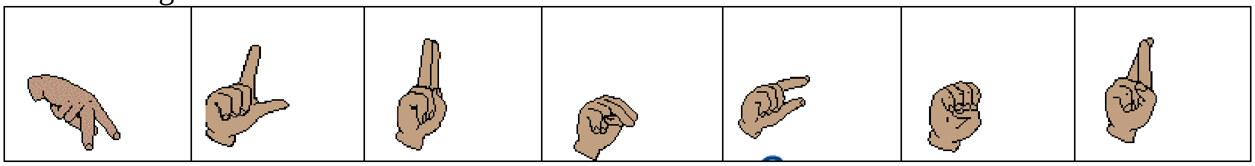
Syringe



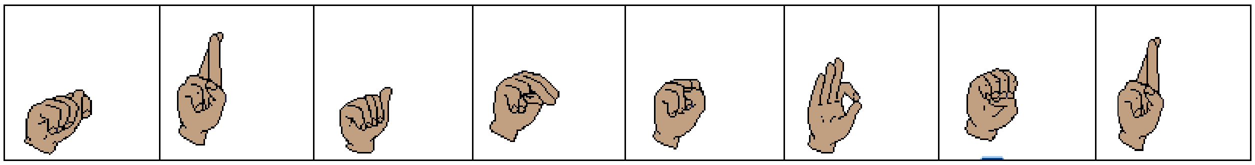
Press



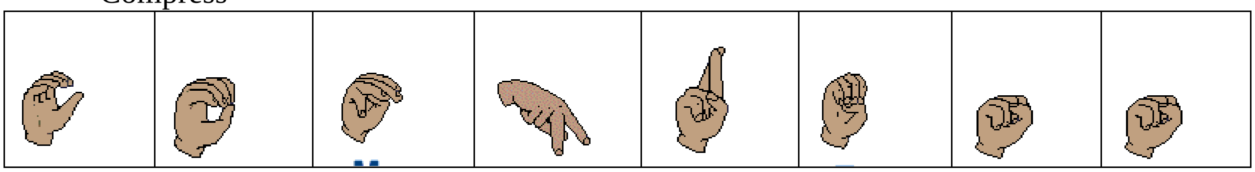
Plunger



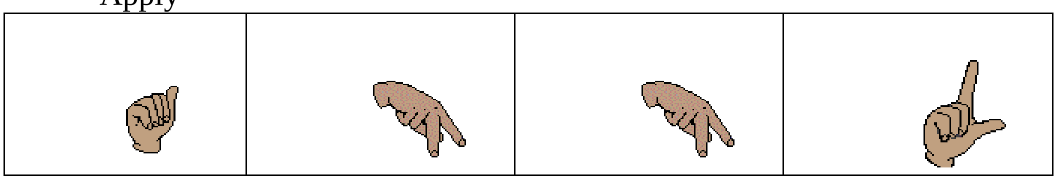
Transfer



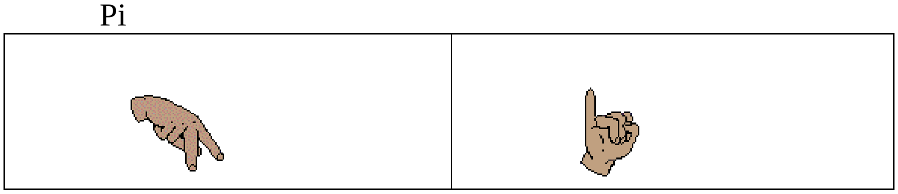
Compress



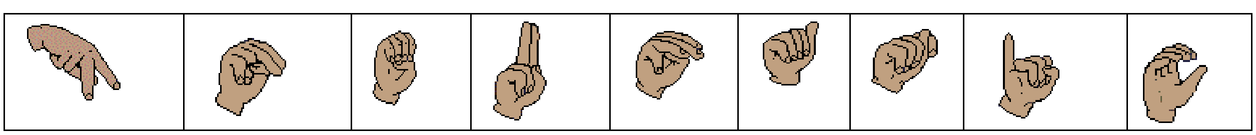
Apply



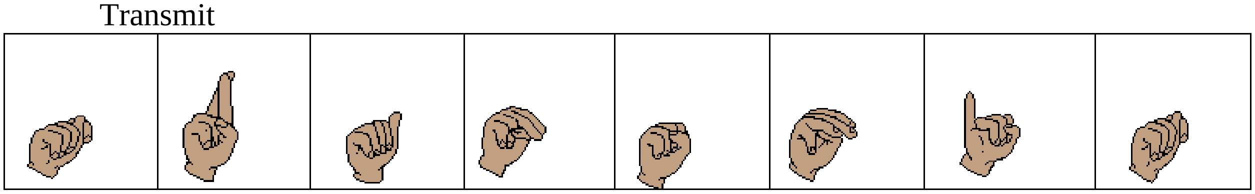
Pi



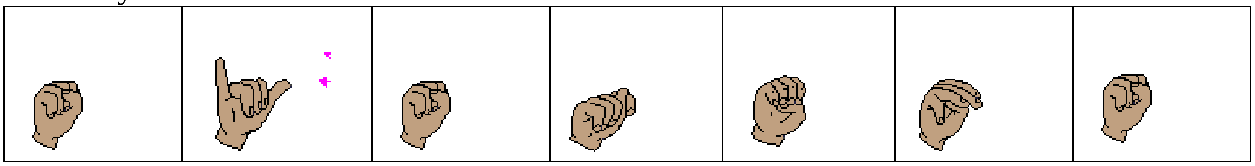
Pneumatic



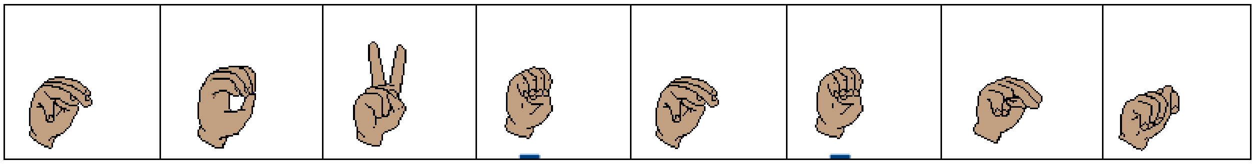
Transmit



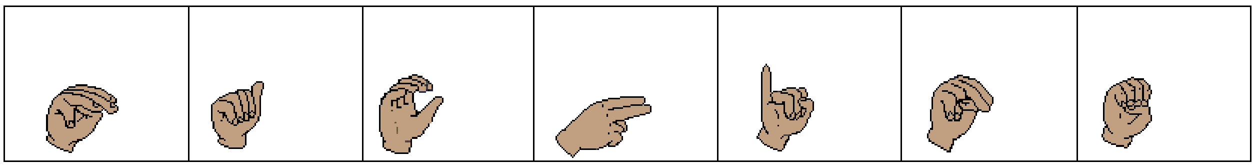
Systems



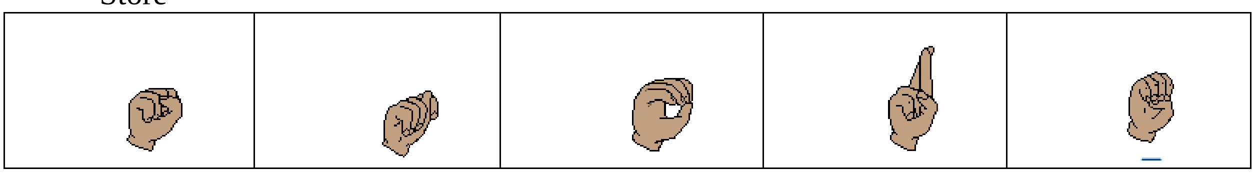
Movement



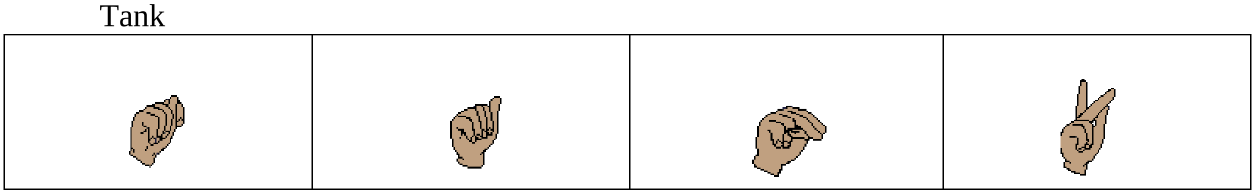
Machine



Store

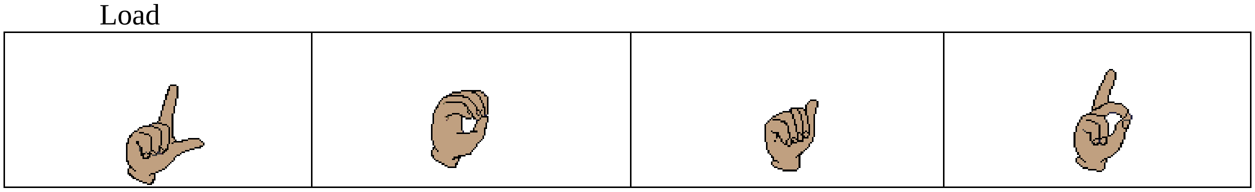


Tank

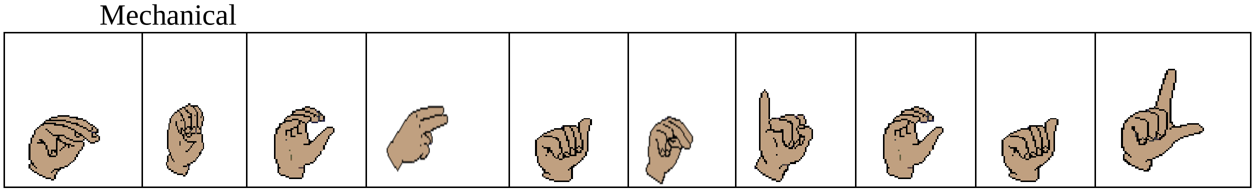


Hydraulics

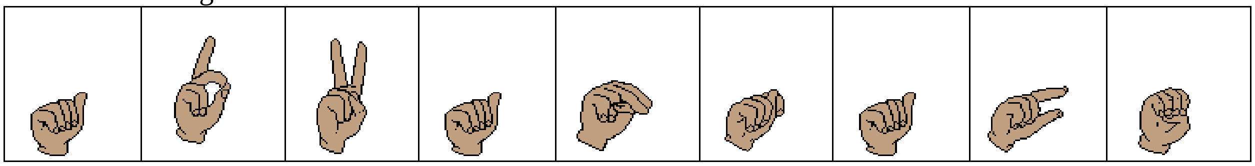
Load



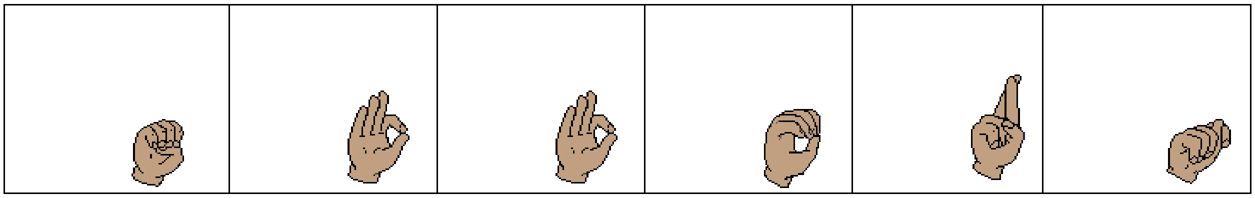
Mechanical



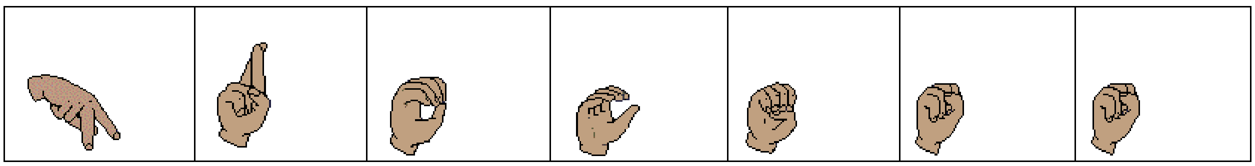
Advantage



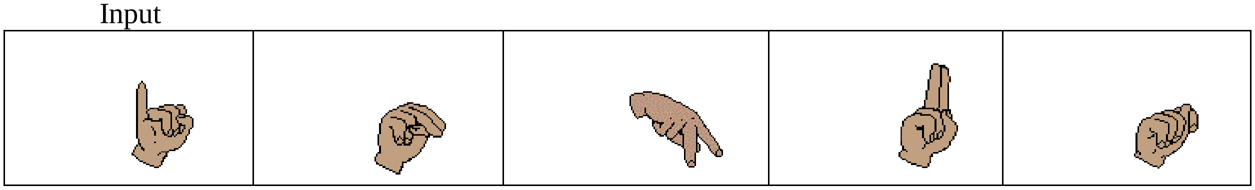
Effort



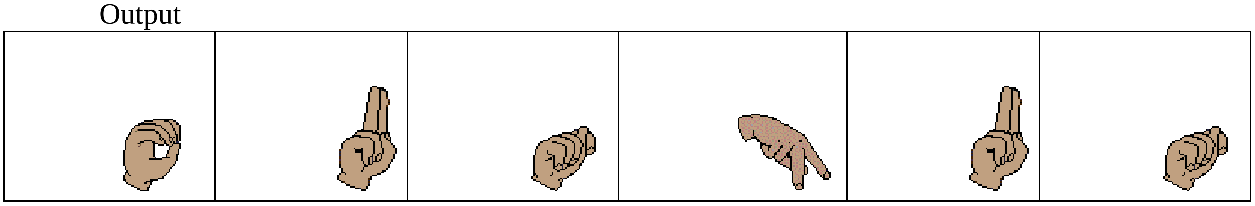
Process



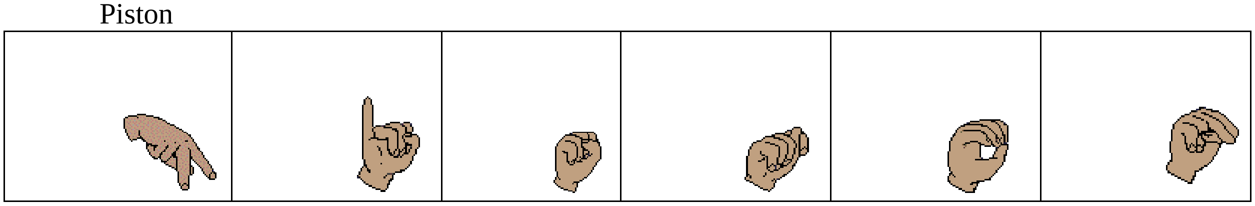
Input



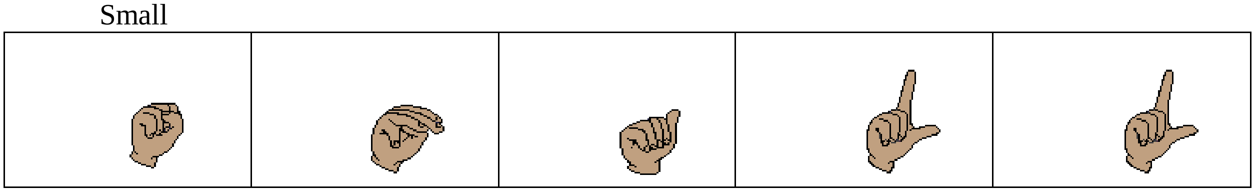
Output



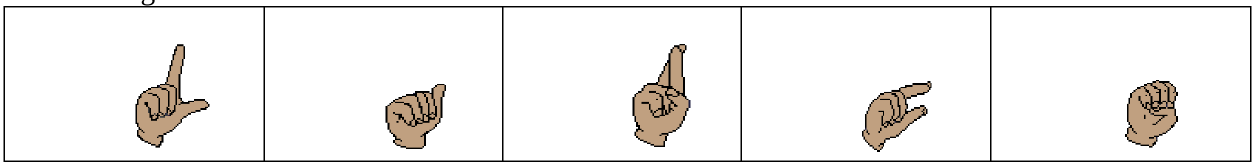
Piston



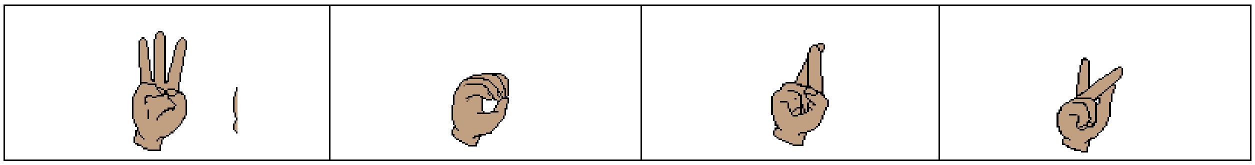
Small



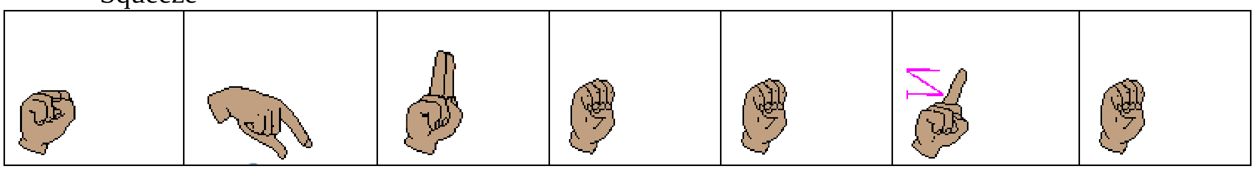
Large



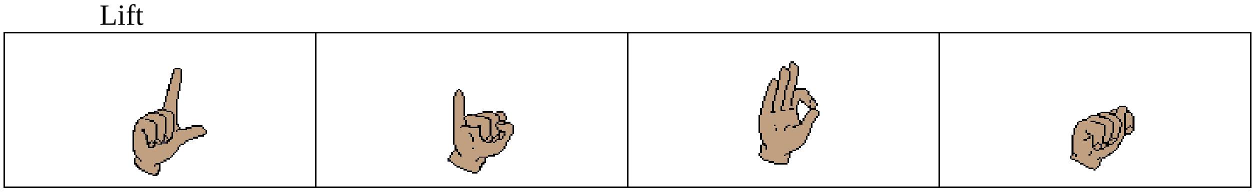
Work



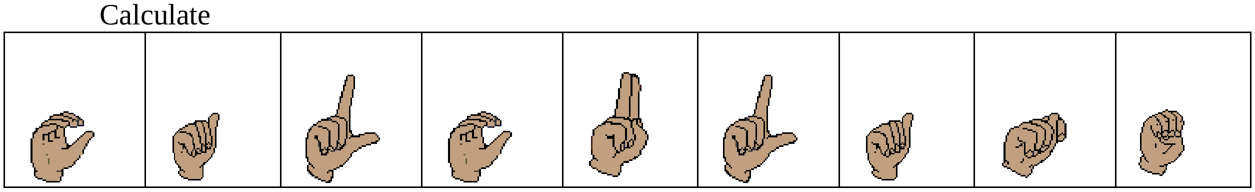
Squeeze



Lift



Calculate



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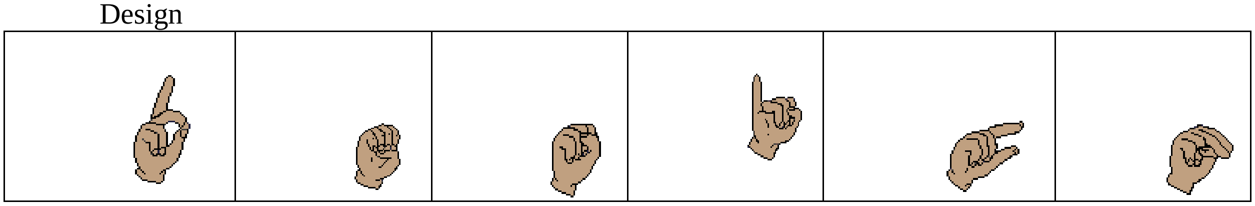

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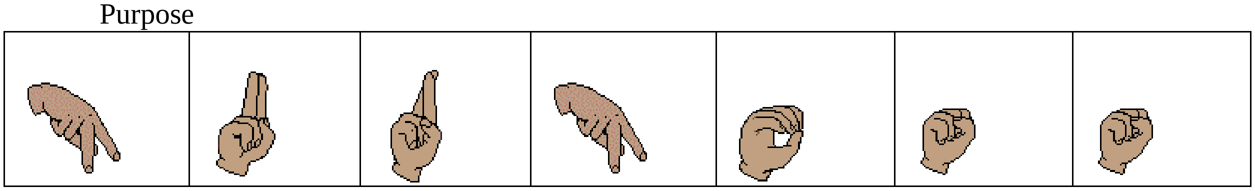

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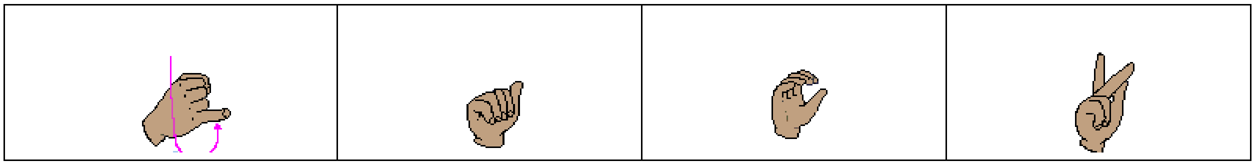

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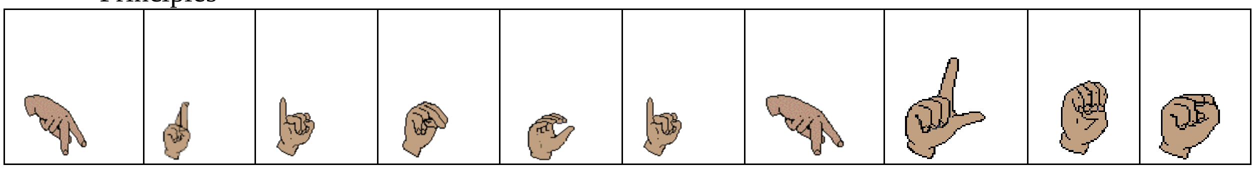

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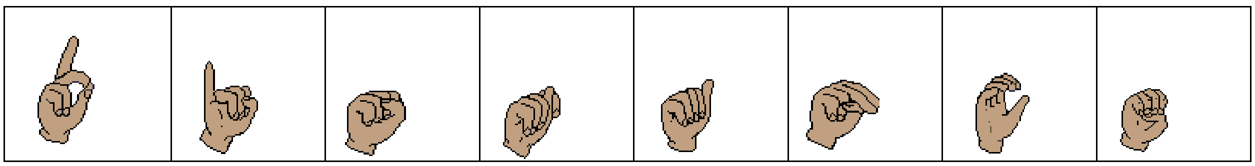

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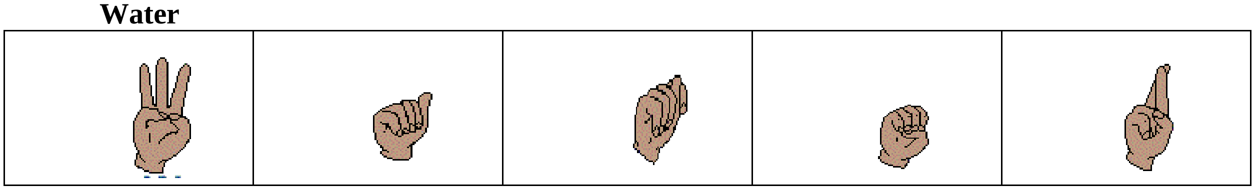

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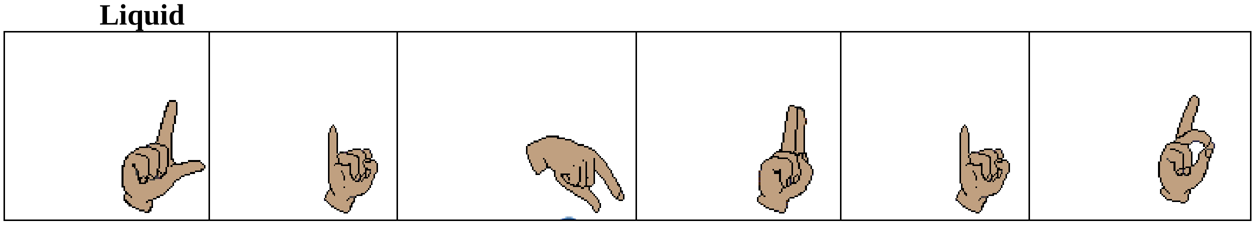

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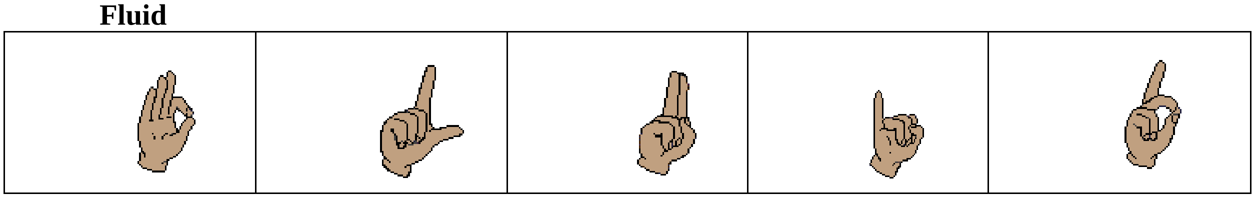

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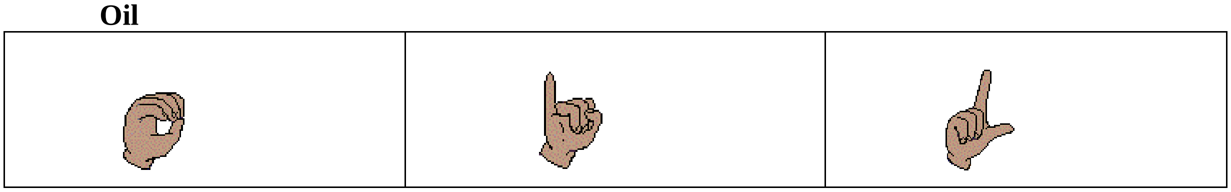

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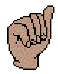	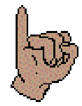	

APPENDIX J: LEARNERS' INTERVIEWS

1. Did you attend a pre-school?
2. How did your family discover that you have to come to the Deaf School?
3. When did you start learning Sign Language?
4. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?
5. Do you agree with the following statements?

(a) Most occupations need maths and Technology skills?

(b) Technology is necessary to design things that are useful.

6 Do you prefer to work on your own or as a group?

7 How did you feel about Mechanical Systems before project or practical lesson was introduced?

8 What changes would you like to see in the classroom to enhance your understanding in Technology?

Learners' responses

Nosipho

1. Did you attend a pre-school?

…yes

Do you remember the name of your pre-school?

…it is here.

2. How did your family discover that you have to come to the Deaf School?

...the Doctor write a letter and the parent bring me to school.

3. When did you start learning sign language?

…in the pre-school.

4. Before you begin primary school did anyone in your home do the following to you: (a) Tell Stories?

… *no*

(b) Say counting rhymes

...no

(c) Play games involving shapes

...no

(d) Write numbers

… *no*

5. How much time do you spend reading for yourself at home?

…*I don't read at home, I read at school.*

How do you do homework?

…*I do my homework at school, waiting for the bus after school.*

6. How many books are there in your home?

… *I know the bible.*

7. How many children's books are there in your home?

… *Nothing.*

8. How many digitals information devices are there in your home?

… *television*

9. Do you agree with the following statements?

(a) Most occupations needs maths, science and Technology skills

…*no*

Why?

…*people sweeping the road, cutting grass, making tea do not need Technology.*

(b) Technology is necessary to design things that are safe and useful.

…*yes*

Why?

…*cell phones, computers and stoves and sometimes motorcars.*

9. How do you feel about Technology in grade 9?

…*good*

Can you explain the reason why?

…*grade 9is the same teacher teaching us in grade eight. Grade 9 has practical*

10. When did you start feeling this way?

…*when I see our project working.*

11. Is Mechanical Systems taught differently in Grade 9 compared to other grades?

… *Yes*

How?

…*there is practical and project.*

12. Do you prefer to work on your own or as a group?

…as a group.

Why?

… If I fear the teacher I ask my friend. If I don't understand my classmates help me.

13. What changes would you like to see in the classroom to enhance your understanding in Technology?

… The teacher must give us more projects.

14. How did you feel about Technology before project or practical lesson was introduced?

*…not easy to understa*nd

15. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?

… English. Because our teacher is using English and the booking writing is English. A test is English

Zekhethelo

1. Did you attend a pre-school?

… Yes I do

2. How did your family discover that you have to come to the Deaf School?

*… The clinic gave the*m a *letter but I don't know why, I remember my parents taking me to school when I was small and this is the school they take me to.*

3. When did you start learning Sign Language?

…when I was at the pre-school they teach me to learn how to use hands to express myself.

Were you able to express yourself the same way at home as you were doing at the preschool?

… No

What was the difference?

… at school I was taught to understand teachers and teachers understand me. I end up saying everything I need and teachers are able to give what I was asking. At home nobody understand me, they take me to doctors and clinics and I don't know why.

How is your communication at home now?

.. we don't talk everytime. We talk litlee when we are on TV and when they want me to do something.

4. How much time do you spend reading for yourself at home?

… *if I'm not on TV, I read magazines or I text my friends.*

5. How many books are there in your home?

Magazines and the Bible.

8. How many digitals information devices are there in your home?

… *TV, computer, cell phone, washing machine.*

9. Do you agree with the following statements?

(a) Most occupations needs maths and Technology skills

… *Yes*

Why?

… *To increase temperature in the stove you start from zero to six. A volume of a radio has got numbers. Speed of a car has got number*

(c) Technology is necessary to design things that are safe and useful.

… *yes*

How?

… *cell phone is useful when I text my friends. A bus is safe and useful when I come to school and go home in the afternoon*

10. How do you feel about Technology in Grade 9?

… *it is difficult*

Why is it difficult?

…*I need to know different topics and the topics have maths and there is a project. The teacher tells us that we must understand all these topics and know how to count.*

12. When did you start feeling this way?

… *in Grade 8 and 9*

13. Is Mechanical Systems taught differently in Grade 9 compared to other grades?

…*yes*

How can you explain the difference?

…*we learn a topic and do a practical. all we are learning is reading and doing practicals*

14. Comment on activities given to you in class and/ homework.

… Activities are making Mechanical Systems clear. If I don't understand explanation from the teacher, I get understanding when we do practical in class.

15. Do you prefer to work on your own or as a group?

… Group is good.

Why?

… If I don't understand an instruction from the teacher from the book, I talk to my classmates asking for their understanding and it becomes easy to go on with my project.

16. What changes would you like to see in the classroom to enhance your understanding in Mechanical Systems?

… I need more practicals and more time to work on my exercises. To do practical before a teacher teach us about the section.

17. How did you feel about Mechanical Systems before project or practical lesson was introduced?

18. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?

… English

Mxolisi

1. Did you attend a pre-school?

…yes.

When did you learn the sign language?

…I learned it from here at this school.

2. How did your family discover that you have to come to the Deaf School?

…the doctor at the hospital tell them to bring me here when I was young.

3. When did you start learning Sign Language?

…from my pre-school when my parents bring me here.

4. How much time do you spend reading for yourself at home?

…before I go to bed, after coming from the volley ball training.

It's good that you playing volley ball, but who helps you with your homework at home?

…nobody I do it myself.

What if you don't understand something in your homework?

…I take it to school the next day, but I try to finish at school while waiting for the bus because I know nobody understands sign language at home.

5. How many books are there in your home?

…bible and the newspapers.

6. How many digitals information devices are there in your home?

…Television, cell phones, and washing machine.

7. Do you agree with the following statements?

(a) Most occupations needs maths and Technology skills

…yes.

Why?

…because cell phone is making easy to communicate. Cars are taking us to schools quickly and fixing that if it is broken force us to have knowledge of Technology.

(b) Technology is necessary to design things that are safe and useful.

…yes.

Why do you say yes?

…with my cell phone, I am able to chat with my friends I found from volleyball who do not understand Sign Language.

8. How do you feel about Mechanical Systems in Grade 9 and why?

…I feel good because our project is *finished and working. When we are doing practical's I understand better but when the teacher is explaining without practical it is difficult.*

9. When did you start feeling this way?

…when we were designing our project it was easy because in our practical lessons we are made to understand how gears are working, how pulleys are working, how hydraulics are working.

10. Is Technology taught differently in Grade 9 compared to other grades?

…yes. We have good practicals in other grades the teachers are using sign language only and I don't understand how these things we are learning work.

11. How do you study for Technology?

…I use my book and notes given by the teacher in class.

12. Comment on activities given to you in class and/ homework.

…I don't enjoy exercises from the book but I like practical's we are doing in class and I don't like doing homework at home because nobody is helping me if I get a problem.

13. Do you prefer to work on your own or as a group?

    …it is good to work as a group because we are able to help each other if I don't understand.

14. What changes would you like to see in the classroom to enhance your understanding in Technology?

    …the teacher must start with the practical because you see the movement of the project. When we are learning and there is no sign for the word it is difficult to understand it even if they sign it alphabetically. If I see movements in practicals I get a chance to talk to my classmates about the movement and come up with our understanding.

15. How did you feel about Technology before project or practical lesson was introduced?

    ...it was not good to understand.

16. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?

    …English. I am taught sign language by teachers who speak English from pre-school.

Sphesihle

1. Did you attend a pre-school?

…yes.

Where was your pre-school?

…it was a primary next to my home.

Was it a deaf primary school?

…no

2. How did your family discover that you have to come to the Deaf School?

…I was not understanding the ways they were using to learn. I used to see children's playing and the teacher talking but I was not hearing what they were saying. Later on the clinic next to my home gave my mother a letter and they bring me to this school.

3. When did you start learning Sign Language?

…when I begin my learning year.

4. How much time do you spend reading for yourself at home?

…I read when I have homework.

5. Who is assisting you in doing homework? Why?

…I do it myself. Nobody at home understands sign language like us at school.

When you are done with your homework how do you spend the rest of the day?

…I chat with my friends on the cell phone.

Why do you prefer to chat with your friends?

…in my home they stop me from doing most of the things because when they get damaged it difficult for me to explain and they do not understand

6. How many digital information devices are there in your home?

…television and cell phones.

How much time do you spend watching TV?

…when there is no one in the home.

7. Do you agree with the following statements?

(a) Most occupations needs maths and Technology skills

…yes.

(b) Technology is necessary to design things that are safe and useful.

…yes

Can you elaborate on your answer?

…because it easier to communicate with the cell phone. You don't hear any sound, you only see what you are talking about and it's easy to understand what other people are saying.

8. How do you feel about mechanical systems in Grade 9? And why?

…I enjoy mechanical systems because there is practical and you see all movements that the teacher is talking about and calculation is understandable and not too much drawing is wanted.

9. When did you start feeling this way?

…when I was getting a opportunity to do practical with my classmates. When we were starting I was afraid to touch anything because I think what will happen if it break.

10. Is Technology taught differently in Grade 9 compared to other grades?

…yes.

Can you explain the difference?

…there is a lot of practical when we are doing a project we work in the workshop.

11. Comment on activities given to you in class and/ homework.

…activities are good because we do them after the teacher has show us the operation. We understand better when we go to the book and Technology give us a chance to work together.

12. Do you prefer to work on your own or as a group?

…I like a group because we share ideas and boys are active in practical we can follow them with other girls to see how they completed their practical's.

13. What changes would you like to see in the classroom to enhance your understanding in Technology?

…we must do practicals, we must look at videos, we must work as a group.

14. How did you feel about Technology before project or practical lesson was introduced?

…it is difficult because I did not understand most of words signed by the signing teacher.

15. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?

…English. Because we are chatting in English. I don't understand the language they are using at home and I don't feel to be a member in my family. I don't hear them when they speak, they don't understand me clear when I sign.

Sphelele

1. Did you attend a pre-school?

…yes.

Where was your pre-school?

…it was next to my home

2. How did your family discover that you have to come to the Deaf School?

…when I was failing to do what other children are doing and when I was not understanding instructions at home

3. When did you start learning Sign Language?

…when I was doing Grade 2 here at school.

Why did you learn Sign Language at Grade 2?

…it was hard for me to pass Grade 1 and Grade 2. In my near school I spent 3 and half years then I came to this school because at home they say I was not hearing and I was not able to understand a person when I don't look at the mouth moving.

4. How much time do you spend reading for yourself at home?

…I don't read at home if I don't have homework.

Who is helping you in doing homework at home?

…nobody because our communication is a problem. Now I don't hear what they are saying and they don't understand what I am asking with my Sign Language

5. How many digital information devices are there in your home?

…TV and cell phones.

Do you have a personal cell phone?

…yes.

How are you using it?

…I sms my friends or my family if there is something I need quickly.

6. Do you agree with the following statements?

(a) Most occupations needs maths and Technology skills

…yes

(b)Technology is necessary to design things that are useful.

…yes.

How?

…cell phone is helping me to say my feelings to anybody. School bus is collecting me from home.

How do you feel about Technology in Grade 9?

…is nice.

Why?

…because we make a project, we get time to stay with our during break doing our project. When we have problems with our projects we talk with classmates and we help each other

7. When did you start feeling this way?

…last year and this year.

8. Is Technology taught differently in Grade 9 compared to other grades?

…*yes.*

How?

…*we learn and do small project and understand what we are learning and the teacher is with us when we are trying our project.*

9. Comment on activities given to you in class and/ homework.

…*I enjoy doing a project in the class. It is difficult when we go home because we write. Nobody is helping me at home, if im in the class the teacher is always helping us.*

10. Do you prefer to work on your own or as a group?

…*I like group.*

11. What changes would you like to see in the classroom to enhance your understanding in Mechanical Systems?

…*to start by doing practical and to learn and to write notes.*

12. How did you feel about Technology before project or practical lesson was introduced?

…*it is difficult because the teacher tell us something new and the words are not having signs, the teacher is signing alphabets.*

13. Which language of communication would you prefer as a medium of instruction, English or vernacular language? Why?

…*English because a person who teach me Sign Language was speaking English and when we sms my friends it is easy with English and can't write IsiZulu*

APPENDIX K: Editor's Certificate

Leverne Gething, t/a WHIZZ@WORDS
PO Box 1155, Milnerton 7435; tel. 021 552 1515; cell 072 212 5417
e-mail: leverne@eject.co.za

10 August 2017

Declaration of Editing of a thesis submitted in fulfilment of the requirement for the degree of Doctor of Philosophy in Education in the School of Education, University of KwaZulu-Natal:

LEARNING OF MECHANICAL SYSTEMS IN GRADE 9 TECHNOLOGY CLASSROOM BY DEAF LEARNERS IN KWAZULU-NATAL: AN EXPLORATION OF A LEARNING OF TECHNOLOGY IN A NON-HEARING ENVIRONMENT

I hereby declare that I carried out language editing of the above dissertation on behalf of

Bhekisisa Maxwell Thabethe

I am a professional writer and editor with many years of experience (e.g. 5 years on *SA Medical Journal*, 10 years heading the corporate communication division at the SA Medical Research Council), who specialises in Science and Technology editing - but am adept at editing in many different subject areas. I have previously edited much work for various faculties at UKZN, including the School of Education. I am a full member of the South African Freelancers' Association as well as of the Professional Editors' Association.

Yours sincerely

LEVERNE GETHING leverne@eject.co.za
M.Phil. (Science & Technology Journalism), Cum Laude

APPENDIX L: TURNITIN CERTIFICATE

Learning of Mechanical Systems

by Bhekisisa Thabethe

Submission date: 27-Feb-2018 08:50PM (UTC+0200)
Submission ID: 922403162
File name: Learning_of_Mechanical_Systems.txt (360.09K)
Word count: 55445
Character count: 307639

Learning of Mechanical Systems

ORIGINALITY REPORT

5%	4%	2%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS