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Science Education for deaf learners

Educator Perspectives and Perceptions

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RESEARCH REPORT

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ABSTRACT

Traditionally, the curriculum for deaf learners mainly involved language acquisition. The emphasis on academic subjects, such as science was marginal. In South Africa, the National Curriculum Statements (NCS) was introduced to redress the inequalities of the past education system. This research report is an investigation of science education for deaf learners. The study involved, firstly, exploring the experiences of educators that teach science to deaf learners and secondly, the identification of possible barriers that deaf learners experience in acquiring scientific knowledge, values and skills.

Methodologically, this research project is located in the qualitative paradigm. The research participants comprised of five educators that teach science to deaf learners. The research sites were schools that cater for deaf learners, and are located in a province of South Africa. To gather data from the participants, the qualitative tools of interviews, field observations and artifact collection were utilized. Findings from the research indicate that there are intrinsic factors, such as literacy, sign language, cognition and motivation, and extrinsic factors, such as policy implementation, instructional strategies and resources that create barriers for deaf learners in science education.

The participants' suggestions that have emerged are also mentioned. Data obtained from the research provides valuable insight for deaf learners, educators that teach science to deaf learners and educational policy makers. The research report concludes with recommendations that could have implications for further research in the context of science education for deaf learners in South Africa.

KEY WORDS:

deaf learners
language acquisition
science education
qualitative research
culture
sign language
curriculum
multicultural

DEDICATION

This work is dedicated to the memory of my mother, Sarie Govinden, whose encouragement, love, patience and reverence for education continues to inspire and motivate me.

ACKNOWLEDGEMENTS

My supervisor, Doctor Claudine Storbeck. There are no words to express my gratitude for your support, invaluable guidance and commitment. It has been a pleasure working with you!

My father, Logan Govinden. Thank you dad, for your love, understanding and helping me realize that the beauty in all things lies in my ability to appreciate them.

My husband, Shane Naidoo. You are much appreciated for being tolerant, supportive and for all the times that you were my "unofficial research assistant".

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The participants of my research and the schools that allowed me access. Your time and input has been greatly appreciated.

Finally, a special thank you to the Whitmore Council of Education for their financial assistance.

DISCLAIMER

I, Sagree Sandra Naidoo declare that this research report:
Science Education for deaf learners: Educator perspectives and perceptions,
is my own work and that all sources that I have used or quoted have been indicated and acknowledged by complete references.

This research report has not been submitted for a degree at any other university.

……

SAGREE SANDRA NAIDOO

ACRONYMS

ASL:	American Sign Language
DEAFSA:	Deaf Federation of South Africa
FET:	Further Education and Training
GET:	General Education and Training
IPC:	Instructional and Practical Communication
LOLT:	Language of learning and teaching
MLE:	Mediated Learning Experiences
NCS:	National Curriculum Statements
NS:	Natural Science
OBE:	Outcomes Based Education
RNCS:	Revised National Curriculum Statements
SSL:	Swedish Sign Language
SASL:	South African Sign Language

DEFINITIONS

Culture

Culture is learned through language. It consists of a large, unpublished code that addresses how one should behave in any given situation. It provides us with a storehouse of ways of believing and behaving, Sheetz (2004: 7)

deaf

Audiologists use the term 'deaf' to identify individuals who have varying degrees of hearing loss. Educators also use this term to label those whose hearing loss necessitates the provision of special services, Sheetz (2004: 17)

Deaf

The term 'Deaf' with a capital 'D' has been used to identify those who have some degree of hearing loss, who identify with and behave like other 'Deaf' people, and who share the same cultural values of the Deaf ethnic group, Sheetz (2004: 18)

Deaf community

Deaf communities are located throughout the world and each is uniquely affected by its location. Within the community members share common goals and work towards achieving them. A Deaf community may include persons who are not themselves Deaf, but who actively support the goals of the community, Sheetz (2004: 19); Storbeck and Magongwa (2006: 116)

Deaf culture

Each of us has several cultural identities. Our beliefs and values, from our family, influence the manner in which we respond to our surrounding. Deaf individuals bring these beliefs and values with them. These ideas are then shared and modified to represent the culture of the Deaf community. Within this culture, there is folklore, history, song, poetry and art, Sheetz (2004: 19)

Science

What is known as 'Science' has its root in African, Arabic, Asian and European cultures. It has been shaped by the search to understand the natural world through observation, codifying and testing ideas, and has evolved to become part of the cultural heritage of all nations. It is usually 'characterized by the possibility of making precise statements which are susceptible of some sort of check or proof' (McGraw-Hill Concise encyclopaedia of Science and Technology, 2nd Edition, p. 1647), as cited in Department of Education (2002: 4)

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Chapter One
Introduction

1.1 STATEMENT OF PURPOSE

The purpose of this study is to investigate the perspectives and perceptions of educators regarding science education for deaf[1] learners.

1.2 CONTEXT

We live and work in a highly technological society that is continually advancing. In this day and age of energy problems, depleting natural resources and the need to make sound personal choices based on scientific knowledge and concepts, there is a need for greater emphasis in science literacy among all individuals. This issue becomes even more urgent for deaf individuals, as research studies (McIntosh, Sulzen, Reeder, & Kidd 1994, Molander, Pedersen, & Norell 2001 and Moores & Martin 2006) indicate that traditionally the subject of science has been greatly neglected in the curriculum for deaf learners.

The curriculum change in post apartheid South Africa was introduced to improve the quality of lives of all citizens by promoting literacy, creativity, critical thinking and values of social justice and equity. It also emphasized a change from the traditional approach to an outcomes based education. According to the Department of Education RNCS document (2005: 120), the Natural Science Learning Area deals with the promotion of scientific literacy by, firstly, the development and use of science process skills in a variety of settings, secondly, the development and application of scientific knowledge and understanding and thirdly, appreciation of relationships and responsibilities between science, society and the environment. Although the new curriculum aims at equal access to education for all learners, there are various factors that influence deaf learners' access to the science curriculum.

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[1] In this study the word deaf refers to various degrees of hearing loss

Education White Paper 6 (2001: 19), which was developed to provide guidelines for Special Needs Education, states that barriers to learning may arise from different aspects of the curriculum, such as:

- The content
- The language or medium of instruction
- How the classroom is organized and managed
- The methods and processes used in teaching
- The pace of teaching and time available to complete the curriculum
- The learning materials and equipment that is used
- How learning is assessed

It is of relevance to note that all of the aspects listed above impact on deaf learners' acquisition of scientific knowledge, values and skills.

1.3 RATIONALE

I have been a Natural Science teacher in a school for the Deaf[2] for the past nine years. I have noticed that deaf learners exhibit great difficulty in acquiring scientific knowledge, skills and values. Furthermore, based on observations, few deaf learners choose science as an option in the Further Education and Training Band[3] at most schools for the Deaf. This would imply that there is limited number of deaf people in the field of science in relation to the deaf population. I would like to explore the possible reasons for deaf learners experiencing difficulty in science education as well as why they are not choosing science as a subject in the Further Education and Training Band.

---

[2] 'Deaf' with a capital 'D' has been used to identify those who have some degree of hearing loss, who identify with other 'Deaf' people and share the same cultural values of the Deaf ethnic group.

[3]The Further Education and Training band refers to grades 10, 11 and 12 in the NCS, the current curriculum in South Africa.

During my teaching experience, I have observed that there has been a lack of sensitivity to multicultural influences in the science classrooms of deaf learners. Differences in cultural beliefs and perspectives in science have often been overlooked. Issues related to sign language and Deaf Culture are not being adequately addressed in these classrooms. I decided to investigate the experiences of educators who teach science to deaf learners, in order to understand the learning opportunities available for deaf learners to become scientifically literate.

1.4 CRITICAL QUESTIONS

1. What are the experiences of educators who teach science to deaf learners?

2. What are the experiences of deaf learners in acquiring scientific knowledge, values and skills, as perceived by their educators?

1.5 RESEARCH OUTLINE

This research report has five chapters.

Chapter One

This chapter provides an introduction to the research report. It includes the statement of purpose, context, rationale and critical questions.

Chapter Two

In this chapter I present a review of literature regarding the educators' perspectives and perceptions of science education for deaf learners. I begin with the historical background and discuss the role of culture in deaf education. A brief overview of the general curriculum for deaf learners is described and how change in attitudes and perspectives through time led to the introduction of science in the curriculum for deaf learners. Concluding this chapter, the implementation of the NCS for deaf learners is explored.

Chapter Three

I explain the qualitative nature of the research design, research methods and analysis in this chapter. I provide an overview as to why this methodology was most suitable for my research. The processes involved in obtaining permission to gather data, at the research sites, and consent from the participants to be interviewed are described. Issues pertaining to ethical considerations are also presented.

Chapter Four

The findings that emerged from the data collection and analysis are presented in this chapter. The research data is introduced according to the themes that emerged and are broadly categorized as intrinsic related issues or extrinsic related issues. The chapter ends with the suggestions made by the participants.

Chapter Five

This chapter concludes the research report by drawing on significant information presented in the preceding chapters to provide a summary of the research findings and the final recommendations are made.

Chapter Two
Literature Review

2.1 INTRODUCTION

We have come a long way since the publication of Stalin's work *Marxism and Questions of linguistics* in 1950, which asserted that deaf people were without a language and therefore abnormal (Zaitseva, Pursglove, & Gregory, 1999:10). Attitudes have changed substantially and society has become more tolerant of different cultural, religious and linguistic communities. However, the acknowledgement of culture and language of deaf people has led to an over-emphasis on language in deaf education. Until recently, the curriculum for deaf learners prioritized language acquisition at the expense of academic subjects (McIntosh et al., 1994). Deaf learners in most countries, South Africa included, now have access to the 'mainstream' curriculum.

Marschark, Covertino and LaRock (2006:189), however, state that equal educational opportunities may not be the same as offering equity in education. Educational structures sometimes focus more on political views and administrative expediency rather than on documented educational value. As the identities of deaf learners become more pluralistic in South Africa, the role of educators in ensuring academic standards is becoming more demanding.

In this chapter, I provide an overview of the curriculum for deaf learners by discussing the influence of culture on education. Educators are increasingly faced with the challenge of creating a multicultural environment, in which all of their learners can be accommodated. Most deaf learners experience barriers with regards to literacy, DEAFSA (2006), therefore achieving scientific literacy becomes an even greater challenge. This situation is exacerbated when educators have to interact with deaf learners, who bring with them their own 'deaf culture', which can cause more difficulties if it is not understood by the educator. I will explore issues related to the science curriculum and how these influence the learning of science by deaf learners.

2.2 THE ROLE OF CULTURE

The role of culture in education will be explained by discussing six factors. These are defining culture, Deaf Culture, culturally responsive educators and instructional strategies, the culture of science, cultural border crossing and multicultural science education.

2.2.1 Defining Culture

It is culture that provides the tools for organizing and understanding our worlds in communicable ways, Bruner (1999: 149). Bruner maintains that individuals 'make meaning' of things and experiences based on situating encounters in their appropriate cultural contexts. Thompson (1990: 132) reiterates this, when he states, "*Culture is the pattern of meanings embodied in symbolic forms, including actions, utterances and meaningful objects of various kinds, by virtue of which individuals communicate with one another and share their experiences, conceptions and beliefs*". Culture, therefore plays an important role in teaching and learning. Broadly defined, culture is a system of meaning and significance. In addition to race and language, there are other significant factors that influence the construction of meaning and are thus part of cultural identity. These may include economic and educational levels, occupation, gender and religion (Cobern, 1993).

2.2.2 Deaf Culture

Deaf people all over the world view themselves as belonging to a linguistic minority with its own culture. DEAFSA (2007) states that Deaf culture has its own history, shared values, social norms, customs and technology which are transferred from one generation to the next. In their discussion of culture, Storbeck and Magongwa (2006: 120 - 121) comment that despite the primary identity evident within the Deaf community, it is becoming more evident that Deaf culture is affected by the plurality of an individual's culture. They discuss the need for deaf children who are born in countries where there is acknowledgement of multiplicity of languages and cultures to be able to learn about deafness, Deaf culture, as well as the language and culture of the general hearing

community. This plurality of identity is presented in Figure 1, acknowledging that deaf people are more than merely their ears and language.

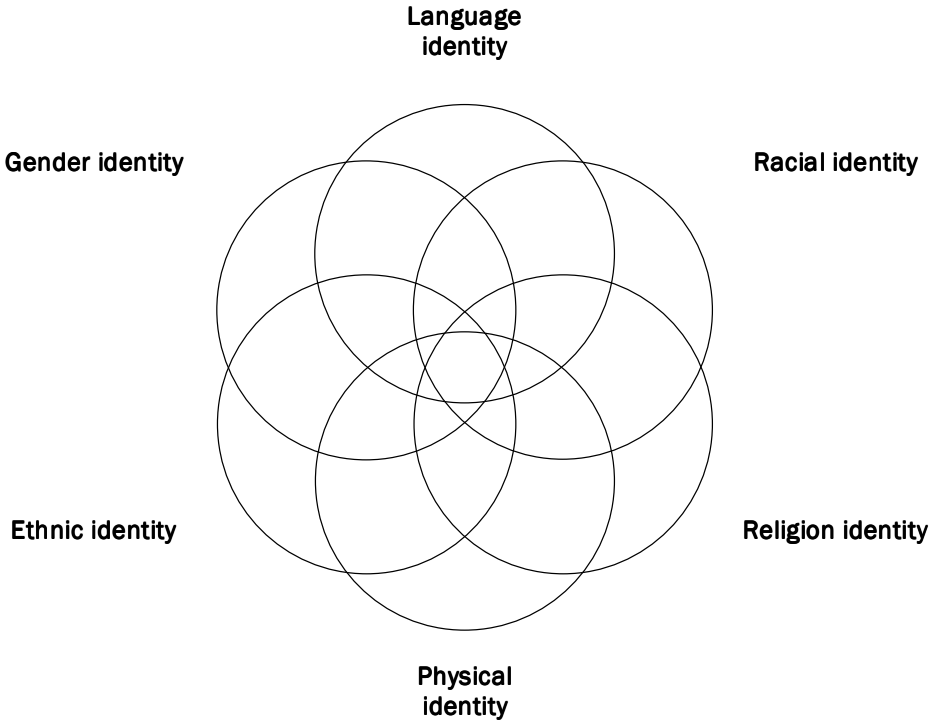


Figure 1: Plurality of the Deaf identity (Source: Storbeck & Magongwa, 2006: 120)

Storbeck and Magongwa (2006: 121), state that intercultural difference can lead to misunderstanding. They use the example, contextualized in South Africa, that if a child from the Black community initiates eye contact, it may be seen as a sign of disrespect; however, according to DEAFSA (2007), it is important to establish eye contact before beginning communication with a deaf person. According to Ogunniyi (1997: 88), in traditional cultures, Black children are to be seen and not heard. Student initiated talks and questions are regarded as gross misconduct and disrespect. Educators need to be

aware of these cultural characteristics, so that they plan and implement appropriate instructional strategies and ensure that deaf learners are educated.

2.2.3 'Culturally responsive' educators and instructional strategies

According to McIntosh et al. (1994: 481), instructional strategies are a key aspect of the role of the teacher. The teacher's interpretation of his or her role, what is taught, how it is taught, use of resources, attitudes and belief's determines how the learners feel about themselves and what they are learning. Certain cultural values and practices may predispose students to accept teachers' authority unquestioningly. Learners may be reluctant to raise questions or challenge knowledge claims as this may be seen as a sign of disrespect (Lee, 2002: 67). It becomes necessary for educators to consider factors such as attitudes and values, as they influence the investigation, construction and application of scientific concepts in science education for deaf learners. In addition to knowing about Deaf culture and how to sign fluently, teachers of deaf learners must be familiar with the values, beliefs, prejudices and stereotypes related to deaf learners (Andrews, 2004: 130). This will empower educators to adequately plan for the needs of their learners.

Fox and Gay (1995: 69), state that "*the extent to which teachers know, appreciate and are able to 'bridge' these cultural differences in the classroom instruction*" will directly affect educational opportunities and outcomes for students from marginal groups. They are of the opinion that effective teaching for diverse learners involves culturally responsive teaching. Gay (2002: 106) defines culturally responsive teaching as, "*using the cultural characteristics, experiences, and perspectives of ethnically diverse students as conduits for teaching more effectively*". Educators need to use appropriate pedagogical actions, such as *cultural scaffolding*. This involves using students own culture and experiences to expand their intellectual horizons and academic achievement (Gay, 2002: 109).

Educators can also encourage learners to help (scaffold) each other, according to their abilities. Bruner (1999: 162) states, when learners 'scaffold' for each other, they become

self reliant and learn to work with each other. This can contribute to the learners developing stronger sense of self esteem. Similar to culturally responsive teaching, is the notion of "instructional congruence" perpetuated by Lee (2002: 66), which is described as the process of merging academic disciplines with students' linguistic and cultural experiences to make the academic content accessible, meaningful and relevant for all students. Teachers need to engage in culturally appropriate communication, cultural artifacts, examples and analogies (Lee, 2002: 68). In this way science education may be seen from a socio cultural perspective.

2.2.4 The 'culture' of science

According to Lemke (2000: 296), a socio cultural perspective on science education means viewing science/ science education as human social activities conducted within institutional cultural frameworks (these may include family, school and community centres). In support of this perspective, Aikenhead (1996: 8) suggests that it is possible to regard learning science as a cultural acquisition. To acquire the culture of science, students must travel from their everyday life world to the world of science found in their classrooms. Students must cross the border to learn science. The learner has to understand and accept the subculture of science and the "norms, values, beliefs, expectations and conventional actions of a group".

Grossman and Stodolsky (1995: 237) state that teachers work in subject-specific contexts and hold a number of subject-specific beliefs related to teaching and learning. With some subjects, such as English they may feel that they have more autonomy than subjects such as science and mathematics. Subject subcultures may be characterized by both beliefs about subject matter and by norms regarding the teaching practice and curricular autonomy. For example, science is generally perceived as a high status subject and that only 'serious students' are capable of science.

2.2.5 Cultural 'border crossing'

Aikenhead and Jegede (1998: 10) discuss the metaphor "teacher as a cultural broker". A science educator who is a culture broker will guide pupils between their life-world

culture and the culture of science and help them resolve any conflicts. A culture broker identifies the culture in which students' personal ideas are contextualized and then introduces another cultural point of view in the context of the students' knowledge (Aikenhead, 2001: 5). Crossing the cultural border involves more than mere translation. An educator who assumes a culture broker role must be sensitive to the culturally-embedded meanings of words. There is a need to take cognizance not only of learners' ways of knowing and communicating in science, but also how they come to know what they know. Aikenhead and Jegede (1998: 3) discuss three issues related to successful science education:

- The degree of cultural difference that students perceive between their life-world and their science classrooms.
- How effectively students move between their life-world culture and the culture of science.
- The assistance students receive in making these transitions easier.

Learners' knowledge and world views are products of history and socio-cultural influences, as well as individual construction, Aikenhead and Jegede (1998: 3). Success in science depends largely on how pupils can move between their life-world culture and culture of science, therefore it is important to understand how these border crossings take place so that effective and appropriate plans can be developed. Lee (2002: 67) states, academic disciplines such as science have ways of producing and evaluating knowledge that have been defined by western tradition, however when cultural and linguistic experiences are used as intellectual resources, students with limited science experience and those from diverse languages and cultures are capable of becoming science literate.

According to Gay, (2002: 112), cultural characteristics provide the criteria for determining how instructional strategies should be modified for diverse students and that teachers should learn how to multiculturalize formal and informal aspects of the education process. Differences in culture can create barriers to the learning of science for deaf learners. These barriers may include issues, such as instructional strategies, language, values, beliefs and attitudes that arise due to the learner belonging to a different

culture. In addition to a deaf learner belonging to the deaf community, he or she may also belong to a racial or religious community that perpetuates specific norms, values and behaviour. It becomes imperative for science educators of deaf learners in 'multicultural' South Africa to consider these cultural differences so that they can be sensitive and accommodating to the needs of these learners.

2.2.6 Multicultural science education

One of the purposes of science education is for students to become scientifically literate and this involves using attitudes and knowledge about science to live as an informed citizen in a technologically advanced nation, Gega (1991: 13). This is reiterated by McIntosh et al. (1994: 480), who state that scientific literacy has become a necessity for everyone as the need to use scientific information, to make choices that arise everyday, increases. In the workplace, more jobs require people to be able to reason, think creatively, make decisions, solve problems and use science and technology effectively. Ogunniyi (1997: 84) states that "*although science education is concerned with issues in science, its primary role is essentially socio-cultural, namely the articulation of science in such a way that even a novice in any society can make sense of science*".

Research in science education indicates that (Atwater, 1996; Aikenhead & Jegede, 1998; Rodriguez, 1998; Barton, 2000; Lemke, 2000) 'hearing' children from diverse cultural and linguistic groups experience difficulty acquiring scientific concepts and find science irrelevant and uninteresting. The question, thus arises, do deaf children find science even more irrelevant and uninteresting? Multicultural education seeks to provide learners with opportunities for empowerment. Rodriguez (1998: 591), states that this notion is particularly important in science education because through multicultural education the empowerment of individuals traditionally underrepresented and underserved in the sciences can be facilitated.

Atwater (1996: 821) defines multicultural science education as "*a field of inquiry with constructs, methodologies, and processes aimed at providing equitable opportunities for **all** students to learn **quality** science*". Multicultural teaching implores teachers to use

examples and content from a variety of cultures to make science more relevant and interesting. In this way, teachers plan for meeting the interests, knowledge and skills of individual learners and build on their questions and ideas. Fox and Gay, (1995: 68) state that multicultural education is a condition for achieving equity of learning opportunities and excellence of achievement for all students and is a 'basic' of democratic citizenship and social justice for a pluralistic society. Deaf learners can have access to resources and equipment that they did not have in the past. These may include availability of interpreters, computers and graphic organizers.

Ogunniyi (1997: 89) states that children from cultural groups who do not emphasize linear and verbal/ analytical forms of instruction are bound to under perform in the verbally dominant classrooms of South Africa. He comments that there should be more emphasis on developing more visually/ holistic oriented instruction and to provide props for learning – especially for second or third language users. Ogunniyi (1997: 89) suggests language development at all levels to improve science instructions. These may include vocabulary through syntax, and the possibility of using mother tongue or sign language as medium of instruction. Multicultural science education provides a framework for improving science education for the deaf in South Africa. If educators plan learning activities based on consideration of factors, such as deaf culture, instructional strategies, learners' prior knowledge, experiences and background, science education would become more accessible to deaf learners as they would have more equitable opportunities at acquiring scientific skills, knowledge and attitudes.

2.3 EDUCATION FOR DEAF LEARNERS

Over the years, people have had divergent views on what and how deaf children should be educated. In this section, education for deaf learners is discussed with regards to: (1) an overview of the curriculum, (2) the issue of literacy, (3) language and communication, (4) prior experiences and knowledge, (5) cognitive engagement and (6) motivation and expectation.

2.3.1 An overview of the curriculum

Moores (2006: 41) states that for a long period of time educators of the deaf laboured under some seriously flawed assumption. There was great emphasis on developing oral language skills of deaf children, based on the underlying belief that speech and language were equivalent. The goal of deaf education was that of "normalization" which could be achieved by training deaf children to speak like hearing children. The field of education of deaf children has undergone major changes, which have had significant implications for curriculum and instruction. According to Moores and Martin, (2006: 3), traditionally, educators of deaf students have struggled with three important questions:

a) *Where deaf children should be taught?*
b) *How should they be taught?*
c) *What should they be taught?*

In the past, the curriculum for deaf learners' education emphasized English, Mathematics and Moral development Moores and Martin (2006: 4). Most of the activities for deaf learners related to English, which included speech, speech reading and English structure. Content areas, such as Mathematics, Social Studies and Science received minimal attention. Deaf learners' success was based on the fluency of their communication in English. This issue is reiterated by Molander et al., (2001: 201). They state that a survey of literature regarding deaf education shows that research on deaf children's learning focuses mainly on language acquisition.

By the start of the 21st century, equity and academic achievement became the goals for deaf education (Moores & Martin: 2006). This resulted in the recognition of the challenges that deaf learners experience with regards to learning content based subjects, such as Science. One of the major challenges that deaf learners face is difficulty with literacy.

2.3.2 The issue of literacy

Regarding literacy, Andrews, Leigh and Weiner (2004: 90 - 91) state,

> Literacy is often thought of as being only a decoding and graphic, perceptual motor activity. But it is more than that. Reading enables very young children to think, develop ideas, communicate and reflect about written language. All of this happens slowly, predictably and naturally if the right conditions are set up and if adults are able to explain to children what print means, in either sign or spoken language.

It is well documented that deaf learners generally experience great difficulty with literacy (Lang & Albertini 2001, Muthukrishna 2001, Sheetz 2004 Andrews et al. 2004, DEAFSA 2006 and Moores & Martin 2006). Deaf learners' exhibit pronounced difficulties with knowledge of English vocabulary and syntax, which become apparent when these students read and write (Lang & Albertini 2001: 260). Moores (2006: 45), states, "*Deafness, per se, has no effect on the acquisition of literacy skills*". According to Moores (2006: 45), a deaf child has the same intellectual capacity as a hearing child, however deaf children are likely to experience difficulties as a result of the following factors:

- Children with hearing loss are not identified as early as possible.
- Deaf children and their families are not getting appropriate advice, training and support.
- Teachers are not developing better ways to instruct deaf learners.

In their discussion of literacy and content based subjects, Andrews et al. (2004: 100), state that very little research has been done on the ways deaf readers' use reading and writing in content subject areas, such as math, science and social studies. To become science literate, the reader must not only understand the concepts of science and the technical science vocabulary but also know how to use reading and writing in the science laboratory and classroom. Marschark et al. (2006: 180) state that, "the relatively poor literacy achievement of deaf children is often ascribed to early language delays".

2.3.2.1 Language

In her discussion of language acquisition, and having a similar viewpoint to that of Moores (2006), Schirmer (2001: 62) states, "*children who are deaf have the same*

cognitive ability to learn language as children with hearing". However, she argues that deaf children learn language from individuals (adults and other children) around them. If language is used consistently by individuals around deaf children, it becomes easier for them to learn language. On the other hand, if individuals around deaf children use language inconsistently around them, it becomes difficult for deaf children to learn language.

Andrews et al. (2004: 166), states "*successful language development in deaf children tends to be facilitated by effective mother/ child communication, enrolment in early intervention programs, and early use of sign language…*" Andrews et al. (2004: 91), discusses how early parent/ child conversations are essential to provide a scaffold or support for the child. These early conversations may include eating, reading, playing or book reading. Through this interaction children learn vocabulary, syntax and the social rules of language.

Moores (2006: 42) states "*human language is not a product of our tongues, teeth and lips; it is a product of our minds*". The distinction that he makes between language and literacy is that language is learned within a social context and literacy is taught. Language is central to the lives of all individuals because it is a means of communicating with others and for thinking and learning. As children enter school, they use language to access academic subjects and this is done through literacy. Sheetz (2004: 83) states that language originates in the home and is influenced by the cultural and ethnic background of the family unit. Deaf children born to hearing parents begin life in a linguistically altered environment. From the onset they are faced with the challenge of developing language through their visual domain, filling in the gaps when words are not understood. As they enter school they are faced with the challenge of developing a language base that is auditory in nature, while simultaneously mastering the information placed before them.

2.3.2.2 Reading

Moores (2006: 46) comments that a hearing child typically begins kindergarten with a mastery of phonology, morphology, syntax, vocabulary and has some home experiences

that provide a foundation for formal literacy instruction (reading and writing). The average 17 year-old deaf child, however, reads at approximately grade four level (Moores, 2006: 46). This poses great challenges for deaf learners as they strive towards access to an equitable curriculum. According to Moores and Martin (2006: 9), "*the emphasis on academic content increases the importance of reading and writing for all, especially deaf students*". Moores and Martin (2006), argue that the standardized tests that are being used are in reality tests of reading, as well as of Science, Math and Social Studies knowledge.

The reader brings prior knowledge and experiences that shape his or her expectations of the material (Schirmer, 2001: 71). As these expectations are confirmed, or not confirmed, the reader develops understanding. Every child's experiences are different, therefore their specific and general knowledge will differ. A child's comprehension will thus depend on their experiences and prior knowledge. Lee (2002: 68) suggests using home language to enhance comprehension and understanding and use culturally appropriate communication, analogies and examples.

According to studies cited by Scheetz (2004: 80), research indicates that several factors pose potential comprehension problems for deaf readers. These include vocabulary, multiple meaning words, indefinite pronouns, figurative language and inferences. In agreement with this view (Schirmer, 2001: 72) discusses the importance of vocabulary knowledge in reading comprehension and being able to distinguish between levels of vocabulary knowledge.

Schirmer (2001: 75) states, "*An important factor in reading ability is metacognition. Metacognition refers to thinking about thinking or reflecting on one's own cognitive processes*". She also discusses how metacognition, when applied to reading can enable the reader to know when and what they do not understand, and invoke strategies for obtaining the needed information. Research cited in Schirmer (2001: 75), states "*Deaf learners benefit from instruction on metacognitive strategie*s".

2.3.2.3 Writing

Writing is the most widely used response mode in academic settings. Through written communication deaf individuals can relate to those that can hear. According to Sheetz (2004: 82), "*numerous studies lead to the general conclusion that the average deaf 18-year-old writes on a level comparable to that of a hearing 8-year-old*". Research studies, Sheetz (2004: 82), that have examined the written language of deaf children highlight their lack of syntactic and semantic knowledge. In addition, findings indicate that deaf children tend to have smaller and more concrete vocabularies, frequently omit words and use fewer adverbs and conjunctions as compared to their hearing peers. Schirmer, (2001: 77) states,

> Educators typically consider deaf children to have more difficulty with writing than reading, however this criteria is based largely in assessment of their writing along one criterion only – correct usage of English sentence structures. When they are taught the qualities of good writing and their writing is analysed along more than one dimension, deaf students demonstrate abilities in areas such as making ideas clear, descriptions, etc.

According to Sheetz (2004: 83), research indicates that mediated learning experiences may help learners with writing difficulties. Educators can 'bridge' familiar language to decontextualized language by engaging learners in activities that will enhance their semantic and syntactic language development. This is reiterated by Lang and Albertini (2001: 260), who state that research on writing by deaf students has broadened to include informal, interactive analyses of content and rhetoric, which indicate that in expressive and creative contexts, deaf students write with clarity and force. However, Lang and Albertini (2001: 260) state that there is a need for additional research on writing to learn in specific areas such as science and mathematics.

2.3.3 'Language' and communication

There are different modes and philosophies that are used in the teaching and learning contexts of deaf learners. It is of significance to understand the different modes and

philosophies and how they impact on the education of deaf learners. According to DEAFSA (2007), language and communication for deaf learners are as follows:

The *oral approach*, which advocates speech and lip-reading as the means to communicate and educate the deaf child. The deaf child relies on technological devices, such as hearing aids and cochlear implants to 'hear' and speak.

Total communication, a philosophy where every possible means of communicating is used with deaf children. In educational settings, it usually means using signed and spoken languages at the same time. Although total communication improves the general communication skills, it does not lead to the full development of sign language skills or to the improvement of written or spoken skills. Children who are educated through total communication still experience serious problems with their language skills, especially with regards to reading, writing, understanding concepts and vocabulary.

The *bilingual-bicultural* approach, which is becoming the most appropriate teaching method for deaf children in most countries, including South Africa. In this approach, sign language and the spoken/ written languages are kept separate in use and in the curriculum. Sign language is respected as the first language for deaf people and is also used as a language of instruction. The emphasis here is on the deaf child learning his or her first language in a natural way. A good command of the first language is crucial to success with the second language because second language users use their first language as a point of reference in the acquisition of a second language.

According to Zaitseva et al.(1999:10/ 11), Vygotsky acknowledged that sign language was the natural means of communication among deaf people and that denying sign language would result in restricting deaf children's intellectual development. However, from the point of view of Vygotsky, sign language, unlike written/ spoken language was not a complete language with the full range of linguistic properties, therefore according to this its use could be of a restricted nature. Therefore (as far back as the 1930s'), he saw it essential that there should be an interaction between the first language of society (sign

language) and the dominant language of the society (written or spoken language), the result of which was bilingualism. Thus the two contemporary systems of teaching deaf children, total communication and bilingual teaching can be considered following in the steps of Vygotsky, (Zaitseva et al. 1999:12).

Research studies cited in Muthukrishna (2001: 159) state that, two principles in effective instruction for the deaf are as follows:

- Deaf learners will benefit from high levels of sign language, as through sign language, tasks and activities can be explained in a meaningful way.
- There needs to be an emphasis on the development of metalinguistic skills, such as the ability to think and talk about language, to recognize the characteristics and explore the structure of language.

Stewart (2006) advocates for the instructional and practical communication (IPC) to teaching deaf learners. This involves the presentation of a framework within which English and SL can be used. Stewart (2006: 207) states that "the consequence of this stance is that teachers will possess the skills to use both languages and the understanding of pedagogy to make sound judgments about when to use English in its print, speech and sign modalities". Stewart (2006: 215) states that deaf children who acquire SL as a first language still face the challenge of learning English, which is a key barrier to the ability to learn curricular content therefore his justification is that, "*despite two decades of use as the primary language of instruction in a number of deaf education programs, no research evidence shows that on average deaf children whose first language is ASL attains a level of English proficiency that is commensurate with their grade level*".

He also discusses a similar circumstance with children who are exposed to English-based signing. Stewart (2006: 216) states that in IPC approach, signing is determined by how teachers feel they can best achieve their lesson objectives. The advantage of IPC is that ASL gives deaf students a means for acquiring a first language and English-based signing provides a means for deaf students acquiring English literacy skills. By having this, the

teacher can devote more time and energy to accomplishing the actual instructional objectives.

2.3.4 Prior experiences and knowledge

McIntosh et al. (1994: 482) state that deaf children might be less likely to have experienced "normal, unstructured" play in which incidental learning occurs, therefore they arrive at school with disparate backgrounds and abilities. It is not easy for deaf children to acquire information through television and radio, unless they are exposed to captioned television programs and can comprehend the captions. Deaf children will learn a great deal about the world through reading, only if their language development and reading skills are up to par, Andrews et al. (2004: 169).

Hearing children, on the other hand, are exposed to science through media such as magazines and programmes on television. They also 'hear' scientific terminology (such as carnivore, velocity, force, etc.) and explanations which stimulates them to think, question and discuss. "Deaf children are generally excluded from this way of meeting science" Molander et al. (2001: 210). As a result pupils memorize theories, concepts and therefore perceive science as uninteresting and of little relevance to their lives.

2.3.5 Cognitive engagement of deaf learners

According to Vacca et al. (1991: 138), schemata are the "building blocks" of cognition. Cognitive psychologists use the term schemata to describe how humans organize and store information in their heads. Schemata also reflect the background, knowledge, experiences conceptual understandings, attitudes, values, skills and procedures of an individual. The schemata theory provides a basis for understanding how deaf learners make sense of new concepts and knowledge. Vacca et al. (1991: 139) state that for comprehension to happen, learners must activate or build a schema that fits with the new information. This occurs in three ways:

- the schema provides a framework that allows learners to 'organize' and 'integrate' new information
- schema allows learners to make inferences, which assist in skills like prediction

- schema helps learners engage in cognitive activity that involves speculation, judgment and evaluation

Research by schema theorists indicates that abstract concepts are best understood after a foundation of concrete, relevant information has been established. The general knowledge provides a framework into which the newly-formed structure can be fitted. The difficulty that deaf learners experience with new information may be attributed to a lack of or inadequate schemata.

Therefore, the importance of play in general and in the cognitive and social development of the deaf child cannot be overemphasized. Andrews et al. (2004: 166) state, "*The level of sophistication in symbolic play exhibited by deaf children may be a function of their level of language development, social behaviour characteristics and cognitive abilities*". The relationship between cognition and language is an interdependent one. Schirmer (2001: 104) states that "*Language acquisition occurs as a result of the child's innate cognitive abilities, cognitive strategies and conceptual knowledge*".

Schirmer (2001: 111) states that deaf individuals have stereotypically been characterized as concrete thinkers. Research cited by Schirmer (2001: 111) states that deaf children tend to rely on visual/ perceptual skills, whereas hearing children rely on abstract thinking skills. Although there is no evidence to indicate that deaf learners are unable to think abstractly, it appears that deaf children need to be guided in developing their thinking at levels beyond the concrete. Unfortunately, early studies, as stated by Marschark et al. (2006: 188) supported the view that deaf children were concrete and literal in their thinking (unlikely to master metacognitive kills), which led to teaching techniques that focused on narrower, more limited approaches to thinking and learning. This in turn resulted in the self-fulfilling prophecy as emphasis on literal language discourages diverse problem solving.

In their discussion of metacognition, Marschark et al. (2006: 188) explain that metacognition involves students having some awareness of their own cognitive processes, and include aspects such as problem solving and comprehension. Marschark

et al. (2006: 188) also state that "*although relatively few studies have examined metacognition of deaf children, what research is available suggests that deaf students are less likely than hearing students to consider alternative approaches to a task prior to undertaking it or while working through it*". Andrews et al. (2004: 83), argue that metacognition skills do not depend on hearing per se, but they do depend on students having many experiences and opportunities for incidental learning so they can formulate metacognitive strategies. Many deaf students who come from hearing families with limited communication skills in the home have not had these incidental and formal opportunities to develop metacognitive skills. One likely explanation for many deaf students' failure to apply metacognitive skills could be as a result of parents and teachers of deaf students often taking a more concrete and directive approach to problem solving with deaf children, to ease the 'communication' (Andrews et al., 2004: 83).

Another strategy, mediated learning experiences (MLE) is discussed by Andrews et al. (2004). According to Andrews et al. (2004: 84) Feuerstein's MLE has been implemented studies at schools for the deaf (in the United States) and research results indicate positive behaviours in the motivation to learn, and in academic performances of the students. According to Harcombe (2003: 51),

> Feuerstein's (1991) view of cognitive development is based on the notion that intelligence is modifiable. Feuerstein's work is based on the premise that if the interaction or mediation between adult and child is optimal, the child's cognition will be improved. Feuerstein has termed this interaction Mediated Learning Experience. Feuerstein maintains that if a child receives adequate MLE from fairly young, he or she is likely to develop cognitively up to the potential allowed by genes.

In their discussion of "educationally relevant cognitive characteristics of Deaf students, Marschark et al. (2006: 187) explain the empirical consideration of cognitive differences between deaf and hearing students in order to determine whether hearing loss per se is a causal factor in the differences. Marschark et al. (2006: 187) claim that, "*With regards to visual processing, for example, deaf signers perform better than either hearing or deaf*

individuals who use spoken language". They mention other research studies indicate that deaf and hearing signers are faster in generating and manipulating mental images than are non signing peers. It is also argued that the mode of communication (speech versus sign) may have some influence. Marschark et al. (2006: 187) support their argument by the fact that such advantages are not found among deaf individuals who rely on spoken language indicates that the results are more related to the effects of sign language rather than hearing loss.

Andrews et al. (2004: 81) state that, the study of deaf children and adults has provided scientists with the opportunity to study the effects of deafness on bilingualism, intelligence and thinking. Early research in deafness and cognition pointed to the negative viewpoint that bilinguals were intellectually inferior. However, there is no empirical research that states that bilingualism has a detrimental effect on cognition and it is now generally accepted that there are cognitive benefits to bilingualism, such as creative thinking, cognitive flexibility and metalinguistic awareness. Schirmer (2001: 106) claims that when children are not fluent in the language of instruction, understanding complex and abstract concepts increases the demand from their cognitive and linguistic abilities, which make it difficult or even impossible for the child to be an engaged learner. This issue will be elaborated on in the next topic.

2.3.6 Motivation and expectation

The role of the teacher determines what is taught, how it is taught and to an extent how deaf children in the classrooms feel about themselves. McIntosh et al. (1994: 481). Andrews et al. 2004: 130), discuss the importance of the expectation that teachers have of their students. They state that new teachers need to be aware of the danger of not stereotyping deaf students who have low reading levels and difficulty mastering English. In spite of those facts, they should believe that deaf students are capable of learning and expect more from them. When children are accepted for who they are and what they are praised for what they are capable of doing, their self esteem is enhanced. Lang (2006: 62), states another factor that strongly influences people's confidence is motivation. A person who is highly motivated to complete a task will be more likely to have a higher

level of confidence in the end result. Motivation can also affect the amount of observational learning a person experiences. McCombs (1984: 200) defines motivation as,

> A dynamic, internally mediated set of metacognitive and affective processes (including expectations, attitudes and beliefs about the self and the learning environment) which can influence a students tendency to approach, engage in, expend effort on, and persist at learning tasks on a continuity, self-directed basis.

Sometimes parents and family of deaf learners establish lowered expectation for them. Frequently deaf children are denied access to daily conversations and incidental learning experiences. In this way deaf children are not provided with the scaffolding required for their development, Sheetz (2004: 141). Vygotsky (1978: 86) describes the Zone of Proximal Development as:

> The distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

The implication here is that if adults want to assist learners to reach their "full potential", they need to provide learning opportunities. Another factor is that deaf children raised in hearing families may struggle with communication and experience difficulties academically. This may affect their self esteem. Sheetz (2004: 56) defines self esteem as the reflection of individuals self worth or self image. From early parent-child interactions, children begin to form their perceptions of who they are and if children do not receive the emotional support and social approval they need, their self image can remain low.

2.4 SCIENCE CURRICULUM FOR DEAF LEARNERS

The science curriculum for deaf learners will be discussed according to the following headings: (1) The introduction of science, (2) curriculum in South Africa, (3) language as a determinant of access to the science curriculum, (4) sign language and (5) the language of science.

2.4.1 The introduction of science

Historically, the priorities in education for deaf learners in the United States were mastery of grammar and on production and understanding of speech, Moores and Meadow-Orlans (1993). Learning programmes of deaf education emphasized these at the expense of content subjects such as science, mathematics and history. Science education for deaf learners was introduced around 1975. McIntosh et al. (1994: 483) explain that the teachers involved in science education at that time were teachers from mainstream schools who responded to the challenge of teaching science to students labeled "handicapped". For these teachers, there was little support or information on teaching science to deaf students.

Research conducted by Lang and Propp (1982: 861) almost a decade later revealed that few science teachers working with deaf learners had adequate pre-service or in-service training in science education. The teachers commented that they felt incompetent teaching science to deaf learners and would like in-service workshops every 4-5 years. More recent research, such as studies conducted, in Sweden, by Molander et al. (2001: 201) still indicate that children's learning focuses mainly on language acquisition. Very little of the literature concerns the teaching and learning of science in the educational environment of deaf learners.

According to studies by McIntosh et al. (1994: 480), in the United States, "*Deaf education is often concerned with the sign/ speech controversy, bilingual-bicultural education. Scientific literacy, while deemed important, may not be considered a priority in school programs for deaf students*". Concurring with this, research cited in Lang (2006: 57) states that in a five year period from 1996 to 2000, not one article in the American Annals for the Deaf related to science instruction. Other research mentioned, Mangrubang (2004), noted that elementary school teachers are responsible for introducing language arts, social studies, mathematics and science, and that of these four, science gets the least attention.

Although these studies are not contextualized in South Africa, the emphasis in education for deaf learners in South Africa seems to be similar to that indicated by McIntosh et al. (1994) and Lang (2006). I have been unsuccessful at locating any research specifically related to science education for deaf learners in South Africa.

2.4.2 Curriculum in South Africa

Curriculum 2005 was introduced by South Africa's democratic government to address the inequalities and injustices of the past. The curriculum is based on constructivist principles, such as start where the learner is at, teacher as a facilitator, active learning by children and design 'bridges' to assist learners. According to the Department of Education: RNCS, (2004: 4),

> The curriculum aims to develop the full potential of each learner as citizens of a democratic South Africa. It seeks to create a lifelong learner who is confident and independent, literate, numerate and multi-skilled, compassionate, with a respect for the environment and the ability to participate in society as a critical and active citizen.

In keeping with this aim, the post apartheid science curriculum recognizes that the people of South Africa operate with a variety of learning styles as well as with culturally-influenced perspectives. The curriculum also promotes meaningful education by introducing learner centred instruction and contextual environmental and global issues, which must provide a foundation on which learners can build throughout life, Department of Education: RNCS, (2004: 121). The learning area of the Natural Sciences features three learning outcomes, which address different competencies, skills and the four content areas. (Refer to appendix 7 for detailed content of the Natural Science curriculum)

As listed in the Department of Education: RNCS, (2004: 122), the Natural Sciences learning outcomes are as follows:

- **Learning Outcome 1: Scientific Investigations**

  The learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts.

- **Learning Outcome 2: Constructing Science Knowledge**

  The learner will be able to interpret and apply scientific, technological and environmental knowledge.

- **Learning Outcome 3: Science, Society and the Environment**

  The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.

Although apartheid policies have been removed from South Africa's education system, "invisible barriers" continue to exist for deaf learners. This will be explained with regards to the access of the science curriculum that deaf learners in South Africa have.

2.4.3 Language as a determinant of access to the Science curriculum

Hodson (1993: 690) states

> Language is a cultural artifact. The ways, in which we use it for remembering, reasoning, evaluating, communicating, and so on are socioculturally determined and have to be learned. In the context of multicultural science education, there are several aspects to the "language problem": diversity of mother tongue, the language of science (specialized terminology, use of everyday words in specific, restricted contexts, and style of written communication), the stylized language of the classroom interaction in general and the use of language based activities to bring about learning.

Most hearing parents in South Africa cannot communicate with their deaf children and this means that deaf children are getting no form of language input until they start school. By this stage it is often too late for the deaf child to acquire the natural language foundation (SASL) needed for acquisition of other languages, such as English, Afrikaans or IsiZulu, DEAFSA (2006: 14). In addition to this, another significant issue facing deaf educators in South Africa today is that of deaf children whose families belong to diverse

ethnic and use a language other than English or SASL as their primary mode of communication. Such language may include IsiZulu, Xhosa or Afrikaans. The implication of this to science education is that these deaf learners may be learning science in a third or fourth language.

Lee (1997: 221) states that "*the norms of science instructional practices have significant implications for students from diverse cultures and languages. These students bring with them their own ways of looking at the world that are representative of their cultural and language environments*". Learners' ways of knowing and thinking may be incompatible with the norms associated with science. When students' language and cultural experiences are in conflict with science practices, they may avoid learning science. In agreement with this, Hodson (1993: 690) adds that when learners with limited linguistic skills can become frustrated when faced with an early insistence of precise terminology (vocabulary is emphasized in textbooks) and formal writing style. This can lead to withdrawal or even alienation from science.

2.4.4 The learning Milieu of Science

Science is organized into fields, such as Biology, Chemistry and Physics because of the overwhelming amount of knowledge available to us. However, Lang (2006: 57) states that, in the field of science education for deaf learners, we have only recently begun to develop a body of knowledge. He comments that although observation and experimentation have been conducted, a basic theory of instruction has not been defined. Lang (2006: 60), states that studies of learning styles of deaf adolescents indicate that they rely on organization and structure in the instructional environment and may be classified as "dependent learners". Lang explains that dependent learners are those that look to authority figures for guidelines on what to do. They find it difficult to develop skills for autonomy and self direction.

Deaf students also arrive at school with disparate backgrounds and abilities. Therefore process oriented type of instruction, as opposed to content oriented instruction (which focuses on listening, reading and memorizing) is appropriate. As process oriented

teaching advocates student-centered learning, learners have control over their learning experiences and are encouraged to 'discover' things for themselves, Lang and Propp: 1982). In this way process oriented teaching allows for a more suitable fit between the child's frame of reference and academic expectations. This may also assist learners to overcome language difficulties.

Lang (2006: 58), states that many dedicated teachers are enthusiastic about teaching deaf students, but they lack effective guidance, training and resources based on educational research. McIntosh et al. (1994: 481) differentiate between "hands-on" and "minds-on" science activities. They state that teachers may confuse experimental competence with cognitive abilities. Some activities disguise the passive learning that takes place while learners' hands are busy. In comparison, "minds-on" involves active learning, on the other hand, involves students initiating experiments, activities and problem solving. The textbook continues to play a central role in classrooms and many of these books include "hands-on" experiments. Lang and Albertini (2001: 259) cite research that reiterates McIntosh et al. (1994) "*unless hands-on science is embedded in a structure of questioning, reflecting and re-questioning, probably very little will be learned*".

Lang (2006: 59), states that science teachers must take reading comprehension into consideration in all aspects of instruction, especially in the use of textbooks and multimedia. Lang (2006: 59), states that the lags of deaf students reading relative to hearing peers tend to increase throughout their school years and this influences deaf learners' access to science learning opportunities. Innovative teaching strategies that have become popular in science are using children's literature and the use of journals to encourage reflective thinking, McIntosh et al. (1994: 481). Children need opportunities o understand how to use and appreciate technology. Lang and Propp (1982: 863) state that "*A majority of hearing-impaired science students appear to be additionally handicapped by a restrictive learning environment. Although science can be taught effectively in the kitchen of any home, one may also hypothesize that there is a relationship between the quality of facilities and the quality of instruction*".

With regards to cognitive strategies and Science, Lang (2006: 59), discusses research results which indicate that minds-on instruction activities, where deaf learners are active, interactive, participative and engaged are associated with advanced academic achievement. He states that some factors that inhibit the cognitive engagement of deaf learners in science may include pace of the instructional activity, the number of speakers involved, language and cultural differences, use of space and communication methods.

Molander et al. (2001: 210) discuss the results of their research study that involved *Deaf pupils reasoning about scientific phenomena*. According to their findings, related to chemistry and physics, they state that when pupils are prompted to present scientific arguments, the pupils respond by saying "*I've learnt this but forgotten it*" or "*I'm not very good at this*". Molander et al. (2001) also observed that there was little evidence of pupils mixing scientific reasoning with life-world reasoning and they felt that the pupils regarded science as something entirely different from and in fact, irrelevant to their world. That science can as a 'culture and an institution' welcome and support some identities is clearly evident. Hodson (1993: 686) states that it seems that the science curriculum does little to raise the self esteem of children from some minority ethnic groups and is seen by many as irrelevant to their experiences, needs, interests and aspirations.

In South Africa, the introduction of OBE in the Science curriculum involved a shift form content focused to competence focused education. The NCS curriculum comprises of three learning outcomes, each with pre-determined assessment standards per grade (refer to appendix 7). Whilst the NCS curriculum has advantages, at present time, it also does not allow deaf learners to fully access it. The main reason is that due to deaf learners 'language barriers'(issues with sign language and literacy), they generally work at a slower pace than mainstream learners. The assessment standards of each outcome are based on content that is progressive. Many deaf learners do not achieve competency in all the assessment standards of a grade, but progress to the next grade. This results in the learners having an insufficient foundation, 'gaps' in their knowledge and an incomplete understanding of concepts.

The NCS does consider alternative assessment methods for deaf learners. According to the Department of Education (2004: 25), the following are considered for deaf learners:

- Sign language interpreter
- Video recording
- Additional time (up to 30 minutes per hour)

DEAFSA (2006: 25) is concerned about the general practice that individual schools for deaf learners are allowed to set so-called "internal papers" for examinations. This creates a situation where some learners are unfairly advantaged in that they are not assessed on the complete amount of work. In addition, obtaining a qualification on this basis does not constitute equality and equity. It may also create problems in employment situations as employers will have false expectations of deaf employees.

Currently, deaf learners in South Africa experience difficulty gaining acceptance into tertiary institutions. The first reason for this is that learners need to have two of the official languages to be accepted. One of which must be their home or first language and the other a first additional language. Deaf learners cannot meet this requirement as SASL, which is their home/ first language, is not recognized as an official language. The second reason is that deaf learners require SASL interpreters, which not all tertiary institutions budget for.

2.4.5 Sign Language

Zaitseva et al. (1999: 11) discuss Vygotsky's attitude toward sign language. As far back as the 1930's, Vygotsky asserted that sign language is a complex language with its own syntax, "*a very richly developed language*" fully capable of expressing different abstract concepts, including ideas, thoughts and facts of a socio political nature. According to Vygotsky, "*sign language is not only a means of interpersonal communication among deaf people, but also a means of inner thought in the child himself/ herself*", Zaitseva et al.(1999: 11). In support of this, Molander et al. (2001: 200) in their discussion of sign language in Sweden, state that "*sign language plays a key role in the special school. It enhances pupil's thinking and creativity…*" Molander et al. (2001: 200) also state that in

schools for the deaf instruction is aimed at promoting bilingualism, with sign language (SSL) as the pupil's first language and written Swedish as their second. As in South Africa, in Sweden the regular compulsory schools and schools for the deaf use the same curriculum in science.

The only language that can be the first language of deaf learners in South Africa, SASL, is not offered as an official school subject in the General Education and Training Band or in the Further Education and training Band, DEAFSA (2006: 11). As a result, deaf learners face disempowering educational experiences and this is evident by the low literacy levels of the majority of the Deaf people and the fact that very few deaf learners register at Higher Education Institutions. According to DEAFSA (2006: 12), a few schools in South Africa have attempted teaching SASL as a subject, however, the educators involved have received no formal training in SASL linguistics, literature or teaching methodology. This has resulted in learners receiving restricted instruction, and many learners end up doing vocational training instead of receiving academic training.

Deaf learners have little access to the regular curriculum because the majority of educators' are not proficient in SASL. A recent survey indicated that only 14% of educators in schools for the deaf can sign proficiently, DEAFSA (2006: 5). Many educators have indicated their need for support in SASL. According to DEAFSA (2006: 12), many attempts by DEAFSA to assist the Department of Education in formal training of educators in SASL were not successful.

Molander et al. (2001: 211) raise questions about the relationship between scientific vocabulary and SSL. They discuss an example from their research, where a learner uses the sign for seconds when he talks about atoms. The absence of uniform signs leads to confusion and can pose serious problems in the understanding of concepts that are stringently defined. This has resulted in divergent views regarding the "language" of instruction in the teaching of science to deaf learners. It is important to note that Moores (2006: 48) expresses his agreement with Stewart's (2006) position regarding Instructional and Practical Communication[1] for deaf students. Moores justifies his stance by the need

for deaf students to be proficient in English, as science, mathematics, literature, history and social studies texts are all in English. As a result, Moores (2006) feels that despite its limitation, English-based signing can be a bridge to English literacy, which in turn would make science more accessible to deaf learners.

2.4.6 The 'language' of science

Wellington and Osborne (2001: 1) are of the opinion that research over the past 30 years shows that one of the major difficulties in learning science is the language of science. Learners need to access the 'knowledge' and 'skills' in science through language. According to Muthukrishna (2001: 158), in many countries, a major concern in the education of the deaf is that the literacy levels of deaf learners are much lower than those of their hearing peers. As a result of deaf learners experiencing difficulty with literacy, science education, which is in many ways, like learning a new language (Ford & Peat, 1988; Lemke, 2000; Wellington & Osborne, 2001) becomes an even greater challenge.

Wellington and Osborne, (2001: 5) maintain that 'science is like learning a language' for the following reasons:

- Firstly, the concepts and terminology in science have a precise and exact meaning in everyday life. For example, conceptual words such as work, energy and power.
- Secondly, science education also involves introducing new words, sometimes in familiar contexts and other times in unfamiliar contexts.
- Thirdly, the language that science teachers use include words, such as modify, compare, evaluate, hypothesize, infer, etc. learners' come across these words mainly through the educators and examinations – but rarely at home or at social events.

Wellington and Osborne (2001: 5) also discuss the need for learners to be taught the technical and specialist vocabulary of subjects and how to use and spell these words. With regards to science, this may include language to express chronology, logic, exploration, hypothesis, comparison and how to ask questions. Learners need to learn the language of science so that they can read critically and actively develop an interest in

science. Lang (2006: 60), concurs with this idea, as he states, vocabulary practice should be introduced before deaf students begin the lesson. The language of science should not be 'watered down' excessively, however. Ideally a science teacher should provide progressively challenging language structures in all reading materials, so that both science literacy and English literacy are developed.

2.5 CONCLUSION

According to Pomeroy (1994), there are two major issues in science education identified by scientists and science educators. The first is the growing disparity between racial, ethnic and gender demographics of the population levels within the scientific establishment at all levels. The second is the failure to produce students who are scientifically literate. An individual's health and economics depend largely on the ability to make wisely reasoned choices, often grounded in an understanding of scientific principles. As the need for scientific literacy increases in South Africa, the failure to educate cannot help but exacerbate the already growing disparities between different socio-economic, cultural and "differently abled" segments of the population.

With South Africa participating in a globalized economy, there is great need for all citizens to be adequately educated and trained. Science educators have often overlooked cultural beliefs and perspectives. However, researchers, such as Atwater (1996); Aikenhead & Jegede (1998); Lemke, (2000) have emphasized the importance of recognizing how the life world of the learner influences their involvement and understanding of science. Deaf learners need to be guided to see the links between the science that is taught in class and their daily lives McIntosh et al. (1995). In this way they will be encouraged to be critical and innovative thinkers and contribute to the world of science. As Lang and Propp (1982: 484) state, "*Overall, the future of science education for deaf learners should look very similar to the future of every other student*".

Chapter Three
Methodology and Analysis

3.1 INTRODUCTION

This chapter deals with the methodological issues involved in my exploration of educators' perspectives and perceptions of science education for deaf learners. I present a discussion of qualitative research and the case study methodology that I used in conducting and gathering my research. My sample group comprises of educators that teach science to deaf learners. The research sites were four schools that cater for deaf learners. They will be described, as well as the processes involved in obtaining access to the research sites and sample group. The research tools employed includes interviews, field records and artifact collection. In addition to this, issues pertaining to validity, reliability, analysis of data and ethical considerations conclude the discussion.

3.2 RESEARCH DESIGN

The research design was that of qualitative paradigm. McMillan and Schumacher (2006: 315) state that, qualitative research describes and analyses people's individual and collective social actions, beliefs, thoughts and perceptions. In my investigation of the experiences of educators who teach science to deaf learners and educators perceptions of learners experiences regarding science education, qualitative research was most appropriate. Through a qualitative paradigm, an in-depth nature of the context of science education was explored. According to McMillan and Schumacher, (2006: 315), qualitative research design is inquiry in which researchers collect data in face to face situations by interacting with selected persons in their settings.

An advantage of the face to face interactions with participants is that I was able to observe and note the educators' non-verbal communication, such as facial expression and gestures. This also provided 'incidental' information about educators' knowledge of sign language and Deaf culture. A qualitative research design allowed for the exploring and gathering of pertinent data regarding science education for deaf learners. In addition

the context (which included the educators' attitudes, values, skills, knowledge and pedagogical style, the site, availability of resources, interpersonal and intrapersonal factors of the learners) was taken into consideration. This contributed to a holistic understanding of the educators' perceptions regarding science education for deaf learners.

3.3 RESEARCH METHOD

The research method includes a discussion of a case study and research plan, which includes the research sites, sample group and research tools for data collection.

3.3.1 Case Study

Within the qualitative research design, I further identified case study methodology as appropriate. In case study, the data focuses on one phenomenon, which the researcher selects to understand in-depth (McMillan & Schumacher, 2006: 316). In my research, the one phenomenon refers to science education for deaf learners. In their discussion of the strengths of qualitative data, Miles and Huberman, (2004: 10) comment that, "*The emphasis is on a specific* ***case****, a focused and bounded phenomenon embedded in its context. The influences of the local context are not stripped away, but taken into account. The possibility for understanding latent, underlying or nonobvious issues is strong*". In support of this, Anderson, (1998: 121) states, that a case study is an investigation defined by an interest in a specific phenomenon within its real-life context.

A case study design was appropriate to investigate science education for deaf learners, from the educators' perspectives as it provided an in-depth understanding of the participants' views, beliefs and perceptions. McMillan and Schumacher, (2006: 318) suggest that case studies are appropriate for exploratory and discovery oriented research, which examines a topic about which there has been little prior research. The justification for my use of a case study is that there has been little or no research related to science education, explored at schools for deaf learners where I have conducted my research. The significance thus is that further inquiry related to this area may be pursued.

3.3.2 Research Plan

The research plan provides a brief outline of the various processes involved in the method of data collection and analysis. This is summarized according to five phases, as indicated below:

Table 1: Research Plan

PHASE	*PURPOSE*
Phase 1	a. The science educators and research sites (schools) are selected. b. The procedure to obtain permission from the selected participants/sites to conduct research is followed.
Phase 2	a. Data collection begins. b. Establishing rapport, trust, reciprocal relations. Adjustment of interviews to suit the participants.
Phase 3	a. The interviews are conducted. b. Tentative data analysis takes place, as the initial descriptions are summarized. c. Field records are used to corroborate data.
Phase 4	a. Emphasis is on closing data collection. b. Interpretations are verified and emergent findings validated by artifact collection.
Phase 5	a. Formal data analysis and construction of meaningful ways to present data.

3.3.3 Research sites

The sites selected to obtain the data were four schools that accommodate deaf learners. These schools are located in Gauteng, which is a province in South Africa. The various steps to obtain permission from the schools were undertaken. The first step involved requesting permission from the school principals (refer to Appendix 1) and Gauteng Department of Education (refer to Appendix 2). The second step was obtaining the consent and providing a guarantee of confidentiality to the school principals.

Where possible, the research sites involved a visit to the science laboratory so that the available resources, apparatus and equipment could be observed. This also allowed me to gather the relevant artifacts to corroborate findings. The field records provided additional information about the research sites before, during and after the interviews. A summary of the field records is presented in table 2.

Table 2: Description of the research sites

	School 1	**School 2**	**School 3**	**School 4**
Educators	*George/ Michael*	*Elton*	*Kelly*	*Celine*
Description of area in which the school is located	Suburban	Semi-rural	Semi-urban	Urban
Funding of the school	Government subsidy	Government subsidy	Government subsidy	Government subsidy/ Other financial assistance
Infrastructure of the school: Laboratory	* Furniture not suitable * Needs more equipment/ apparatus	Well equipped and fully functional	No laboratory	Well equipped and fully functional
Curriculum offering	* Offered Physical Science & Biology in the past * Now offers science up to grade nine only	Offered Physical Science in the past * Now offers science up to grade nine only	* Never offered any science after grade nine * Now offers science up to grade nine only	* Offered Physical Science, Biology, Physiology in the past * Now offers science up to grade nine only
Availability of hostel facilities	No	Yes	Yes	Yes
Background of learners	Average to low socio-economic status	Average to low socio-economic status	Average to low socio-economic status	Good to average socio-economic status

Synthesis: Table 2 - Description of the research sites

The four schools involved in the research are government subsidized. In addition to this subsidy, school 4 receives other funding. As a result, school 4 has sufficient resources. At school 4, the laboratory is fully functional and it has all the necessary apparatus for teaching science. School 2 also has a well equipped laboratory. School 1 has a laboratory, but needs appropriate furniture and more apparatus. Unfortunately, school 3 does not have a science laboratory, which most likely, may have contributed to the school having never offered any discipline of science after grade nine. Whilst at present the other three schools also offer science only up to grade nine, they did offer disciplines of science up to grade 12 in the past. It is also of relevance to note that three of the schools have hostel facilities, to accommodate learners whose homes are not within travelling distance of the school. This indicates that the learners who are residents of these schools do not have interactions and support from their parents while they are at school. This places these deaf learners at a disadvantage as many researchers have indicated the importance of parent – child communication for educational success, McIntosh (1994); Andrews (2004); DEAFSA (2006).

3.3.4 Sample group

My samples for the research were purposefully selected so that the utility of information obtained from them was increased. As educators that teach science to deaf learners are most knowledgeable and display expertise in providing information regarding the teaching of science, as well as the experiences of deaf learners in science education, they were be selected to be participants in the research. Permission was requested from the educators and this included a brief outline of the research study (refer to Appendix 4). Thereafter consent was obtained from the educators and confidentiality guaranteed (refer to Appendix 5). The sample size consisted of five educators that are currently teaching science to deaf learners, of which three were male and two female. All of the educators have attended in-service training for NCS and are well informed of issues pertaining to the ‘new’ curriculum as well as the assessment procedures and requirements.

3.3.5 Research Tools for data collection

Freebody, (2003: 81) states that case study methodology uses multiple data collection and analytic procedures. These are aimed at providing researchers with opportunities to

- compare and contrast interpretations
- expand on the relevance of the project
- explore findings that are disconfirming of original hypotheses and impressions

Case studies use a variety of data gathering techniques and methods that are determined by the researcher. The tools that I utilized to gather information include interviews, field records and artifact collection. These research tools allowed me the flexibility required in gathering the data. My primary research tool was interviews. Field records and artifacts, such as educator plans/ schedules of work/ assessment records/ samples of learners work were used to corroborate findings.

a) Interviews

Interviews and discussions are key data collection strategies in the case study research, McMillan and Schumacher (2006: 350). Anderson, (1998: 190) defines an interview as a specialized form of communication between people for a specific purpose associated with some agreed subject matter. According to Anderson (1998: 190), there are advantages to the interview as a method of data collection, such as:

- *People are more easily engaged in an interview than completing a questionnaire, thus there are fewer problems with people failing to respond.*
- *The interviewer can clarify questions and probe the answers of the respondent, providing more complete information.*
- *Interviewing enables the interviewer to pick up non-verbal cues, including facial expression, tones of voice and cues from the surroundings and context.*

Interviews are valuable for accessing participants' opinions, beliefs, values, literacy-practices and shared learning experiences. Anderson (1998: 191) discusses the two types of interviews. Normative interviews are used to collect data which is classified and analysed statistically. This type of interviews often includes many interviewers, all of whom are trained to ask questions in a similar way. Their ability to interview for reliable

and valid responses is seen as more important than their knowledge of the subject. In contrast the other type of interview, which is called a key informant interview, requires the interviewer to be an expert in the subject under discussion. The researcher here is not interested in statistical analysis of a large number of responses, but wants to probe a small number of individuals, who have experience or knowledge about the subject being discussed. The type of interview that I conducted was the key informant interview. The emphasis in my research was on gathering information from participants that displayed expertise, knowledge and skills in science education for deaf learners.

The interviews were of a semi-structured nature. McMillan and Schumacher (2006: 204) state that semi-structured questions have no choices from which the respondent selects an answer. Rather the question is phrased to allow for individual responses. The semi-structured questions of the interview allowed me to obtain unique responses from each participant therefore pertinent issues' such as beliefs', perceptions, attitudes, as well as emergent data were obtained from the educators through the face-to-face interaction. In addition, through the face-to-face interaction, I was able to use probing questions and ensure that emergent data was elaborated and clarified (refer to appendix 6 for interview schedule). Freebody, (2003: 133), states that the advantage of semi structured interviews is that although interviews begin with a pre-determined set of questions, they allow for some latitude in terms of relevance. To some extent, what is taken to be relevant to the interviewee is pursued. Semi-structured interviews were relevant in my research as they allowed me to establish the core issues to be covered, but at the same time allowed participants to discuss other issues, which they thought were pertinent.

The interview was phrased in a language that the participants' are at ease with, as some participants are second English language users. Using a language that the participant is at ease with also eliminated any miscommunication. When conducting an interview, it is often difficult to write everything that the participant is saying whilst concentrating 'what' is being said. To alleviate this problem, I used a tape recorder so that I would be able to capture everything that the participant said. Bassey (1999: 81) states that the advantage of using a tape recorder for the researcher is that she can attend to the direction

rather than the detail of the interview and then listen intently afterwards. Everything on the tape can be transcribed at a later stage. The interview environment was negotiated so that participants felt comfortable, secure, and able ease to speak openly from their point of view.

b) Field records

Anderson (1998: 128) states that field notes are an indispensable data source. Field notes are the researchers' detailed and descriptive record of the research experience, including observations, or reconstruction of dialogue, personal reflections, a physical description of the setting, and decisions made that alter or direct the research process (refer to table 2 for description of research sites). Observations recorded during the interview also revealed incidental significant details, such as non-verbal communication (gestures, facial expression, competence in sign language and awareness of Deaf culture). Anderson (1998: 134), states descriptions of the context in terms of location or time of the interview may be included as part of the observations and that understanding the research environment and all its political, social, psychological, economic and cultural dynamics is vital to producing rich, useful and valid findings.

c) Artifact collection

Artifacts may take three forms: personal documents, official documents and objects (Schumacher & McMillan, 2006: 356). In my research, the emphasis was as follows:

- *Personal documents* - educators grade/ year plans
- *Official documents* - science curriculum, assessment guidelines from department
- *Objects* - samples of learners' work (drawings, projects, assignments, models)

There was an emphasis on collection of pertinent 'products' used by science educators of deaf learners or relevant to the context of science education for deaf learners. Knobel and Lankshear (1999), state that artifact collection helps construct contextualizing data (additional details) for a study. The use of artifacts assisted me in the understanding and corroboration of the educator's perceptions, values and attitudes regarding science education for deaf learners.

3.4 ANALYSIS

According to Anderson (1998: 157), basically data analysis involves four elements:

- *Interpreting your findings while in the field*
- *Coding and organizing the data into themes and constructs*
- *Searching for disproving themes or evidence*
- *Testing alternative interpretations of the data to see if your understanding changes*

In my exploration of science education for deaf learners, I followed the general process of data analysis for qualitative research, as represented by McMillan and Schumacher (2006: 364).

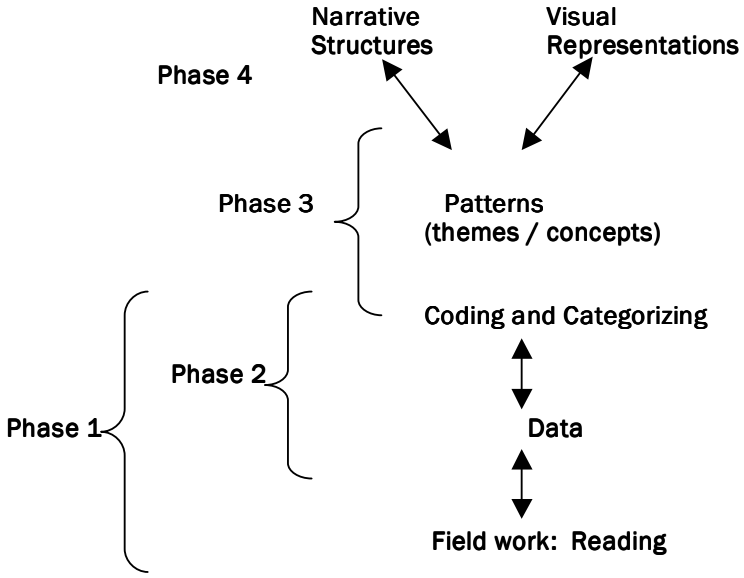


Figure 2: General Process of inductive analysis; (Source: McMillan & Schumacher, 2006: 365)

According to McMillan and Schumacher (2006: 364), qualitative data analysis is a relatively systematic process of coding, categorizing and interpreting data to provide explanations of a single phenomenon of interest. As represented by figure 2, data analysis is an ongoing, cyclic process that is integrated into all phases of qualitative research. The first step, (which relates to phases 1 & 2) in my data analysis process was to transcribe the tape recordings, verbatim from the interviews. To ensure authenticity I

transcribed the tapes myself after each interview. Field notes and important information that I summarized after each interview added to the data. However, these were separated from the 'actual' data to minimize 'potential' subjectivity of the data analysis. McMillan and Schumacher (2006: 350) discuss the importance of separating field notes and reflex records from actual observation. Anderson (1998: 128) comments that field notes are an indispensable data source.

The qualitative research approach that I used, also involved organizing the data into descriptive themes that emerged during the data collection and preliminary analysis. Anderson (1998: 158) states that the preliminary phase of data analysis occurs while collecting the data and is considered a distinct advantage for case study research. Observations recorded during the field work were recorded so that my thoughts, ideas and reflections were ongoing and this provided valuable insight to 'patterns' in the data. McMillan and Schumacher (2006: 366) refer to this as interim analysis and they state that, *interim analysis occurs during data collection and serves two purposes:*

(a) to make data collection decisions

(b) to identify recurring topics

In the next step, (which relates to phases 2 & 3 in figure 2) the data was coded and categorized, which led to the identification of themes. The two distinct categories that emerged were intrinsic and extrinsic factors. The themes that were identified are represented below:

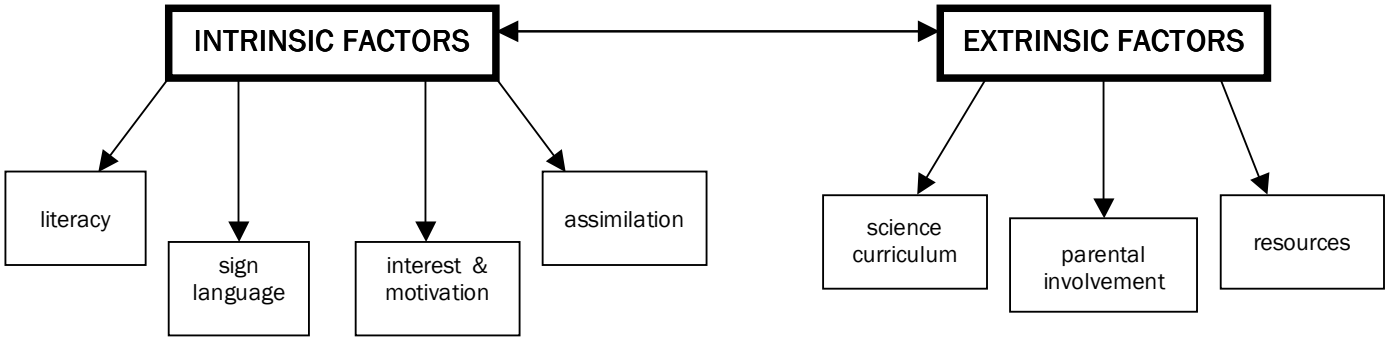


Figure 3: Categories and themes

In my research the field notes included nonverbal communication (sign language ability, facial expression and awareness of deaf culture). McMillan and Schumacher (2006: 359) state that analysis of nonverbal communication is very important in most qualitative studies as the recording of facial expressions, gestures and movements can be triangulated with verbal data. An illustration by McMillan and Schumacher (2006: 374) to represent triangulation for logical pattern is presented.

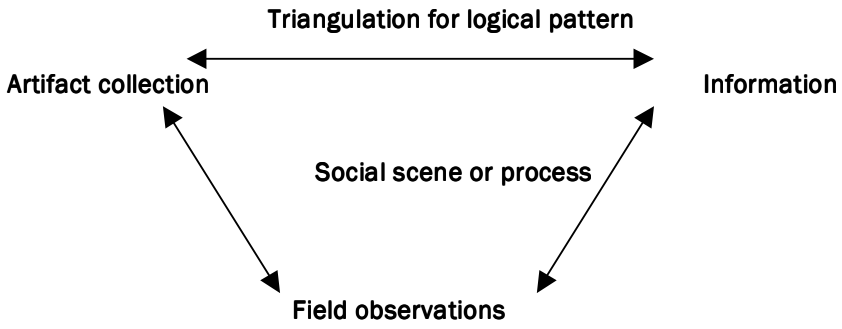


Figure 4: Triangulation (Source: McMillan & Schumacher, 2006: 374)

Artifacts, such as educator plans, Department guidelines, assessment policy and learners portfolio's were used to 'cross check' data and corroborate findings from the interviews and field observations.

3.5 RELIABILITY AND VALIDITY

Anderson, (1998: 12) states, that in qualitative research, reliability suggests that different qualitative researchers would come to the same conclusions given exposure to the same situation. The extent to which data relate to objective criteria will improve reliability. Kvale (1996: 64) states that it has been claimed that the qualitative research interview lacks objectivity, due in particular to the human interaction inherent in the interview situation. In principle, however the interview can be an objective research method. Here, Kvale (1996: 64) explains objectivity as freedom from bias refers to reliable knowledge checked and controlled, undistorted by personal bias and prejudice.

Validity is the compliment to reliability and refers to the extent to which what we measure reflects what we expected to measure (Anderson, 1998: 13). Validity to the qualitative researcher generally refers to the extent to which the stated interpretations are in fact true. According to Anderson (1998: 131), qualitative analysis relies heavily on a process known as triangulation (the use of multiple data source and data collection methods and theories to validate research findings). Triangulation also helps eliminate bias and can help detect errors in the research.

3.6 ETHICAL GUIDELINES

The role of the researcher involves interpersonal skills, such as building trust, keeping good relations, being non-judgmental and respecting the norms of the situation would be displayed as this ensures a reciprocal and cooperative context. Kvale (1996: 117) states that moral research behaviour is more than ethical knowledge and cognitive choices; it involves the person of the researcher, his or her sensitivity and commitment to moral issues and action. The ethical decisions made by the researcher are critical to the knowledge and quality of the research project. The interviewer is the main instrument for obtaining knowledge, therefore being familiar with the context (value issues, ethical guidelines and ethical theories) may help in choices.

Researchers are expected to be truthful in data collection, analysis and reporting of findings. It is here that trustworthiness becomes significant. Refer to appendix 4 for briefing guidelines related to the participants. My role as the researcher involved ensuring that participants were treated with respect and sincerity. After gaining permission from them, the following was explained:

- a detailed description of the method of data collection
- an assurance of confidentiality and anonymity
- an assurance that no harm (physical/ emotional) would come to them
- at any time, they could decide not to continue as a participant

According to Kvale (1996: 116), Informed consent entails informing the research subjects about the overall purpose of the investigation and the main features of the design, as well

as of any possible risks and benefits from participation in the research project. Informed consent further involves obtaining the voluntary participation of the subject with his or her right to withdraw from the study at any time, thus counteracting potential undue influence and coercion.

Kvale (1996: 114), further states, that confidentiality in research implies that private data identifying the subjects will not be reported. The protection of subjects' privacy by changing their names and identifying features is an important issue in the reporting of interviews. Researchers in a democratic society can expect certain freedoms, such as the freedom to investigate and ask questions, the freedom to express ideas of others, and the freedom to publish research findings (Bassey, 1999: 74), however, they need to respect the privacy and dignity of participants.

3.7 CONCLUSION

In this chapter I have discussed reasons for my choice of a qualitative research methodology. The research plan provides a broad outline of the various phases of the research method which included aspects such as request for permission from the school principals and educators, a guarantee of confidentiality and analysis of data. The methodology was informed by the focus of the research, which was to obtain information form the educators about their perspectives and perceptions regarding science education for deaf learners. The primary research tool, interviews allowed for the exploration of educators' experiences, feelings, attitudes and beliefs' in natural situations through face-to-face interactions. However, field records and artifact collection were instrumental in providing useful and valid information, which assisted in contextualizing and corroborating data from the interviews. The next chapter pertains to the findings of the research study.

Chapter Four
Findings and Discussion

4.1 INTRODUCTION

In this chapter, I present the results of the qualitative investigation which explored science education for deaf learners at the various chosen sites. The issues presented are the views, perceptions and experiences of the participants, educators that teach science to deaf learners. The information presented is in response to the following questions that the study explored:

(1) What are the experiences of educators who teach science to deaf learners?

(2) What are the experiences of deaf learners in their acquisition of scientific knowledge, values and skills; as perceived by their educators?

The findings of the research were obtained from data collected through the qualitative tools of interviews, field observations and artifact collection. The findings will be outlined in four broad sections. This will be followed by a synthesis and where possible, I draw on theoretical underpinnings from the literature review in chapter two to elucidate arguments and elaborate on the research questions.

4.2 PRESENTATION OF DATA

The qualitative data collected at the research sites revealed numerous factors that impact on deaf learners acquiring scientific knowledge, values and skills. The findings will be discussed according to four broad sections, which are as follows:

- Details of Participants
- Participants attitudes/ feelings regarding science education for deaf learners
- Factors creating challenges for deaf learners in science education
- Suggestions by the participants

4.2.1 Biographical details of the participants

The table below represents the details of the participants. The participants were five educators who teach science to deaf learners in schools for the deaf. The information represented in the table is the educators' responses to questions 1 – 5 (refer to appendix 6 for interview schedule).

Table 3: Biographical details of Participants

	George	**Elton**	**Kelly**	**Celine**	**Michael**
Gender	Male	Male	Female	Female	Male
Age Group	20 – 30	40 – 50	20 – 30	40 – 50	30 – 40
Number of years in a mainstream school	0	25	0	10	0
Number of years in a school for deaf learners	2	1	4	20	15
Total number of years experience	2	26	4	30	15
Grades taught	7 – 9	8 – 12	7 – 9	8 – 12	4 – 12
Qualifications/ Competencies	Higher Education Diploma Currently studying 1st year Deaf Ed. ---------- *informal sign language workshops at school * NCS trained	Higher Education Diploma ---------- *informal sign language workshops at school * NCS trained	Higher Education Diploma ---------- *informal sign language workshops at school * NCS trained	Further Diploma in Education/ B A Degree ---------- *informal sign language workshops at school * NCS trained	B S C Honours Teaching Diploma ---------- *informal sign language workshops at school * NCS trained

Synthesis: Biographical details of participants

The participants comprised of two females and three males, which provided fairly equitable representation from each group. Two of the participants, George and Kelly, seem relatively 'new' to the teaching profession, having two years and four years of teaching experience respectively. Both George and Kelly have had no experience in a mainstream school. One participant, Michael, has fifteen years of experience in a school for the deaf, but also no experience in a mainstream school. The other two participants, Elton and Celine, each have over twenty five years of experience and have both taught in mainstream schools for twenty five years and ten years respectively. The graph provides a representation of the participants teaching experiences.

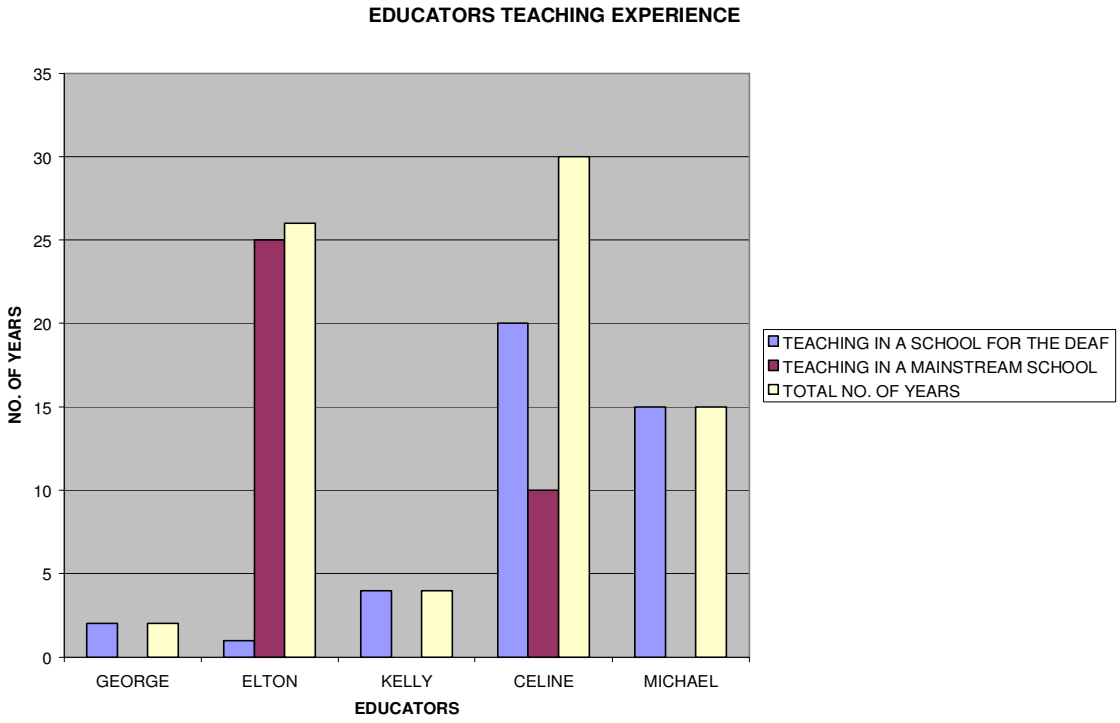


Figure 5: Graph indicating educators teaching experiences in years

With regards to the grades taught, George and Kelly have taught grades seven, eight and nine. Elton and Celine have taught from grade seven up to grade twelve. Michael has had experience teaching from grade four up to grade twelve. All five educators are qualified and have had adequate training in science education. They also indicated that they have attended in-service training for the new curriculum in South Africa, NCS.

Whilst, the educators are equipped to teach science, their sign language qualification seems minimal. They have no formal training in deaf education or sign language, although one educator, George indicated that he was currently in his first year of postgraduate study in Deaf Education. According to DEAFSA (2006: 13), despite the fact that SASL is the only language that is accessible to deaf learners, the language is not a requirement for trainee educators even at two universities that offer it as a major on undergraduate level in the faculty of Humanities.

Through field observations, while interviewing the educators, I was able to note that the educators' were competent in sign language. They indicated that they had acquired sign language skills through training workshops at their respective schools. DEAFSA (2006: 12) states that "some schools offer SASL training opportunities for both educators and parents, but there is no formal monitoring system or uniform training programmes". Therefore, sign language training of this nature often results in inconsistency in SASL linguistics, literature and teaching methodology.

In concluding this section, the biographical details of the participants, it is significant to note that the participants, five educators that teach science to deaf learners, indicate that they are adequately trained to teach science, but have no formal training in Deaf Culture or sign language. The next section relates to the educators attitudes and feelings regarding science education for deaf learners.

4.2.2 Participants attitudes/ feelings regarding science education for deaf learners

As stated in the previous section, the participants were five educators that teach science to deaf learners. The information presented in this section was participants responses to questions 8, 9 & 12 (refer to appendix 6 for interview schedule). It was of relevance to determine the attitudes and feelings of the educators so as to understand how this impacts on the learners, in science education. McIntosh et al. (1994: 48) state that the role of the teacher determines what is taught, how it is taught and to an extent how deaf children in the classrooms feel about themselves. When deaf children are accepted for who they are and what they are capable of achieving, their self esteem is enhanced and they are more

confident, Sheetz: (2004); Lang: (2006). There were two issues that emerged from the educators' feelings and attitudes about science education for deaf learners. The first issue relates to the educators themselves and the second issue to the learners.

a) Educators attitudes and feelings about *their teaching of science to deaf learners*

It was heartening to observe that all five educators were enthusiastic, motivated and committed to teaching deaf learners. They felt that deaf learners are appreciative and compassionate to others, which makes them [the educators] feel happy to work with deaf learners. Despite two educators, Elton and Celine, having over twenty five years of experience, all five educators indicated that they were eager and willing to learn and implement new teaching and assessment strategies. Lang (2006: 58) states that many dedicated teachers are enthusiastic about teaching deaf students, but they lack effective guidance, training and resources based on educational research. Lee (2002: 68) discusses the notion of 'instructional congruence', which is described as the process of merging academic disciplines with students' linguistic and cultural experiences to make the academic content accessible, meaningful and relevant to all students.

In addition, the educators mentioned that they felt it was necessary for educators of deaf learners to empower themselves with deaf culture and proficient sign language skills. Gay (2002: 112) states that cultural characteristics provide the criteria for determining how instructional strategies should be modified for diverse students and that teachers' should learn how to multiculturalize formal and informal aspects of the education process. The educators also felt that they needed more guidance and support from the Department of Education. DEAFSA (2006: 12) states that many educators have indicated their support for training programmes. However, despite many attempts by DEAFSA to enlist the support of the Department of Education for formal training of educators in SASL, no such training has been implemented in schools for Deaf learners as yet nor has it been a formal requirement for teachers to have training before they enter schools for the Deaf.

b) Educators attitudes and feelings regarding *the learners and science education*

The educators felt that science is just as important for deaf learners as it is for any other person. Gega (1991: 13) states that one of the purposes of science education is for students to become scientifically literate so that they can live as an informed citizen in a technologically advanced nation. The educators indicated that deaf learners need to be encouraged to acquire scientific knowledge, values and skills by questioning the things around them and providing more opportunities for deaf learners to explore experiment with scientific phenomena. Fox and Gay (1995: 68) state that multicultural education is a condition for achieving equity of learning opportunities and is a 'basic' of democratic citizenship and social justice for a pluralistic society. This notion is of relevance to deaf learners and science education in a country as diverse as South Africa. Atwater (1996: 821) discusses multicultural science education, which implores teachers using examples and content from a variety of cultures to make science more relevant and interesting.

The educators mentioned that their schools are not offering any science courses after grade nine. In response to this, some educators' felt that this situation was not fair as deaf learners are capable in science and that some learners exhibit interest and potential in science. Grossman and Stodolsky (1996: 237) are of the opinion that subject subcultures, which include norms, teaching practice and curricular autonomy, may influence how teachers work. For example science is perceived as a high status subject and that only 'serious students' are capable of science. It is of importance to understand this in relation to the perception of deaf learners and their learning styles. Andrews (2004: 130) states that in addition to knowing about Deaf Culture and how to sign fluently, teachers of deaf learners must be familiar with the values, belief's, prejudices and stereotypes related to deaf learners.

To conclude this section on the participants' attitudes and feelings regarding science education for deaf learners, the salient points were; (1) educators that teach science to deaf learners are enthusiastic and committed to their work, however they indicate that there is a need for in-service training and more support from the Department of Education for educators that teach deaf learners, and (2) deaf learners need to be supported so that

they have more positive and motivating experiences related to science education. The third section of the findings to be discussed is factors that create challenges for deaf learners in science education.

4.2.3 Factors creating challenges for deaf learners in science education

The educators discussed, in response to questions 6, 7 and 10, the various factors which they felt created challenges for deaf learners in their acquisition of scientific knowledge, values and skills. These factors are thematically explained and presented as either intrinsic or extrinsic factors.

4.2.3.1 Intrinsic factors

Intrinsic factors are aspects that relate to the individual learner. The intrinsic factors that are discussed in this study are of equal importance and are diagrammatically represented below:

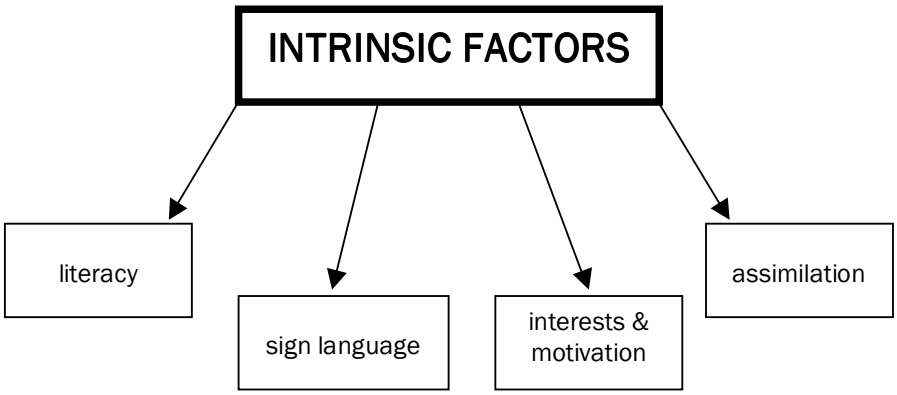


Figure 6: Intrinsic factors

a) Literacy

Literacy is the first intrinsic factor that will be presented. Andrews (2004: 90 - 91) discusses the importance of literacy as it enables young children to think, develop ideas, communicate and reflect. Although Moores (2006: 45) states that "Deafness, per se, has no effect on the acquisition of literacy skills", it is well documented that deaf learners generally experience great difficulty with acquiring literacy skills (Lang & Albertini 2006, Sheetz 2004, Andrews et al. 2004 and Moores & Martin 2006).

Celine stated, “I don’t think that deaf learners have the language to cope… even when they get to grade nine… like now I’ve got a lovely boy who just doesn’t have the language to cope. There’s nothing wrong with his brain and he’s keen, but it’s so hard for him and it depends solely on his working and the support he gets as to whether he will succeed …mmm… and I don’t think he can because he’s just lost too much language over the years! Celine was also concerned with language and development. She stated “deaf learners have difficulty making links, and I think that is because they don’t have language and if they don’t have language – there are problems with development of the child, such as thinking skills.”

Celine commented that deaf children often have difficulty expressing themselves in a written form and that this poses a barrier to those learners that want to have an academic career, as in order to follow an academic career path, the learner would have to be able to express themselves in writing. Celine also claimed that deaf learners cannot research and make meaning of information. She states that this makes it difficult to do OBE with deaf learners.

George stated “It’s the English that they are struggling with and for us [educators] to demand a written assessment is a problem for them.” He substantiated his argument by saying that when he gives his learners a written assessment and they perform badly, he signs the questions to them and their results are much better. George stated that this is without the learners studying again after the written assessment so he feels that the learners were not able to comprehend the questions from the written assessment.

Elton discussed how language causes complications for deaf learners in science education. He states “It’s the vocabulary like condensing and evaporating that they [the learners] do not understand”. He explains that deaf learners need to see things for themselves and then they understand, however the obstacle is the assessment. Elton claimed that often his learners cannot express themselves in a written form. With regards to this point, Elton comments that there is no support from the department, even though they [the educators have asked for guidance].

Kelly stated, “Learning science is like learning a third language, for our deaf learners”. She used the example of, “it’s like they have sign language first and, then it’s Zulu at home, and suddenly at school it’s Science in English. In addition to this, she stated “the language of science is also difficult for deaf learners’. Michael stated “I think literacy is the core of their difficulty”. He claimed that deaf learners cannot research as a result of their problems with literacy. He explains that although some learners have access to computers and the internet, they still experience difficulty accessing information due to their literacy problems.

Michael supports the view that deaf children would learn best in their mother tongue. He (as Kelly also stated) adds that they [deaf learners] are learning science in a second or third language. Michael comments “they [deaf learners] need to have good command of language, as a person doing science… deaf learners need to be able to express themselves and question certain things.

Celine discussed a friend of hers who is profoundly deaf – but a doctor. Celine said that her friend managed because she had tremendous support from her family and a speech therapist everyday which helped with her language proficiency. She also attended a hearing school and decided not to learn sign language. Initially the medical faculty refused to accept her, so she completed her BSc with honours and thereafter went back to them. Eventually they agreed and she is a qualified doctor. She does not practice medicine because of the communication difficulty, but has specialized in the field of pathology and has worked at hospitals.

Michael related a similar experience. He stated that there was one learner, who was profoundly deaf, but coped well with science up to grade twelve. He explained that she had a high literacy level that enabled her to read, understand and explain concepts.

Synthesis: Literacy

All of the educators felt that the greatest challenge for deaf learners in acquiring scientific skills, values and knowledge is their difficulty with literacy. The educators commented

on different aspects of literacy. From their observations, deaf learners are receiving science instruction in a third or sometimes, even fourth language. Although sign language is recognized as a deaf person's first language, DEAFSA (2006), many deaf children are being introduced to English which is their second language and in some cases, their third language, before they have gained competency in sign language (their first language). This impacts negatively on deaf children's grasp of concepts, understanding and comprehension in English, which in turn impacts on their learning of science.

Schirmer (2001: 62) states that deaf children have the same ability to learn language as hearing children, however they generally have difficulty with language acquisition as result of insufficient support from their home environments. Marschark et al. (2006: 180) state that the poor academic performance of deaf learners is often ascribed to early language delays. Michael supports the view that children learn best in their mother tongue. For deaf learners this is not always possible. Although the medium of instruction can be sign language, deaf children still need to learn science through English. It therefore becomes imperative for deaf children to have a well developed sign language ability, which will enable them to grasp English concepts more easily. However, as SASL is not officially recognized as a language, deaf learners experience other barriers, such as inconsistency/ lack of uniform signs, etc. which impacts on their development of schema. Molander et al. (2001: 200) state that sign language is important in enhancing a deaf child's thinking and creativity.

In addition to deaf learners' difficulty with acquiring language skills, the educators also mentioned the "language of science". Thus, many deaf learners experiencing difficulty with learning science through English (their second or third language), they also have to be able to understand and use the "language of science" appropriately. Researchers such as Wellington and Osborne (2001: 1) are of the opinion that one of the major difficulties in learning science is the language of science. Science as a subject does have a 'language' of its own – there are words and phrases that have specific meanings in science and these may differ in meaning from everyday use of these words or phrases.

The language of science also leads to difficulty with comprehension. This problem is compounded by the difficulty deaf learners experience with language. Sheetz (2004: 80) states that vocabulary, multiple meaning words and figurative language can lead to comprehension problems for deaf readers. Lang (2006: 60) is of the opinion that science teachers should begin the lesson by introducing the vocabulary. He feels that a science teacher needs to develop activities to enhance science and English literacy.

Deaf children experience difficulty expressing themselves in a written form, which makes it challenging for them to learn academic subjects. Scheetz (2004: 82) discusses research which indicates that deaf children's writing lacks syntactic and semantic knowledge and that they tend to have smaller and more concrete vocabularies. However, other research, such as Schirmer (2004: 77), indicate that when deaf children are taught the qualities of good writing and their writing is analysed along more than one criterion only (correct usage of English sentence), deaf learners demonstrate abilities in areas, such as making ideas clear and descriptions. This is reiterated by Lang and Albertini (2001: 260) when they state that deaf learners can be creative and expressive in their writing. It is interesting to note that the two deaf learners mentioned by Celine and Michael were successful at academic studies. They had three common factors. These were exceptionally good levels of literacy, highly motivated and had good support from their families.

b) Sign Language

The second intrinsic factor identified was sign language. Sign language is widely accepted as a deaf person's first language, DEAFSA 92006). In South Africa there are many barriers that deaf learners face as a result of their first language, SASL, not being recognized as an official subject in schools and tertiary institutions. Sign language of both the educator and learner will be discussed in relation to how it influences the curriculum.

George stated that one of the major challenges of teaching science to deaf learners is that there are no standardized signs. He discussed "the learners may have touched on

photosynthesis in grades five or six, but because the signs are not consistent from primary to secondary school, I have to start from the basics." Elton's comments were in agreement with what George stated. According to Elton "at our school, we have learners from all corners of South Africa. They come from Limpopo, Cape Town and Kwa Zulu Natal, and they all have varying signs". Elton added that "there are no signs for some concepts, for example kinetic energy… so you [the educator] have to explain and show them [the learners] moving… and after a while, they are going to forget. There's no sign for mechanical energy, so you [the educator] have to show the learners the meaning of the word – like carrying a chair or pushing the door… but this can also lead to misunderstanding.

Celine stated that the words that do not have signs are a problem. She commented " I tend to take out all the unnecessary words because they don't sign all the words… even if you make them use a dictionary, it does not help because they cannot associate a written word with the meaning'. Celine felt that deaf learners experience great difficulty assimilating when there are no signs. She states "they cannot associate a written word to an action or even a picture." She added that with deaf learners, science educators often make their own signs for words. She used an example, "the word chlorine – you cannot sign it so my learners and I made up a sign… but then, we are the only one's that are using this specific sign…so maybe the fault is in bad signing."

Michael felt that sign language is limiting with regards to teaching science. "Basically, we don't have enough signs to cover all the science concepts and terminology". Michael also stated "science is an exact subject…definitions are concise. You can't change certain laws, for example Newton's third law of motion – you can't really change the terminology. There are certain words that you have to use and there are no signs for them. So in a way the message gets distorted."

Synthesis: Sign Language

With regards to sign language, the first issue relates to the difficulties that occur as a result of not having standardized signs, specifically in science education. Misunderstandings take place when:

- Educators use different signs for the same word
- Educators use the same sign for different words
- Signs differ from primary school to secondary school
- Signs differ from school to school

This issue is corroborated by Molander et al. (2001: 201) when they discuss how the absence of uniform signs can lead to confusion and serious problems in the understanding of concepts.

The second issue pertains to the constraints of sign language. Sometimes, there is no exact sign for a term or concept, so the educator has to provide an explanation for the term or concept, example kinetic energy. These explanations by the educators can have other repercussions, such as inconsistent signing and the 'quality' of the explanation will be dependent on the educators' sign language ability. According to DEAFSA (2006: 5), a recent survey indicated that only 14% of educators can sign proficiently, therefore this becomes an important determinant of learners' understanding.

In addition to this, there are certain laws, principles and rules in science which are exact, and if there are no signs for these words, the learners experience difficulty with the vocabulary and with fully grasping the concept related to these laws, principles and rules. In an attempt to overcome these challenges that deaf learners experience with sign language in learning science, Stewart (2006) advocates for the IPC. According to Stewart (2006: 215), learners who acquire ASL as their first language still face the challenge of learning English, which is a key barrier to their ability to learn curriculum content. It is important to note that Moores (2006: 48) expresses his agreement with Stewart's position regarding IPC. Moores (2006) states that despite its limitation, English-based signing can be a bridge to English literacy, which in turn would make science more accessible to deaf learners.

c) Interest and Motivation

The third intrinsic factor discussed is interest and motivation of deaf learners. A child's interest and motivation in science will influence his confidence in activities and observational learning that a child experiences (Lang, 2006: 62).

Elton stated that science for deaf learners has to be basic. He justified his answer by saying, "they are just not interested in elements and compounds." Rather, we should try to do more practical things for them to understand, such as this element is harmful and that one is useful in the kitchen. He felt that we should things for them to understand science, which at the same time, would also prepare them for the future. He also stated, "if you take chemistry experiments in grade twelve, you do sulphur and its compounds. The learners cannot tell you that this is nitrogen and that is sulphur. They don't know! They don't want to know!" For that time, when you write it on the board – they know it and by the next day they have forgotten.

Michael stated that chemistry takes place at a molecular level so you have to look at reactions. He explained, "There's no sign for atom or molecule so it becomes difficult for the deaf child to visualize. Now with a hearing child – you can say to them 'visualize this atom', but a deaf child doesn't have those words, so what does he visualize? At matric [grade 12] level – there are certain complex reactions that learners need to understand because there are different products and by- products." Michael felt that the main problem with chemistry for deaf learners is that they can't 'see' the reaction happening. Therefore – there's no meaning or interest for them. Michael also stated, "Teachers focus on textbook based activities which are limiting because there are no signs for all the words… science should be taught as an experiential subject so that deaf learners can experience phenomena, which will lead to them understanding"

Celine discussed how she felt – that deaf learners cannot work independently – they cannot make meaning of what's in the books. Celine commented that the main difficulty with Physical Science was that the learners were not interested, especially with the experiments. She stated, "The pictures and captions in the books only help to a certain

extent, I changed from Physical Science to Biology because Biology is more concrete. We tried biology for a year – but the learners seemed to hate learning about the plants – cell types and adaptations." However, she stated that from her observations, she noticed that the learners scored well in the sections regarding the body. So the following year she changed to Physiology. She stated, "We did Physiology for three years and it went well, even the children who struggled with language managed to pass."

Celine stated that when she first started at the school she could not connect the children to learning. She discussed, "Then one day, I found an article in the newspaper about chlorine and other chemicals in the water and what they might be doing to our body. So I took the article and simplified it and I had the best lesson. That's when I realized that they were interested because it was happening to them and it was meaningful."

According to Elton, "we are stressing the learners with what we are teaching." He states, to them a leaf is a leaf… and the differences don't matter. He further explains, "When I'm doing density, I take a bird's feather, some foam and a brick. First I have to sign the words to them because the words don't mean anything to them. Then when we do the calculations – it doesn't mean anything to them – they cannot see the relevance of what they are doing to their everyday lives. And the vocabulary, such as heaviest and lightest/ float and sink, is difficult for them to understand."

Synthesis: Interest and Motivation

The educators discussed the content of the science curriculum and how it affects the learners' interest and motivation. In their discussion of Physical Science and Chemistry, the main issue pertained to the experiments. According to Elton, the learners experience difficulty with the vocabulary and terminology. Wellington and Osborne (2001: 5) state that children need to learn the specialist vocabulary of subjects in order to actively develop an interest. Lang (2006) concurs with this idea and proposes that vocabulary practice should be introduced to deaf students at the beginning of the lesson.

Elton also stated that deaf learners do not seem interested in experiments. Elton added that the content for deaf learners needs to be relevant and useful to them, so that they can apply scientific principles in their daily lives. In support of this Ogunniyi (1997: 84) states that a primary role of science education is so that even a novice in society can make sense of science. Michael and Celine supported Elton's point of view regarding the experiments. Michael maintained that deaf learners have difficulty with concentration of experiments and reactions for two reasons: Firstly, there are no signs for all the reactions or products; and secondly, deaf learners cannot visualize the required objects/ reactions. Molander et al. (2001) discuss the importance of proper sign language usage in chemistry experiments. With regards to deaf learners not being able to visualize, there could be several reasons for this. It has been documented (McIntosh: 1995; Andrews: 2004) that deaf learners have had insufficient opportunities of play and incidental learning, which could result in deaf learners having limited schemata. Vacca et al. (1991: 138) state that schemata reflect the background, knowledge, experiences, conceptual understanding, attitudes, values, skills and procedures of an individual.

Celine explained that only when the content is related directly to the learners, do they find the activities interesting. Atwater (1996: 821) argues for multicultural science teaching as it implores science teachers to use content form a variety of culture to make it more relevant to the learners. Celine 'traced' the science offering at her school over the years. She explained that the learners were not motivated in Physical Science as they found the abstract calculations boring, so she tried Biology, which is more concrete. Within Biology, she found that the learners were only interested in the section about the body. Hence the following year, she introduced Physiology and found that even the learners who struggled with language passed. In support of this, Aikenhead (1996: 8) suggests that it is possible to regard learning science as a cultural acquisition and for students to acquire the culture of science, they must travel from their everyday life to the world of science found in their classrooms.

In addition, the learners' success at Physiology may be attributed to two factors: Firstly, the role of the teacher, (McIntosh et al., 1994: 481) determines what is taught and to an

extent how the deaf children in the classroom feel about themselves. Andrews et al (2004) also state that the expectation that teachers have of their students is important. It is possible that Celine's supportive role ensured her learners' success. Aikenhead (1996) discusses the role of teacher as a 'culture broker' as being influential in the learners acquisition of science concepts. The second factor relates to motivation. Lang (2006), states that motivation increases a person's confidence and this results in them having a greater self esteem. Sheetz (2004: 56) defines self esteem as the reflection of individuals self worth which affects their academic performance.

The educators were also of the opinion that deaf learners cannot work independently as they experience difficulty using resources by themselves. Lang (2006), states that deaf learners generally look to authority figures for guidance. Michael stated that teachers tend to focus on textbook activities which are limiting (as there are no signs for all the words). He felt that science should be taught as an experiential subject so that learners can 'experience' phenomena, which will lead to understanding. McIntosh et al. (1994: 481) discuss the need for science teachers to develop "minds-on" activities which encourage active learning.

d) Assimilation

The fourth intrinsic factor is assimilation. As a result of many deaf children coming from hearing families, with limited communication skills, they have not had adequate opportunities for incidental learning to take place (Andrews, 2004: 83). This may result in them having insufficient schemata, which makes it difficult for deaf learners to assimilate information. Vacca et al. (1991: 139) state that schema provides a framework that allows learners to 'organize' and 'integrate' new information.

Elton stated that children cannot relate things. For example, "When I'm doing electricity and I tell them to draw a parallel circuit – even when I've given them a worksheet with symbols and everything… they cannot relate it and draw the diagrams by themselves." Elton stated that they cannot associate a word with a picture. It's very difficult for them, their thought is isolated. For example, in this diagram (refers to a diagram of a plug), it

says here E, L and N. At the bottom I have the words Earth wire, Live wire and Neutral wire. When I ask them to label the diagram of the plug out of a class of about fifteen, only two or three would get it right.

Celine stated that they are interested in the introduction – but as soon as you get to the calculations and things become abstract – they lose interest. We tell them something in the classroom and we expect them to remember it – but they are not getting the reinforcement that hearing kids get (from the television, radio and they read magazines) the deaf kids are just looking at the pictures.

Celine stated that deaf learners struggle to make connections. Even if a learner did understand an experiment – he would not be able to transport the information to another area. She explains, "For example when I'm doing filtration, I get the children in groups. I give each group a mug of dirty water, a beaker, a funnel and filter paper and I ask them to clean the water. They take the mug of dirty water and pour it through the funnel into the beaker. They do this over and over until somebody decides to use the filter paper. Even then they just place it over the beaker so all the water fall off the side of the beaker. Only after quite a while one learner will decide to tuck the filter paper in and the rest will follow. Now I'm talking about fourteen and fifteen year olds. This is just a simple basic thing, yet it takes them so long." However, she reasoned, "I think it's got to do with their experiences. Hearing children are learning so much from their mum's and dad's while they are helping in the kitchen or somewhere. They ask questions and are getting answers. That's not happening with our deaf learners."

Synthesis: Assimilation

In their discussion of assimilation, educators felt that deaf learners' thought is isolated. The educators described basic activities, where learners had to relate information from one source to another and they could not work by themselves. This aspect links with the learners' interest as well where Lang (2006) states that deaf learners are 'dependent', as in needing instructions from the teacher. Elton and Celine stated that deaf learners cannot make associations between words and pictures and between words and actions.

The educators commented that as soon as the activities became abstract, the learners would lose interest. Schirmer (2001: 111) states that deaf learners have stereotypically been characterized as concrete thinkers. Although there is no evidence that deaf children are unable to think abstractly, it appears that they need to be guided in their thinking levels beyond the concrete (Marschark et al., 2006: 188). The educators reasoned that, from their view, the difficulties that deaf learners experience are as a result of a lack of incidental learning and reinforcement from their surroundings. McIntosh et al. (1994: 482) state that it is often difficult for deaf learners to acquire access through the television and radio. Andrews et al. (2004: 169) comment that the learners would be able to access information, only if their reading skills are up to par. The educators explained that hearing children are constantly asking questions and receiving answers, interacting with their parents and siblings in family activities, such as cooking and washing the car. Deaf children seldom get the opportunity to have these experiences. Among many deaf children, the communication between them and their hearing parents and siblings is limited (Andrews, 2004 & DEAFSA 2006).

To summarize, the four intrinsic factors discussed, literacy, sign language, interest and motivation and assimilation are inter-related and are of equal importance. However, it is important to mention that difficulties that deaf learners experience with literacy are attributed to a lack of early identification of a deaf child's hearing loss and insufficient support for the child and the child's family. Sheetz (2004: 141) states that, sometimes, parents and family members of deaf learners establish a lowered expectation for them. Frequently deaf children are denied access to daily conversations and incidental learning experiences, which has often resulted in deaf learners facing difficulties with all aspects of literacy. This in turn impacts on their learning of science education.

4.2.3.2 Extrinsic factors

Extrinsic factors relate to aspects that are out of the learners' control. The extrinsic factors discussed in this study are diagrammatically represented below and are discussed in order of importance as perceived by the educators.

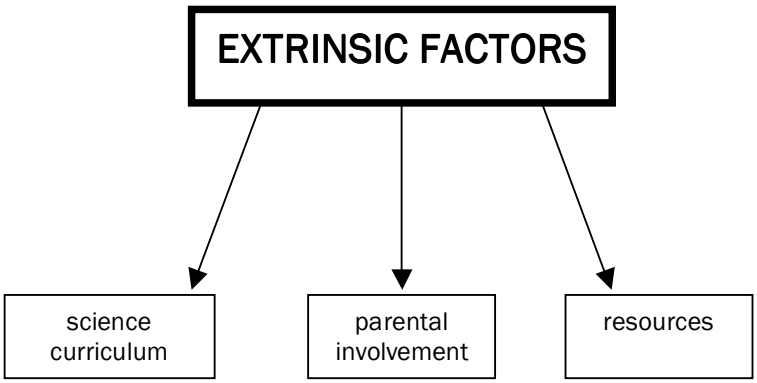


Figure 7: Extrinsic factors

a) The Science Curriculum

The first extrinsic factor discussed is the 'actual' science curriculum. The NCS was introduced in South Africa to provide equal educational opportunities for all learners, Department of Education (2002). Educators discussed the barriers that deaf learners experience with the curriculum according to the different aspects of the curriculum. These include the content of the curriculum, the timeframe of the curriculum and proper grounding.

Content of the curriculum

Educators had differing views and attitudes regarding the science content. All five educators stated that they are implementing the NCS. Elton stated "In both the documents I have, White Paper 6 and Inclusive Education, there is no mention of **exactly** what to do. These documents just give you an idea and the rest is left to the teacher." Elton commented that all work has to be adapted. He explained that assignments and projects have to be as practical as possible. Elton also stated that there is no guidance from the department officials on exactly how to 'adapt' the work.

Celine stated, "Prior to OBE [the NCS], we did offer Physical Science and it was successful. We had the lower grade when I first started – the lower grade was the core of the syllabus, but it was interesting. It was good because they still did metals and non-metals, acids and alkalines, etc. things that they could use in their lives." She stated that after OBE was introduced, they stopped Physical Science at her school. Celine

mentioned two reasons for this. Firstly, the lower grade was scrapped after OBE was introduced, and secondly the children were coming in with less foundation. She stated that they tried Biology, but the learners were not keen and they struggled with the vocabulary. She did observe that they enjoyed the section on the body, so she introduced Physiology and it went well.

However Celine stated, "With NCS and OBE, Physiology is one of those subjects that has dropped away. It's now called Life Sciences and is more like the old Biology, (with experiments and plants) and has quite a bit of Geography. I think OBE is wonderful for developing a really intelligent child with an inquiring mind – OBE is a lot of work for the teacher and getting all of the materials and resources all the time is not always possible. Also, I think it's a little 'easier' in the primary school because it's fun and exciting for the learners. When they get to high school and there are calculations and theories – it becomes boring for the learners".

Celine stated that the content is too much for one year, she discussed "we tend to take the core. In terms of assessment, mostly it's LO1 and LO 2 that can be done – with LO 3, you can try, but you won't get much from them. This keeps their scores low." (Refer to appendix 7 for LO's for the NCS). She discussed, "There isn't really a core syllabus with OBE, so this teacher is doing this and that teacher is doing that. Some have done electricity and others have not – so it had become too hard for them to cope. Celine stated that her school has decided not to offer any science after grade nine. She stated that she has a group of skills learners that are doing horticulture, which incorporates a lot of science. It's about organic gardening and making compost – that kind of thing. The learners enjoy it because it practical and they can use it.

Michael stated that he found OBE better because lessons are more meaningful, it's more hands-on, more experiential. He stated, "There are processes that kids have to go through and they can figure things out for themselves." However, he felt that the NCS was designed for mainstream learners, especially with regards to timeframes and pace setters. He felt that it should be adapted to suit our [deaf] learners. He clarified that when he said

adapted – he did not mean "water down" – he meant that it should be changed or modified to suit deaf learners. He discussed, "For example – in English there's an oral component that is changed to suit the deaf – the same can be done in science." He felt strongly that we should make science more accessible to deaf learners. Michael discussed how he changed his methods over the years. Now, with NCS, he has shifted focus from written assessments to more practical assessments. He said he was testing the same assessment standards but using different methods.

Michael stated that he thought, "The content is more meaningful now, in the past we memorized everything and we stored everything in our short term memory. Afterwards we could recall very little. Now I think that things are more meaningful." He also explained that now we [educators] are using experiences of learners and science is about developing more practical and critical thinkers. We now promote problem solving, which we did not have in the past.

Michael also thought that taking science at school level was one thing – but pursuing it at university is another thing. He felt that tertiary institutions do not adequately support deaf learners with regards to science. He felt that the interpreter has to have a science background in order to explain certain concepts and stated, "If an interpreter does not have a science background – certain information will be lost."

Synthesis: Content of the curriculum

All of the educators stated that they are implementing the NCS, which is the national curriculum. Whilst they were happy that their learners had access to the national curriculum, they also felt that the adaptations of the curriculum (mentioned in the policy documents), which are allowed for deaf learners, are not clearly stated. This leads to inconsistency in schools for the deaf. According to White Paper 6, Special Needs Education (2001), there is no precise adaptation framework.

Another issue mentioned by the educators was that the disciplines of science, Physics, Biology and Physiology have different impacts on deaf learners. Celine mentioned that

before NCS her school offered Physical Science at a lower level. She explained that although it was just the core of the syllabus, it was interesting for the learners and comprised of information which was relevant and useful to them. Celine stated that after NCS, she stopped Physical Science for two reasons. The first was that the lower grade was dropped and the second was that the learners were coming into secondary school with an inconsistent foundation, which made the teaching and learning process unmanageable.

She stated that her school does not offer any science after grade nine. There is a group of skills learners that are currently doing horticulture, which includes some science. Celine commented that the children find it interesting and they are able to use the knowledge in their lives. It is of importance to note that all the educators interviewed mentioned that their schools were not offering any science after grade nine. In addition to this Michael mentioned tertiary education. According to DEAFSA (2006) at present, deaf learners in South Africa are finding it difficult to gain access to tertiary institutions as they do not have two languages (SASL is not officially recognized) and not all institutions are budgeting for interpreters.

The educators had divergent views on the NCS and the approach, Outcomes Based Education. Michael stated that OBE is more meaningful than the curriculum in the past, as he felt that the focus is now on experiential learning which promotes problem solving, creative and critical thinking. However, he felt that The NCS was designed for mainstream learners, especially with regards to the timeframe and that it needs to be 'adapted' to suit deaf learners. He discussed exactly what he meant by adapt, which was that the language should be modified to suit deaf learners but not the content. Lang (2006: 60) states that the language of science should not be 'watered down', excessively. According to him the teacher should provide activities that develop both science and English literacy.

Celine felt that OBE created some challenges for deaf learners. Firstly, Physiology is no longer a subject in NCS and secondly, Celine felt that it is not always practical and

possible to obtain all the necessary resources. She felt that in the primary school, OBE seems easier as it can be fun and exciting, but in the secondary school the level of work increases and the learners become bored with the content. Lee (2002: 66) perpetuates the notion of instructional congruence, which involves the teacher engaging in culturally appropriate communication, examples and analogies to make content more relevant and meaningful. Educators can encourage deaf learners to be interested in the scientific and technological invention of hearing aids and cochlear implants, which has had tremendous impact on the lives of people with hearing loss

Timeframe

The pace of learning of deaf learners is generally slower than hearing learners, as a result of their barriers in literacy (Lang & Albertini, 2001 and Andrews et al., 2004). George felt that the content for deaf learners for one year is too much. He explained that as a result of the inequalities in the past and the sign language difficulties with science terminology – deaf learners have a 'void' to fill. He stated that "first we have to get a solid grounding – thereafter, we can achieve the outcomes set for each grade (seven, eight and nine)". He also added, "If the timeframes need to be increased so that deaf learners can achieve the outcomes, it should be done". Elton agreed that it's too much to do in one year. He said "We tend to take the core of the syllabus". Kelly, Celine and Michael all agreed that it was difficult for learners to complete even half of the assessment standards for the learning outcomes each year.

George stated "It's the English that they are struggling with and for us [educators] to demand a written assessment is a problem for them." He substantiated his view by saying that when he gives his learners a written assessment and they perform badly, he signs the questions to them and their results are much better. George stated that this is without the learners studying again after the written assessment so he feels that the learners were not able to comprehend the questions from the written assessment. Celine commented, "When you work with deaf learners, the pace is really slow and the reason for this is that they don't have peripheral knowledge". She discussed an example from one of her Physiology lessons. The learners and she were discussing the collarbone and

the learners, who were fifteen and sixteen years old, did not know where the collarbone is located. Celine had to stop the lesson and explain to the learners as to where the collarbone is located and why it is called the collarbone. According to Celine – this is happening all the time and this results in the pace being slow.

Synthesis: Timeframe

The educators stated that they tend to take the core of the syllabus, as the learners work at a slower pace than hearing learners. There are several reasons, according to them, for this. These include literacy, the 'language of instruction', that deaf learners have limited peripheral knowledge, inadequate resources and insufficient parental support. The main reason is the difficulty that deaf learners generally have with literacy (language, reading and writing) is due to the sign language issue. According to DEAFSA (2006: 11), the only language that can be the first language of deaf learners is not an official school subject. This impacts on the learners' acquisition of English concepts, which in turn influences their learning of science. As a result of the learners working at a slower pace, they find it difficult to complete all the assessment standards and this creates 'gaps' in their knowledge. Ogunniyi (1997: 89) states that children from cultural groups who do not emphasize linear and verbal analytical form of instruction are bound to under perform. He comments that there should be more emphasis on developing more visually/ holistically oriented instruction, especially for second or third language users.

Proper grounding

In science, there are concepts and principles which are built on and expanded as learners move to higher grades. Deaf learners often experience difficulties as a result of the inability to make 'connections'. This may be attributed to insufficient schemata in deaf learners as a result of deaf children having limited learning opportunities. Vacca et al. (1991) state that schemata reflect the background, knowledge, experiences, conceptual understandings, attitudes, values and skills of an individuals. Michael explained, "Certain principles need to be taught at the foundation phase. The learners need to understand certain scientific concepts and know the terminology from the foundation level because science is a language on its own – just like Maths has its own language, so

too in science – there's a language. George felt that more needs to be done in the primary schools so that the learners have proper grounding. He also felt that common signs from the primary school need to be developed so that learners' knowledge can be 'built on' and there should be more practical work.

Celine discussed another issue that relates to some deaf learners. She said that from her experience, deaf learners are sent to primary schools that are close to their homes, and then when they get older and need to attend secondary school, they are sent to schools which are away from home. This, she feels is a huge setback for these children because the sign language is different – the environment and she stated, "I don't think they ever fully catch up…"

Synthesis: Proper grounding

The educators felt that learners need to have a strong foundation in science from primary school so that the learners' knowledge, skills and values in science can be built on. Gay (2002: 106) discusses culturally responsive teaching, which involves scaffolding. They also maintained that more needs to be done in primary schools to expose learners to the 'language of science' and experiments. Wellington and Osborne (2001: 5) discuss the need for children to understand the language of science so that they will develop an interest in science. Celine discussed the issue of where some deaf children are sent to primary schools that are close to their homes and sent to 'better' schools away from home.

The main reason for this is that there are only seven schools for the Deaf in Gauteng province, which results in parents being forced to send their children to board at these schools when they are old enough. Deaf children find it difficult to cope with this transition and this affects their learning negatively. Ogunniyi (1997: 88) states that student initiated talks and questions are seen as a sign of disrespect therefore educators need to be aware of how these values or attitudes impact on children's learning.

b) Parental Involvement

The second extrinsic factor identified is parental involvement. Parents determine how their children feel about themselves and their learning. Their expectations are influential in their children's education, Sheetz (2004: 141).

Elton stated that there is little parental involvement and that most learners from his school stay at the hostel. He states that the children are eager to learn. He says "So if I want to see the children – they will come from about half past two till about five or so… some would even come at half past six, after supper for extra lessons." Elton also felt that some children are 'traumatized' by the fact that they are deaf. He discussed how this problem is sometimes compounded in Black children, as their parents feel that they are not 'normal' and disowns the child. The majority of the children at his school are brought up by their grandmothers – very few of them actually have the support of their natural parents.

Celine observed that support from home is not good. She explained that most of their parents are busy working and have little time to support their children educationally. She also stated, "Often there's only a mum or grandmother, whose priority is to earn enough money for basic necessities." George and Michael felt that most deaf learners at their school have hearing parents and experience difficulty communicating with them.

Synthesis: Parental Involvement

The educators felt that, with the exception of a small percentage of learners, most deaf children do not have adequate support from their natural parents. Sheetz (2004: 141) states that sometimes parents and family of deaf learners have lowered expectation from them. In doing so, they are not providing the learner with the 'scaffolding' required during their development. There were three major issues that emerged. The first was that some deaf children are not 'accepted' by their families. Due to their hearing loss these children are seen to be 'abnormal' which, results in the children feeling isolated. When children are accepted for who they are and what they are capable of doing, their self

esteem is enhanced, Andrews (2004). Lang (2006: 62) states that children who are motivated are more confident.

The second issue was that most hearing parents have difficulty communicating with their deaf children. Most hearing parents in South Africa cannot communicate with their deaf children, DEAFSA (2006). This means that deaf children are getting no form of language input until they start school. By this stage it is often too late for a deaf child to develop his/ her natural language, SASL, which is needed for the acquisition of other languages, such as English. Andrews et al. (2004: 83) states that many deaf children who come form hearing families with limited communication skills in the home have not had incidental and formal opportunities to develop metacognitive skills, which is beneficial to a deaf learner.

The third issue relates to the learners' background and socio-economic status. The educators stated that in some homes, there is only a mother or grandmother as the primary caregiver, whose priority is to go to work in order to meet the family's financial needs. Unfortunately, this results in there being little or no time for these children to interact with the mother or grandmother. Andrews et al. (2004: 166) discuss the importance of mother child communication for successful language development.

c) Resources

The third and last extrinsic factor to be discussed is resources. Learners' interactions with resources are important in determining how effectively they are able to acquire scientific knowledge, values and skills. Educators are sometimes reluctant to plan activities in the laboratory for deaf learners, as a result of the 'stereotypical' assumption that deaf learners are concrete thinkers, Schirmer (2001: 111). The barriers that deaf learners experience with literacy makes it difficult for them to access textbooks, worksheets and information from computers.

George stated that he has a laboratory, which he utilizes at present. He felt that the laboratory is not appropriately designed and has unsuitable furniture which makes it

difficult to conduct experiments and for learners to work in group activities. He added that some of the equipment needs to be upgraded and that the school does not have all the required apparatus. Michael stated that he thought the laboratory at his school is not used as it is supposed to be used. He felt that "the laboratory needs to be a specialist room and that learners' from all phases should be able to use it".

Kelly explained that the main difficulty she and the learners experience is that there is no laboratory and other equipment. She improvises with objects around the school. Elton and Celine commented that their respective laboratories are fully functional and contained adequate resources. All of the educators commented on the difficulty of working with textbooks, especially with literacy being a major issue. The educators also stated that they make their own notes in the form of worksheets and activity sheets, as the learners find it difficult to comprehend information from the textbooks.

Synthesis: Resources

In their discussion of resources, the educators commented on two issues. These were the science laboratory and textbooks. A brief description of the educators science laboratories are as follows:

George	Elton	Kelly	Celine	Michael
Laboratory does not have appropriate furniture and resources need to be upgraded	Laboratory is well equipped and fully functional	No laboratory	Laboratory is well equipped and fully functional	Laboratory does not have appropriate furniture and resources need to be upgraded

Table 4: Description of educators' science laboratories

As indicated by table 4, only two educators have well resourced science laboratories. One educator has no laboratory and the other two educators state that their science laboratory is in need of renovation and the equipment needs to be upgraded. Kelly discussed the

difficulties that her learners experience with experiments as a result of not having a laboratory. Lang and Propp (1982: 863) state that there is a relationship between the quality of facilities and the quality of instruction.

All of the educators indicated that their learners experience great difficulty working with the textbooks. This is largely due to the literacy challenges that deaf learners face. Lang (2006: 59) states that science teachers must take reading comprehension into consideration, especially in the use of textbooks. Research indicated by Sheetz (2004: 80) indicates that several factors pose potential comprehension problems for deaf readers, such as vocabulary, multiple meaning words and figurative language. In support of this Hodson (1993: 690), adds that learners with limited linguistic skills can become frustrated by the vocabulary emphasized in textbooks.

Educators stated that they develop their own notes and activity sheets, as learners cannot work from the textbooks. In addition, deaf children were taught aspects from the curriculum that the educator chose to teach. If an educator felt that a topic was too difficult, he/ she would leave it out and look for another topic. The Department of Education accepted this 'selective process' as no within the department was an expert on educating deaf children DEAFSA, 2006: 33). As a result, there has been an inconsistency in the content that educators teach to learners. DEAFSA (2006) is concerned about the unfair advantage that deaf learners have, where in some schools the learners are not being assessed on the complete amount of work. This does not constitute equity and equality and can create problems, such as employers having false expectations of deaf employees.

To summarize, this section on extrinsic factors it becomes necessary to understand the relationship between the extrinsic factors and the intrinsic factors. The three extrinsic factors identified, the science curriculum, parental involvement and resources determine not only the interest and motivation of learners in science education, but also the access that deaf learners have to science education. Harcombe (2003: 51) discusses Feuerstein's view of cognitive development. Harcombe (2003) states that, Feuerstein's work is based

on the premise that if interaction between adult and child is optimal, the child's cognition will be improved. If consideration is given to this notion of Mediated Learning Experience, in the education for deaf learners, then parents and educators have a key role to play in supporting deaf children to achieve their full potential.

4.2.4 Educator perspectives for 'the way forward'

This study was concerned with the investigation of science education for deaf learners from the educators' perspectives. During the course of the interview and in response to questions 11, 13 and 29 (refer to appendix 6 for interview schedule), the educators mentioned certain factors, which they believed would improve science education for deaf learners. These factors are categorized and presented as, (a) factors relating to educators, and (b) factors related to learners.

a) Factors related to educators

Firstly, educators stated that it would be beneficial if a forum were created for educators that teach science to deaf learners. At this forum, issues related to the pace of the learning outcomes and assessments, as well as uniformity of science sign language for terms, concepts and laws could be developed. Teaching methods and assessment strategies could also be discussed and successful methods/ strategies shared. Secondly, the suggestion was for educators to increase their knowledge about Deaf culture and become proficient in sign language.

b) Factors related to learners

The first issue related to learners pertains to the method of instruction. The educators suggested that 'experiential' type learning would be more appropriate for deaf learners. It was also mentioned that instructional strategies and learner activities should encourage learners abstract thought and ability to connections. The second issue relates to the actual content of the science curriculum. The educators had divergent views on 'what' deaf learners should be taught. The five educators can be clustered into three groups according to their perspectives. It was interesting that educators who had similar

characteristics were also of similar opinions (refer to table 3 for biographical details of educators).

The first cluster consists of Celine and Elton, who have both (1) taught up to grade twelve, (2) had experience in mainstream schools and (3) been teaching for more than twenty five years. They felt that in-depth 'pure' science is not suitable for deaf learners. They were of the opinion that science for deaf learners should be more relevant and practical so that the knowledge, skills and values can be used to the benefit of deaf learners in their daily lives. The educators mentioned activities related to chemicals in the kitchen and agricultural related science.

The second cluster consists of George and Kelly, who are fairly 'new' to the teaching profession. The characteristics that they have in common are that (1) they have taught grades seven eight and nine only, (2) they have never taught in a mainstream school and (3) they have been teaching for less than five years. They felt strongly that science for deaf learners should be included up to the FET band. They stated that this was necessary so that deaf learners may have equal career opportunities, such as becoming nurses and paramedics.

The last and third cluster consisted of Michael only. Michael's characteristics were that (1) he was teaching for fifteen years and (2) he had experience teaching science to deaf learners form grade four up to grade twelve. His suggestion was that science education for deaf learners should move away from 'textbook' learning to 'experiential' learning. He felt that activities should allow learners to 'experience' scientific phenomenon and arrive at their own conclusions. He also commented that deaf learners should not be treated differently from hearing learners; according to him, deaf learners should be encouraged to question the world around them. However, he added that in order for deaf learners to cope with science, their literacy needs to improve.

4.3 CONCLUSION

In this chapter I have presented the findings of my research. I have endeavoured to use the data to gain an understanding into the experiences of educators that teach science to deaf learners, as well as their perceptions of deaf learners' experiences with science education. What has emerged from the data is that there are issues that create challenges for both the educators and the learners.

These issues were categorically discussed as either intrinsic or extrinsic factors. The intrinsic factors included (a) literacy, (b) sign language, (c) interest and motivation and (d) assimilation. These factors are influenced to a large extent by the extrinsic factors, which include (a) the science curriculum, (b) parental involvement and (c) resources. According to McIntosh et al. (1994), deaf education is often concerned with the sign-speech controversy, bilingual- bicultural education that science education, while being of importance, is not regarded a priority in schools for the deaf. This has resulted in relatively little research, in comparison to other areas, being conducted in the area of science education for deaf learners, Lang (2006: 57).

It is significant to note that the key barrier to deaf learners acquiring scientific knowledge, values and skills is identified by the educators as being literacy. Although Moores, (2006: 45) states that, *Deafness per se has no effect on the acquisition of literacy skills*, he discusses possible reasons for deaf learners experiencing difficulty with literacy, such as, children with hearing loss as not identified as early as possible and deaf children and their families are not getting appropriate advice, training and support to help them establish effective communication and facilitate literacy skills.

Most hearing parents in South Africa cannot communicate with their deaf children and this means that deaf children are getting no form of language input until they start school. By this stage it is often too late for the deaf child to acquire the natural language foundation, SASL, DEAFSA (2006: 14). This is substantiated by Marschark et al. (2006: 180) who state that, "the relatively poor literacy achievement of deaf children is often ascribed to early language delays". In addition, deaf learners need to be able to read and

comprehend information. Schirmer (2001: 75) discusses the importance of metacognition in reading and also cites research which indicates that deaf learners benefit from metacognitive strategies. In their discussion of literacy and content subjects, Andrews et al. (2004: 100), state that very little research has been done on the ways deaf readers' use reading and writing in content subject areas, such as math, science and social studies. More research in this area is needed so as to plan relevant and meaningful strategies for deaf learners. Deaf learners may benefit from scaffolding.

Vygotsky, (1978: 86) describes the Zone of Proximal Development as,

> The distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers.

The implication here is that if adults want to assist deaf learners to reach their "full potential", they need to provide deaf learners with the necessary 'guidance' and learning opportunities. Educators can implement appropriate pedagogical actions, such as *cultural scaffolding*. This involves using students own culture and experiences to expand their intellectual horizons and academic achievement (Gay, 2002: 109). The role of the educator as a *cultural broker* (Aikenhead & Jegede, 1998: 10) who guides learners from their life-world to the science may also benefit deaf learners. In this way, the content of science can become accessible, meaningful and relevant for deaf learners.

Chapter Five

Summary and Conclusion

5.1 INTRODUCTION

Current literature indicates that a basic theory of instruction for deaf learners has not been defined (Lang, 2006: 57). Research studies (Hodson 1993, Atwater 1996, Aikenhead 1998 and Lemke 2000) indicate that many hearing learners often perceive science as uninteresting and irrelevant to their lives. The aim of this study was to explore educators' perspectives and perceptions of science education for deaf learners in Gauteng, a province in South Africa. Five educators that teach science to deaf learners, at four schools for the deaf, were selected as participants of the research study. The critical questions that were explored are, (1) What are the experiences of educators that teach science to deaf learners? and (2) What are the experiences of deaf learners in their acquisition of scientific knowledge, values and skills; as perceived by their educators?

5.2 THEMES THAT EMERGED FROM THE DATA

The data gathered in response to the critical questions revealed that there are challenges involved in science education, both for the educators that teach science to deaf learners, as well as the deaf learners themselves. The factors that create challenges for the educators and the factors that create challenges for the deaf learners directly influence each other. These factors are categorized as intrinsic and extrinsic factors. Figure 8 on the next page is a representation of the themes that emerged.

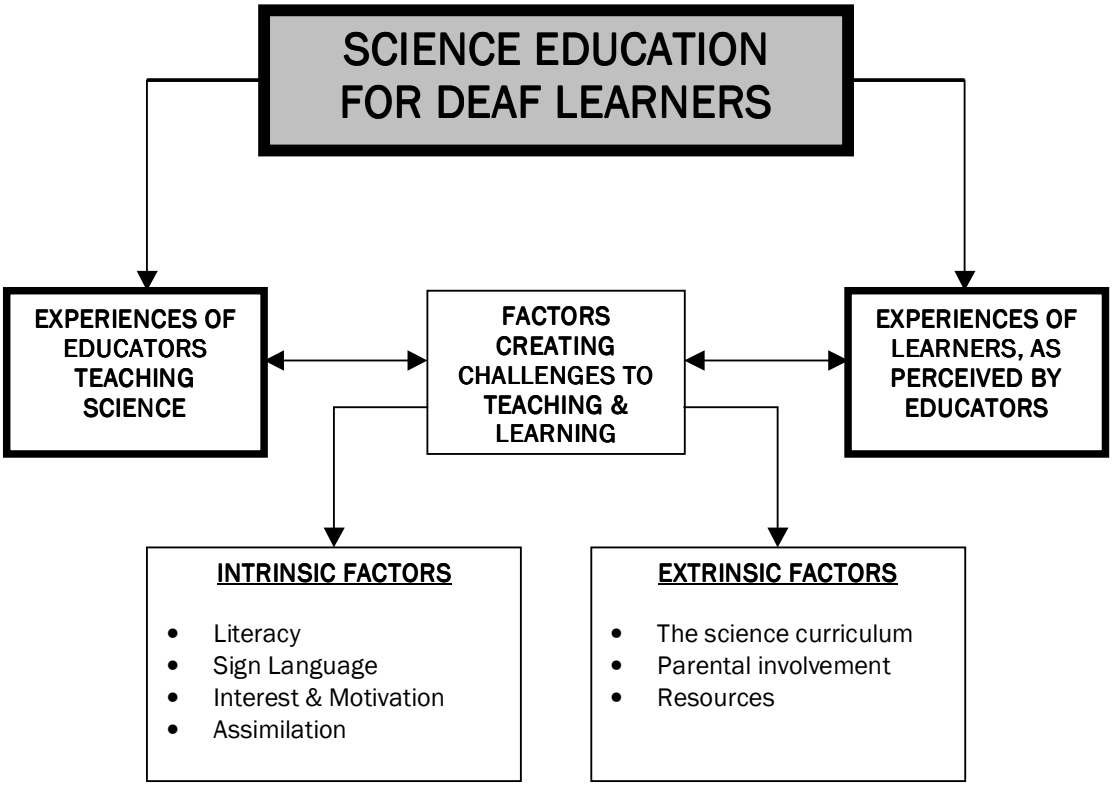


Figure 8: Factors influencing science education for deaf learners

The intrinsic factors included the following issues:

- Deaf learners difficulties with all aspects of literacy
- Challenges associated with sign language, such as lack of consistent signs and sign language not being recognized as an official language in South Africa
- Deaf learners not exhibiting motivation to study scientific knowledge, concepts and principles/ little interest to further their studies in the field of science
- Deaf learners difficulty in assimilating information and making associations

The extrinsic factors included the following issues:

- Deaf learners experiencing difficulty accessing the curriculum (as a result of the language/ content/ pace of teaching/ instructional style)
- Insufficient parental involvement and support/ motivation
- In some cases, a lack of adequate resources and apparatus

The challenges experienced by deaf learners with science education indicate that the intrinsic factors and extrinsic factors are of equal importance. In the next section I provide a summary of pertinent issues regarding science education for deaf learners.

5.3 SCIENCE EDUCATION FOR DEAF LEARNERS

An overview of the curriculum indicates that traditionally the field of education for deaf learners emphasized oral language skills, based on the flawed assumption that speech and language were equivalent (Moores, 2006: 41). According to McIntosh et al. (1994: 480) content based subjects, such as science received minimal emphasis. Eventually in 1975, science was introduced for deaf learners (Moores & Martin, 2006: 4). Although a basic theory of instruction for deaf learners in science has not been defined (Lang, 2006: 57), researchers are developing a body of knowledge related to science education for deaf learners.

In South Africa, deaf learners experience many challenges in accessing the science curriculum. One major challenge is as a result of their first language (SASL) not being recognized as an official language, DEAFSA (2006). This has resulted in educators that teach in schools for the deaf not being trained in sign language by the Department of Education. The consequence of educators not being trained by the Department of Education is that educators are not consistent in their signs and explanations of scientific terminology. According to a survey by DEAFSA (2006), only 14% of educators at schools for the deaf can sign proficiently.

Another challenge that deaf learners face with regards to the science curriculum pertains to literacy. It has been documented that deaf learners generally have difficulty with literacy (Lang & Albertini 2001, DEAFSA 2006 and Moores & Martin 2006). Thus, due to deaf learners difficulty with aspects of literacy (language, reading, writing), there is often the assumption that deaf learners are incapable of learning certain content based subjects, such as science. Although Moores (2006: 45) states that deafness per se has no effect on the acquisition of literacy skills, he discusses factors which are likely to result in deaf learners experiencing difficulty with literacy. These factors are (1) if children with

hearing loss are not identified as early as possible, (2) if deaf children and their families are not getting appropriate advice, training and support and (3) if teachers are not developing better ways to instruct deaf learners. Deaf learners' acquisitions of the various aspects of literacy are dependent on the parental involvement and support that they receive from their educators. Marschark et al. (2006: 180) state that the relatively poor literacy achievement of deaf learners is often ascribed to early language delays. Deaf children learn language from individuals (parents and family members) around them.

Research cited by Sheetz (2004: 80) indicates that several factors pose potential comprehension problems for deaf readers. These include vocabulary, multiple meaning words, figurative language and inferences. Schirmer (2001: 75) reiterates this, but also states that deaf learners benefit from instruction of metacognitive strategies. Studies that have examined the written language of deaf children highlight their lack of syntactic and semantic knowledge (Sheetz, 2004: 82). According to Sheetz (2004: 83), research indicates that mediated learning experiences help learners with writing difficulties. Other studies Schirmer (2001: 77) and Lang and Albertini (2001: 260) indicate that if the criteria of assessment of deaf learners writing is changed from only one criterion, correct usage of English sentence structure, to include other criteria, such as making ideas clear and descriptions, deaf learners do have creative writing ability.

According to McIntosh et al. (1994: 482), deaf children are less likely to have experienced "normal, unstructured" play, during which incidental learning takes place. Due to communication difficulties with their hearing parents, deaf children are also more likely to be excluded from activities such as reading, cooking or playing with their parents. As a result, deaf children are not developing the necessary schema, which they can use as a frame of reference. Vacca et al. (1999) state that schema provides a framework that allows learners to "organize" and "integrate" new information. Schirmer (2001: 104) states that deaf learners have been stereotypically characterized as concrete thinkers, which have led to teaching techniques that focus on narrower, more limited

approaches to thinking and learning. In this way, deaf learners are discouraged from problem solving.

In addition to the challenges that deaf learners face with sign language, literacy and assimilation, they are also learning science in a third or fourth language. This is explained as follows. Sign language is recognized as a deaf child' first language, English is their second language and 'science' is their third. Wellington and Osborne (2001) are of the opinion that many of the difficulties that children experience with science are due to the 'language' of science. In some cases, a deaf child's second language may be one other than English, such as Afrikaans or Xhosa, which makes English their third language and science their fourth.

Grossman and Stodolsky (1995: 237) state that teachers work in subject specific contexts and hold a number of subjects specific beliefs related to teaching and learning. Thus in subjects, such as science, educators may feel that only 'serious' learners are capable of learning science. Thus the role of the educator is instrumental in the direction that learners follow. According to McIntosh et al. (1994: 481), the teachers' interpretation of his or her role, what is taught, how it is taught, the teachers' beliefs and attitudes determine how the learners feel about themselves and their learning. In addition to being able to sign proficiently, educators that teach deaf learners need to be aware of the values, beliefs, prejudices and stereotypes related to deaf learners (Andrews, 2004: 130).

Gay (2002: 112) states that cultural characteristics provide the criteria for determining how instructional strategies should be modified for diverse students. Deaf children do not only belong to the Deaf community, but also to different racial, religious and gender groups which may affect their learning of science. Storbeck and Magongwa (2006: 120) use an illustration to explain the plurality of the deaf identity (this illustration is represented on page 19). Atwater (1996: 821) states that multicultural teaching implores teachers to use examples and content from a variety of cultures to make science more relevant and interesting. Other researchers, Fox and Gay (1995: 68) and Rodriguez (1998: 591) maintain that through multicultural education, individuals that have

traditionally been underrepresented can be empowered and social justice can be achieved in a pluralistic society. Ogunniyi (1997: 89) states that children from cultural groups who do not emphasize linear and verbal/ analytical forms of instruction are bound to under perform in the verbally dominant classrooms of South Africa. Ogunniyi (1997) is of the opinion that there should be more emphasis on developing more visually oriented instruction and to provide props for learning, especially by second or third language users.

In South Africa, the NCS was introduced by the democratic government to address the inequalities and injustices of the past education system. All learners now have access to the national curriculum. Whilst deaf learners also have equal access to the curriculum, they may not have equitable access to the curriculum. Deaf learners are experiencing great difficulty accessing the science curriculum due to the challenges that they face in education. These challenges (issues with sign language, literacy, assimilation, learning science as a third or fourth language, difficulty accessing the curriculum, insufficient parental involvement and inadequate resources) result in the pace of teaching and learning being slower than at mainstream schools.

The science curriculum has learning outcomes and assessment standards structured per grade, which also progress from one grade to the next. Deaf learners that do not complete the learning outcomes and assessment standards for a specific grade have to work harder so as to 'catch-up' on those that they have not completed. This results in many deaf learners becoming de-motivated and therefore unsuccessful at science. Hodson (1993: 690) states that learners with limited linguistic skills can become frustrated with terminology and the formal writing style, which can lead to withdrawal and alienation from science. Aikenhead and Jegede (1998: 10) discuss the metaphor "teacher as a cultural broker". A science teacher who is a cultural broker will guide learners from their life-world culture to the culture of science and help them resolve any conflicts. There may be a need for educators that teach science to deaf learners, to assume "cultural broker" roles in order to assist their deaf learners to be more successful in science.

5.4 RECOMMENDATIONS

As this study sought to explore science education for deaf learners, the recommendations focus on the stakeholders in the 'support system' for deaf learners. These include, (1) The Department of Education, (2) educators and (3) parents.

5.4.1 The Department of Education

In keeping with White Paper 6 (2001), the Department of Education needs to plan adequately to meet the needs of deaf learners. Department officials involved in this planning should have experience teaching at school/s for the deaf. In addition, at least one of the planners should be deaf so that valuable insight from an 'insider' perspective is gained. Organizations, such as DEAFSA should also be consulted. Aspects such as, (a) the curriculum, (b) training for educators and (c) resources should be examined and made to be more inclusive. These aspects will be discussed in detail.

(a) The curriculum

- The most important issue, which needs clarification, is when and if sign language is going to be recognized as an official language.
- The science curriculum needs to be appropriately structured for deaf learners. This would involve planning from the Foundation Phase→ Intermediate Phase→ Senior Phase→ FET Phase. Special consideration needs to be given to the timeframe for the achievement of Assessment Standards
- At present very few learners are choosing science as an option in the FET Phase. The Department of Education should investigate this. Science should be promoted for deaf learners, and adequate support must be shown, even if this requires introducing other learning areas related to the field of science, such as Horticulture.
- By the Department of Education providing deaf learners the support that they need, as listed in the point above, they would also incidentally be providing deaf learners with the opportunity to choose their careers. Thus deaf learners would also have the opportunity to study at tertiary institutions, in the field of science.

(b) Training for Educators

- Pre-service training should offer educators the option to be trained as specialists in the field of education. This would ensure that educators that work at schools for the deaf are adequately prepared, both theoretically and practically.
- In-service training should be provided for educators who are already employed at schools for the deaf. Training should include areas such as sign language, Deaf Culture as well as the subject specific revisions.
- Thereafter, in-service training should be conducted at least once every two years, to keep educators updated on the latest trends and successful strategies and methodologies for teaching deaf learners.

(c) Resources

- The Department of Education should ensure that all schools for the deaf have fully functional laboratories, where learners from all phases can benefit from activities conducted in the laboratories.
- A co-ordinated project should be undertaken between the Department of Education and the schools for the deaf. The aim of this project should be to assist educators to establish uniformity in their use of textbooks and workbooks and that their worksheets and assessments are consistent.
- If financial constraints allow, schools for the deaf should be provided with more visual resources, such as projectors and screens.
- The Department of Education needs to collaborate with the television channels to provide some National Geographic/ Wildlife programmes that are subtitled or have interpreters. This would allow deaf learners the opportunity to acquire scientific concepts incidentally and to build schema.
- There should be a website created for educators that teach science to deaf learners so that these educators can contact each other to share their experiences and support one another.

5.4.2 Educators

As already indicated [in section 5.4.1(b)], educators that teach at schools for the Deaf need to be trained. Adequate training for these educators includes relates to issues stated below:

- Educators need to understand the 'plurality of the deaf identity'. They need to be culturally responsive and consider the factors which influence deaf learners' learning of science. Educators should consider implementing multicultural science education to make science more meaningful to deaf learners.
- Educators need to understand that their expectations of their learners are significant. Therefore, they need to be encouraging and supportive, and not base their judgments of deaf learners based on assumptions, prejudices and stereotypes.
- As deaf learners generally have difficulty with literacy, science educators can use the content of science to promote, both 'English literacy' and 'science literacy'. The use of innovative strategies such as children' literature and journals in science classrooms may assist deaf learners to improve their skills in reading, writing, thinking, reflecting and problem-solving.
- Educators should not only focus on written assessments for deaf learners. Other methods of assessments should be included. These may include demonstrations, practical work and projects. Learners can be made aware of the weightings, with regards to the mark allocation of the different assessments.
- Educators need to be creative and innovative in their teaching. They need to determine which approach would be most suitable for their learners. This may involve using collaborative teaching, peer teaching, scaffolding, mediated learning experiences or graphic organizers.
- It may be of interest for educators teaching science to deaf learners in South Africa to explore the 'Instructional and Practical Communication' to teaching deaf learners. This was advocated by Stewart (2006) and the aim is to assist deaf children in learning content based subjects.
- It may be beneficial for educators to involve the community in deaf children's science education. This can be done by promoting community projects and

competitions, which involve team efforts of hearing and deaf people. Deaf adults can become involved and serve as role models for deaf learners.

5.5.2 Parents

Hearing parents of deaf learners need to understand the differences that their deaf child perceives between themselves and their family. Parents and other family members need to be sensitive not to exclude the deaf child from developing in a 'normal' way. Early intervention, such as the *Hi Hopes Programme* can assist families to empower themselves so that they are able to support the deaf child.

- Deaf children need to be stimulated and supported to develop literacy skills. Thus parents need to be proficient in sign language, which would enable them to communicate effectively with their child.
- Deaf children, like hearing children, should be allowed sufficient time for play and activities with parents/ adults, such as reading, storytelling, playing games and watching television or movies together. This would allow deaf learners to develop both language skills and cognitive ability.
- Parents need to accept their children for who they are and what they are capable of doing. This will allow deaf learners to develop positive self images. Like hearing children are all unique, so too are deaf children. Parents should not have a lowered expectation of their child because of their hearing loss as this would not allow their child to reach their full potential. On the other hand, parents should not have unrealistic expectations of their child as this would place the child under undue pressure.

5.5 FUTURE RESEARCH

This study endeavoured to find out the perspectives and perceptions of educators that teach science to deaf learners at four schools in Gauteng. The investigation revealed that there are factors which create challenges for the learners and the educators. These factors were categorized as intrinsic factors (which included literacy, sign language, interest & motivation and assimilation) and extrinsic factors (the science curriculum, parental

involvement and resources). However, as with all research, the investigation has raised other relevant issues, which need to be explored in future research. These are as follows:

- The LOLT for deaf learners in science education
- Parental involvement in science education for deaf learners
- Making science content more meaningful to deaf learners
- Deaf learners and multicultural science education
- Examining the assessment of deaf learners in science education
- Introducing metalinguistic and metacognitive strategies in science education
- Exploring assessment strategies for deaf learners in science

5.6 LIMITATIONS OF THE STUDY

In this research, it was not possible to interview all the educators in the province that teach science to deaf learners. There are two reasons for this. Firstly, as a result of educators being unavailable due to other commitments and secondly, the timeframe of the research did not allow for an extended period of time during which all educators teaching science could be accommodated.

It would also have been interesting to interview educators that teach science to deaf learners from other provinces, as well. This would have provided valuable insight into the similarities and differences in experiences pertaining to science education for deaf learners. The findings of this research give us reason to reflect on science education for deaf learners, however, I make no widespread generality of the research results as the research was exploratory and the sample group small.

5.7 CONCLUSION

Educating all learners to function and contribute to a world that increasingly depends on science and technology requires that science education be inclusive to deaf learners as well. Current perspectives in science education, such as Aikenhead (1996) *Border crossing*; Atwater (1996) *Multicultural science education*; Lemke (2000) *Socio-cultural perspectives in science* and Gay (2002) *Culturally responsive teaching*, advocate for the

science curriculum and instruction to accommodate learners of all races, genders and abilities.

The curriculum for deaf learners in the past did not emphasize content based subjects, such as science. As a result, research pertaining to science education for deaf learners is limited (Lang, 2006). In South Africa the introduction of the NCS allowed for deaf learners to have equal access to the curriculum. However, equal opportunities may not be the same as offering equity in education (Marschark et al., 200: 189). White Paper 6 (2001: 11) states that a new unified education system [NCS] must be based on equity, on redressing past imbalances and on progressive raising of the quality of education and training. However, deaf learners in South Africa continue to experience barriers to learning. These barriers include (1) the language or medium of instruction, (2) the teaching methods, (3) the pace of teaching and time available to complete the curriculum, (4) the learning materials and equipment that is used and (5) how learning is assessed.

According to DEAFSA (2006), the only language that can be the first language of deaf learners is not recognized as an official language. This results in a lack of uniformity in sign language, thus making it difficult for deaf learners to become literate and fully access the curriculum. Hearing parents and family members often have difficulty communicating with deaf children. Hence deaf children are getting little or no language input until they start school. By this stage, it is often too late for the deaf child to acquire the natural language foundation (SASL) needed for the acquisition of written languages, such as English (DEAFSA, 2006: 14). Deaf children also experience difficulty with literacy due to insufficient opportunities of 'normal' play and adequate support from adults (Moores: 2006).

The barriers that most deaf learners experience with accessing the curriculum often result in the pace of teaching being slower. Although the policy on inclusion, White Paper 6 (2001), states that allowances can be made for learners that require more time, this is not practically implemented as there is no specific guidelines on the time allowances. Concessions are given for specific tasks. These include the use of a sign language

interpreter, the use of video recording and additional time (up to 30 minutes per hour). However, there seems to be a misunderstanding of policy, as concessions are only implemented with regards to specific assessments, whereas it would be more beneficial to allow deaf learners more time in the actual teaching and learning process. This would give deaf learners more time to achieve the assessment standards for the different learning outcomes that have been set per grade. There also needs to be a shift in the focus of assessment strategies. Less emphasis should be placed on formal, written assessments, where the main criterion is correct usage of language structure.

Ogunniyi (1997: 88) states that, in terms of cognitive functioning, and despite copious criticism, verbal instruction is still dominant forms of instruction in South Africa. The language of instruction and examinations tend to favour students with high verbal, linear and analytical memoritor abilities than those with visual/ holistic abilities. Thus deaf learners who, according to research are good at visual processing (Marschark et al., 2006: 187), may under-perform in these verbally dominant classrooms.

Department of Education (2002: 4) states that the learning of science involves the development of process skills that may be used in everyday life, in the community and in the workplace. Through science education, learners develop the ability to think objectively, reason, investigate, reflect, analyze and synthesize. Deaf learners should not be excluded from the opportunity of developing these skills and having a good quality of life. Findings from my research indicate that science education poses challenges for many deaf learners. However, these challenges may not all be unique to deaf learners acquiring scientific knowledge, values and skills; rather they involve issues such as literacy, sign language, cognitive engagement, parental involvement and resources, which impact on deaf learners acquisition of knowledge in all areas. It is possible that deaf learners do understand scientific principles and concepts, but encounter difficulty communicating their abilities.

At present, people all over the world are faced with problematic situations, such as depleting resources, global warming, overpopulation, hunger, poverty and the AIDS

pandemic. In times of crisis (as we are now in) the challenge to refocus our values becomes a priority (Ogunniyi, 1997: 89). I am in agreement with Hodson (1993: 706), who states, "*We can reorient our science and technology away from the reckless pursuit of economic growth toward more humanitarian ends- the alleviation of human misery (poverty, hunger, poor health, political oppression, etc.) and toward the solving of current environmental problems and the establishment of environmentally sustainable technological practices*".

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Appendix 1: Letter of request

Attention: The Principal

My name is Sandra Naidoo and I teach at a Special school in Johannesburg South. The learning areas that I am involved in are Natural Science and Technology. I am currently completing my Master's Degree in Education at the University of Witwatersrand. My research report aims to investigate the implementation of science education in the curriculum for the Deaf.

The aim of the study is to explore the challenges that science educators experience when teaching Deaf learners and the added responsibility of ensuring that this is done, whilst considering the multicultural context in which South African schools are placed. My research will involve exploring firstly, the experiences of educators that teach science to deaf learners, and secondly some of their perceptions regarding deaf learners in science education.

I hereby request permission to conduct such research at your school. My proposed research will be conducted at schools in the latter half of 2007 and would take the form of interviews. The interviews will be conducted with educators, after school hours and at a time and place of their convenience. My research may involve classroom observations, after which learners may be interviewed. I would also appreciate being able to examine learners portfolios and the educators assessment records. Should you require any further information regarding the research, you may contact me on 083 468 9008 or at sandra.naidoo@webmail.co.za

Please give this request the due consideration. I look forward to a positive response from you.

Regards
Sandra Naidoo

Appendix 2: Request to Gauteng Department of Education

GAUTENG DEPARTMENT OF EDUCATION

RESEARCH REQUEST FORM

REQUEST TO CONDUCT RESEARCH IN INSTITUTIONS AND/OR OFFICES OF THE GAUTENG DEPARTMENT OF EDUCATION

1. **PARTICULARS OF THE RESEARCHER**

1.1	**Details of the Researcher**
Surname and Initials:	
First Name/s:	
Title (Prof / Dr / Mr / Mrs / Ms):	
Student Number (if relevant):	
ID Number:	
Gender (Male/Female):	

1.2	***Private Contact Details***
Home Address	**Postal Address (if different)**
Postal Code:	**Postal Code:**
Tel: ( )	
Cell:	
Fax: ( )	
E-mail:	

2. **PURPOSE & DETAILS OF THE PROPOSED RESEARCH**

2.1	**Purpose of the Research (Place cross where appropriate)**
Undergraduate Study – Self	
Postgraduate Study – Self	
Post-Doctoral Study	
Private Company/Agency – Commissioned by Provincial and/or National Government Department/s	
Private Research by Independent Researcher	
Non-Governmental Organisation	
National Department of Education Commissioned Study	
Commissions and Committees	
Independent Research Agency	
Statutory Research Agency	
Independent Study by Higher Education Institution	

2.2	**If Post-Graduate Study – Please indicate by placing a "X" in the appropriate column**	
Honours	***Masters***	***Doctorate***

2.3	**Full title of Thesis / Dissertation / Research Project**

2.4	**Value of the Research to Education (Attach Research Proposal)**

2.5	**Student and Postgraduate Enrolment Particulars (if applicable)**
Name of institution where enrolled:	
Degree / Qualification:	

Faculty:	
Department:	
Name of Supervisor / Promoter:	

2.6	**Employer (where applicable)**
Name of Organisation/School:	
Position in Organisation:	
Head of Organisation:	
Street Address:	
Postal Code:	
Telephone Number (Code + Ext):	
Fax Number:	
E-mail:	

2.7	**PERSAL Number (where applicable)**

3. **PROPOSED RESEARCH METHOD/S**

(Please indicate by placing a cross in the appropriate block whether the following modes would be adopted)

1. ***Questionnaire/s (If Yes, supply copies of each to be used)***

YES		**NO**	

2. ***Interview/s (If Yes, provide copies of each schedule)***

YES		**NO**	

3. ***Use of official documents***

YES		**NO**	

If Yes, please specify the document/s:

4. ***Workshop/s / Group Discussions. (If Yes, Supply details)***

YES		**NO**	

5. ***Standardised Tests (e.g. Psychometric Tests)***

YES		**NO**	
If Yes, please specify the test/s to be used and provide a copy/ies			

4. **RESEARCH PROCESSES**

1. ***Types of Institutions.*** **(Please indicate by placing a cross alongside all types of institutions to be researched).**

INSTITUTIONS	**Mark with "X" here**
Primary Schools	
Secondary Schools	
Technical Schools	
ABET Centres	
ECD Sites	
LSEN Schools	

Further Education & Training Institutions	
Other	

2. ***Number of institution/s involved in the study.*** **(Kindly place a sum and the total in the spaces provided).**

Type of Institution	**Total**
Primary Schools	
Secondary Schools	
Technical Schools	
ABET Centres	
ECD Sites	
LSEN Schools	
Further Education & Training Institutions	
Other	
GRAND TOTAL	

3. ***Name/s of institutions to be researched.*** **(Please complete on a separate sheet and append if space is deemed insufficient).**

Name/s of Institution/s

4. ***District/s where the study is to be conducted.*** **(Please mark with an "X").**

District	
Johannesburg East	

Johannesburg South	
Johannesburg West	
Johannesburg North	
Gauteng North	
Gauteng West	
Tshwane North	
Tshwane South	
Ekhuruleni East	
Ekhuruleni West	
Sedibeng East	
Sedibeng West	

NOTE:

If you have not as yet identified your sample/s, a list of the names and addresses of all the institutions and districts under the jurisdiction of the GDE is available from the department at a small fee.

5. ***Number of learners to be involved per school.*** **(Please indicate the number by gender).**

Grade	***1***		***2***		***3***		***4***		***5***		***6***	
Gender	**B**	**G**	**B**	**G**	**B**	**G**	**B**	**G**	**B**	**G**	**B**	**G**
Number												

6. ***Number of educators/officials involved in the study.*** **(Please indicate the number in the relevant column).**

Type of staff	**Educators**	**HODs**	**Deputy Principals**	**Principal**	**Lecturers**	**Office Based Officials**
Number						

7. ***Are the participants to be involved in groups or individually?*** **Please mark with an "X".**

Participation	
Groups	
Individually	

8. ***Average period of time each participant will be involved in the test or any other research activity*** **(Please indicate time in minutes)**

Participant/s	Activity	Time

9. ***Time of day that you propose to conduct your research.*** **Please mark with an "X".**

School Hours	During Break	After School Hours

10. ***School term/s during which the research would be undertaken.*** **Please mark with an "X".**

First Term	Second Term	Third Term

DECLARATION BY THE RESEARCHER
1. ***I declare that all statements made by myself in this application are true and accurate.***
2. ***I have read and fully understand all the conditions associated with the granting of approval to conduct research within the GDE, as outlined in the GDE Research Briefing Document, and undertake to abide by them.***

3. ***Should I fail to adhere to any of the approval conditions set out by the GDE, I would be in breach of the agreement reached with the organisation, and all privileges associated with the granting of approval to conduct research, would fall away.***

Signature:	
Date:	

DECLARATION BY SUPERVISOR / PROMOTER / LECTURER
I declare that: -
1. ***The applicant is enrolled at the institution / employed by the organisation to which the undersigned is attached.***
2. ***The overall research processes meet the criteria of:*** ○ ***Educational Accountability*** ○ ***Proper Research Design*** ○ ***Sensitivity towards Participants*** ○ ***Correct Content and Terminology*** ○ ***Acceptable Grammar*** ○ ***Absence of Non-essential / Superfluous items***

Surname:	
First Name/s:	
Institution / Organisation:	
Faculty:	
Department:	
Telephone:	
Fax:	
Cell:	
E-mail:	
Signature:	
Date:	

N.B. This form (and all other relevant documentation where available) may be completed and forwarded electronically to Ebrahim Farista (ebrahimf@gpg.gov.za) or Nomvula Ubisi (nomvulau@gpg.gov.za). The last 2 pages of this document must however contain the original signatures of both the researcher and his/her supervisor or promoter. These pages may therefore be faxed or hand delivered. Please mark fax - For Attention: Ebrahim Farista at 011 355 0512 (fax) or hand deliver (in closed envelope) to Ebrahim Farista (Room 911) or Nomvula Ubisi (Room 910), 111 Commissioner Street, Johannesburg.

Appendix 3: Consent and Confidentiality – School Principals

Part A: Letter of Consent

I ……. the principal of ……. School for the Deaf, have consented for my school to be a site of research in Sandra Naidoo's Master of Education studies. I have also granted permission for the educators to participate in the research. I understand that the data collected and analysed as a result of the research will form part of the main body of her Master's Research Report to be submitted to the School of Education at the University of the Witwatersrand. I understand that my school and educators will be guaranteed anonymity during the actual research process as well as in the final report.

…… ……
Principal's Signature Date

…… ……..
Researcher's Signature Date

Part B: Guarantee of Confidentiality

I, Sandra Naidoo, hereby guarantee anonymity and confidentiality to the school and staff of …….in their participation in my Master of Education research. Confidentiality will be guaranteed both, during and after the research process as well as in the final research report.

…… ……
Principal's Signature Date

……. ……..
Researcher's Signature Date

Appendix 4: Briefing guidelines for Educators

Introduction

My name is Sandra Naidoo and I have been a Natural Science educator at a school for the Deaf for nine years. I am completing my Masters Degree in Education at the University of the Witwatersrand and as such I am conducting an inquiry into deaf learners and science education.

I am interested in exploring:

(1) The experiences of educators that teach science to deaf learners.

(2) The experiences of deaf learners in science education as perceived by their educators.

Participation

As a science educator of deaf learners, you do not have to participate. Your participation is totally voluntary. Interviews will be conducted, which will be audio-taped and transcribed. The research will require you to offer your opinions, feelings, experiences and perceptions about the teaching and learning of science to deaf learners. You can refuse to answer any question or offer any information at any point in the research process. This study will be conducted after school hours, at a convenient time and place for you. I would also like to examine the science curriculum at your school, teacher plans, and schedules of work, learners' portfolios and your records of learner's assessments.

Benefits

Firstly, research findings will be used in my M Ed. Research Report. Secondly, your participation and input could help with future planning in science education for deaf learners. This may result in an improvement of policy, practice and the development more inclusive resource materials for Deaf learners.

There are no risks involved for the participants.

Confidentiality

Any information that you exchange in this research is confidential. To ensure confidentiality, no identifying information about you will be recorded in the research findings. Pseudonyms will be used for the participants and the schools that they are located in. Research records will only be used for the purposes of this study and for the writing up of my M Ed research report. These will be destroyed after I have completed my report.

Concerns

If you have any questions about this study or your rights as a research participant, you may contact:

- Sandra Naidoo on 083 468 9008
- Dr. Claudine Storbeck, School of Education, University of Witwatersrand on 011 7173750

Appendix 5: Consent & Confidentiality – Participants

Part A: Consent from participants

I ……. have consented to participate in Sandra Naidoo's Master of Education studies. I understand that the data collected and analysed as a result of the research will form part of the main body of her Master's Research Report to be submitted to the School of Education at the University of the Witwatersrand. I also understand that her studies will be used for educational purposes. I understand that I will be guaranteed anonymity during the actual research process as well as in the final research report.

By signing this, I consent to the following - [Tick the relevant block/s]:

- ☐ To be interviewed by the researcher
- ☐ To be tape-recorded by the researcher
- ☐ To be observed by the researcher, whilst teaching science
- ☐ To the researcher viewing my records of learner assessments and learners portfolios

I expect to be given a copy of this consent form to keep.

…… ……

Participant's Signature Date

…… ……

Researcher's Signature Date

Part B: Guarantee of Confidentiality

I, Sandra Naidoo, hereby guarantee anonymity and confidentiality to

……. in his / her participation in my

Master of Education research at …….. School for the deaf.

Confidentiality will be guaranteed both, during and after the research process as well as in the final research report.

…… ……

Participant's Signature Date

…… …. ……..

Researcher's Signature Date

Appendix 6: Interview Schedule for Educators

Biographical Details

1 How long have you been teaching science? _____

2 How long have you been teaching science in a school for the Deaf? _____

3 Have you taught science in a mainstream school and for how long?

_____

4 What grades have you taught and for how long?

_____

5 What is your highest level of qualification? Please state specify according to:

5.1 Science Education

_____

_____

5.2 Deaf Education

_____

_____

_____

5.3 Other

_____

Teaching experiences

6 What are some of your experiences when teaching in a mainstream school? (if yes to Q3)

_____

_____

_____

_____

7 What are your experiences when teaching science to Deaf learners?

_____

_____

_____

_____

8 What are your perceptions of hearing learners' attitudes towards learning science?

_____

_____

_____

9 What are your perceptions of deaf learners' attitudes towards learning science?

_____

_____

_____

10 If the teacher states learners experience some of the difficulties in Q9 – What are some reasons for learners experiencing challenges in the learning of science?

_____

_____

_____

11 How can we, as educators assist deaf learners to overcome these barriers or challenges? (What are your ideas and possible solutions?)

_____

_____

_____

_____

12 Have you always taught science? / How did you start teaching science at this school?

_____

_____

_____

_____

13 Any other comments about science education for Deaf learners.

_____

_____

_____

Infrastructure of the school

14 Approximate the race of the learner population in your science class according to percentages:

Race	Percentage	Language
White		
Coloured		
Indian		
Black		
Other		

15 What language is dominant as the first language of the learners in your class?

_____

16 What language is dominant as the second language of the learners in your class?

_____

17 What is the language policy regarding the instruction of learners at your school?

_____

_____

_____

18 What do you think of the resources available for the Deaf?

_____

_____

_____

19 How do you feel about your school laboratory and science equipment?

_____

_____

_____

_____

21 How is your school classified? (School for the Deaf/ Special School)

_____

22 What is the learner population at your school? (Approximate in percentage)

Deaf	
Hard of Hearing	
Hearing	
Learning Disability	
Other	

23 What grades/ phases does the school cater for?

_____

_____

24 If the school caters for FET, is science offered as an option for deaf learners this year? _____

25 If yes to question 24, how many learners have chosen science this year?

_____

26 Does the school follow the National Curriculum Statements in the teaching of science? _____

27 If yes to question 26, how does the school implement the various aspects of the science curriculum – are there any specific methods/ learners assessments?

_____

_____

_____

_____

28 If no to Q4, please state the curriculum that the school uses.

_____.

29 Any concluding comments…

_____

_____

_____

Appendix 7: Natural Science Curriculum

Learning Outcome 1 most clearly represents Critical Outcome 6. It also gives meaning to Critical Outcome 1 by emphasising that learners should increasingly formulate questions and problems for themselves. Furthermore, when learners do investigations they build Critical Outcomes 2, 3, 4, and 5.

Learning Outcome 2 most clearly represents Critical Outcomes 4 and 5. The activities required to build Learning Outcome 2 also reflect Developmental Outcome 1.

Learning Outcome 3 most clearly represents Critical Outcomes 6 and 7. It also contributes to building Developmental Outcomes 2 and 3.

The meaning of the Learning Outcomes and their relationship to the Assessment Standards

In this section, each Learning Outcome is examined, first in terms of its meaning, and second in terms of its relationship to progression in the Assessment Standards.

Learning Outcome 1: Scientific Investigations

The learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and environmental contexts.

Meaning

Competence in this Learning Outcome can be seen as the learner searches for information from books and resource people, generates products and questionnaires, collects data and materials from nature or industry, creates testable questions and fair tests, and explains conclusions. The learner shows initiative and puts his or her mind to practical problems of at least four kinds:

- *problems of making:* e.g. 'How can we make a very sensitive thermometer?' or 'How can we make our own magnetic compass?' or 'How can we make a system that will give water to a plant automatically?' or 'How can we make a solar-energy oven?'
- *problems of observing, surveying and measuring:* e.g. 'How can we find out what nocturnal animals do at night?' or 'How could we find out which kinds of fuel people in this area use?' or 'What do successful gardeners do to get a good crop?' or 'How can we measure the volume of a drop of water?' or 'How much water does a plant lose in a day?' or 'How can we show the change in the position of Venus each morning?
- *problems of comparing:* e.g. 'Which liquid soap is the best?' or 'Which cloth will keep you warmest on a cold day?' or 'Which glue is the strongest?' or 'Which batteries are the most economical?'
- *problems of determining the effect of certain factors*: e.g. 'What is the effect of increased dropping height on how high a ball bounces?' or 'What is the effect of making the water hotter when you dissolve sugar?' or 'Which conditions make seeds germinate fastest?' or 'Do the roots of seedlings grow downward because the water is down below?'

Each kind of problem calls for conceptual knowledge of science, as well as creative thought and systematic testing of ideas. The four kinds of problem listed here overlap, of course. For example, to determine the effect of changing one factor, the learner needs to set up a fair way of comparing the effects as that factor is varied. The four kinds of problems represent a range of the kinds of intellectual demands that Learning Outcome 1 makes on learners.

Relationship to Assessment Standards

Progress in this Learning Outcome is seen in terms of increasing competence in perceiving, describing and testing relationships between variables. The Assessment Standards reflect this increasing growth in competence. By the end of Grade 9, the learner will have a good understanding of a variable as a factor which might influence a situation, and be able to describe how a change in one variable may cause a change in another variable. The learner will also be able to apply that knowledge to simple problem solving. The learner's imagination, curiosity and ability to ask good questions will increase and broaden. The learner's skill at doing practical work and evaluating investigations, or judging whether an investigation was a fair test of an idea, will also increase. The section on 'Process Skills across the three Learning Outcomes' later in this chapter gives more detail on the kind of activities which build competence in this Learning Outcome.



Learning Outcome 2: Constructing Science Knowledge

The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.

Meaning

The learner's competence in this Learning Outcome can be seen in the ability to collect or extract information from various sources, and then to organise and analyse that information. The learner is building a framework of knowledge by using science concepts repeatedly in a widening range of situations. The learner sees the usefulness of concepts which explain a range of phenomena and link a range of ideas. Building this competence involves process skills such as interpreting information by interrogating pictures and diagrams, transforming information from one form to another (e.g. from text to a graph or vice versa), looking for patterns in data, or expressing a relationship between two variables. (The section on 'Process Skills across the three Learning Outcomes' later in this chapter gives more detail on the kind of activities which build competence in this Learning Outcome.)

Relationship to Assessment Standards

The Assessment Standards for Learning Outcome 2 appear later in this chapter, and in more detail in Chapters 3 and 4. Note that this Learning Outcome is not assessed in the Foundation Phase.

- The simplest expression of this Learning Outcome, but an essential one, is that *the learner can recall meaningful information when it is needed*. All learners from Grades 4 to 9 must be able to do this. This Revised National Curriculum Statement does not want learners to memorise material which has no meaning or connections for them; however, this Learning Outcome recognises that the ability to retrieve connected ideas is still a valuable intellectual skill.

- The next expression of this outcome is *categorisation*. Categorisation is used extensively in science because it is an effective intellectual tool for reducing the great complexity which scientists find in nature. Categorisation is a general term encompassing the more well-known terms 'sorting', 'grouping' and 'classifying'.

- A more advanced ability is comprehension, shown in the *interpretation of information*. The learner must be able to change the information from one form to another (e.g. from words to numbers or graphs), explain it in her or his own words, find appropriate examples of it, make inferences and predictions from it, and relate it to other information.

- The next higher level of ability is *application of knowledge*. Application means the ability to select and use knowledge in new and unfamiliar situations. This often means selecting and correctly using concepts, rules, methods, formulae and theories to produce an answer or product.

These are minimum expectations, of course. At any grade, teachers can call for higher levels of understanding, such as analysis, synthesis and evaluation.



Learning Outcome 3: Science, Society and the Environment

The learner will be able to demonstrate an understanding of the interrelationships between science and technology, society and the environment.

Meaning

This is a challenging Learning Outcome, with potential to broaden the curriculum and make it distinctively South African. Its meaning is examined under four headings:

- *Education should help people to become problem solvers*: Whereas Learning Outcome 1 calls for problem solving of closely-defined problems, Learning Outcome 3 calls for the learner to become a scientific problem solver in the context of South African society. The learner will be an adult in a society which faces many problems; the society needs creative thinking to find new solutions, as well as steady application of old solutions that are still effective. Whereas traditional education places a high value on the learner knowing answers to standard questions, this Revised National Curriculum Statement also places value on the learner being able to solve problems and think of ethical alternatives. Alternatives can come from completely new ideas, from adaptations of current ideas and practices in other societies, or by revisiting traditional practices and technologies.

- *Traditional technologies may reflect people's wisdom and experience*: Indigenous or traditional technologies and practices in South Africa were not just ways of working; they were ways of knowing and thinking. Traditional technologies and practices often reflect the wisdom of people who have lived a long time in one place and have a great deal of knowledge about their environment. Wisdom means that they can predict the long-tem results of decisions, and that they can recognise ideas which offer only short-term benefits. Much valuable wisdom has been lost in South Africa in the past 300 years, and effort is needed now to rediscover it and to examine its value for the present day.

Knowledge and wisdom can be lost as new technologies become popular, or as people move away from their well-known environments. In the past, in South Africa and in Africa as a whole, people were moved off their land or pressed to take up other kinds of work or to farm unfamiliar crops for export. Established practices were changed, stable societies were broken up, and knowledge was no longer taught in the context where it applied. In this way, much knowledge was lost.

The movement of people nowadays and the impact of new technologies still results in knowledge being fragmented and lost. Sometimes it is passed on but it is abstract, without the context for understanding and applying it. (For example, detailed traditional knowledge about the soil is hard to teach to people who no longer depend on the soil.) Perhaps people who have that knowledge are no longer respected because their knowledge does not seem to be relevant to the modern world.

Given this history, it is fitting that traditional and indigenous knowledge systems should be included among the ideas the learner examines when building Learning Outcome 3.

- *The scientific and technological choices people make reflect their values*: The values of people are seen in the ways they choose to deal with problems, and even in the choice of issues which they define as problems. For example, in our society not long ago, disabled people were not recognised as having a full right to participate in society - their difficulties were simply not seen as problems which needed solutions. Learning Outcome 3 requires that the learner acquires increased understanding of the way values influence people's choices of technological and scientific solutions.

- *Different world-views are usually present in the science classroom*: One of the underlying differences between modern science and technology on the one hand, and traditional and indigenous knowledge systems on the other hand, is the existence of different world-views. The prevailing world-view of science is based on empiricism. Very briefly, empiricism believes that a scientist can observe things objectively, without influencing the event being observed or being influenced by it. Empiricism believes that if something can be observed and measured in some way, it is real and can be used to explain why events happen in nature. On the other hand, empiricism believes that those things which cannot be observed and measured are of no value in explaining why events happen.

  Empiricism fuelled the growth of modern science over the past 400 years and has been remarkably effective in generating accurate and reliable knowledge about the natural world. As an approach to understanding nature, it is used in research and science education in all countries of the world. It is challenged by those who argue that pure empirical science does not concern itself with questions of meaning and value, and is therefore too limited a way of understanding the world.

  There are other world-views. For example, in South Africa many people hold a strong world-view which says that people are not separate from the earth and its living things; they believe that all things have come from God or a creative spirit and therefore have spiritual meaning; events happen for spiritual as well as physical reasons. Traditional and indigenous knowledge systems and technologies developed within this system of thought. They were closely connected to the physical and social environment in which people lived and were thus sensitive to impacts on that environment. Nowadays, many commentators see this as a strength of indigenous knowledge systems and argue that there is much to learn from these ways of knowing.



Learning Outcome: 1 Scientific Investigation

The learner will be able to act confidently on curiosity about natural phenomena, and to investigate relationships and solve problems in scientific, technological and enviromental contexts.

Grade R Level	Grade 1 Level	Grade 2 Level	Grade 3 Level	Grade 4 Level
Planning investigations				
Learner contributes towards planning an investigative activity.	Learner plans an investigation independently.	Learner plans an investigation as part of group.	Learner uses materials selected by the group in order to communicate the group's plan.	Learner contributes ideas of familiar situations, needs or materials, and identifies interesting aspects which could lead to investigations.
Conducting investigations and collecting data				
Learner participates in planned activity.	Learner independently participates in planned activity.	Learner participates in planned activity independently or as part of a group.	Learner participates constructively in the activity with understanding of its purpose.	Learner explores the possibilities in available materials, finding out how they can be used.
Evaluating data and communicating findings				
Learner thinks and talks about what has been done.	Learner thinks about what has been done and says what has been found out.	Learner shows and explains what was intended and how it was done.	Learner explains and reflects on what action was intended, and whether it was possible to carry out the plan.	Learner talks about observations and suggests possible connections to other situations.

Grade 5 Level	Grade 6 Level	Grade 7 Level	Grade 8 Level	Grade 9 Level
Planning investigations				
Learner lists, with support, what is known about familiar situations and materials, and suggests questions for investigation.	Learner helps to clarify focus questions for investigation and describes the kind of information which would be needed to answer the question.	Learner plans simple tests and comparisons, and considers how to make them fair.	Learner identifies factors to be considered in investigations and plans ways to collect data on them, across a range of values.	Learner plans a procedure to test predictions or hypotheses, with control of an interfering variable.
Conducting investigations and collecting data				
Learner carries out instructions and procedures involving a small number of steps.	Learner conducts simple tests or surveys and records observations or responses.	Learner organises and uses equipment or sources to gather and record information.	Learner collects and records information as accurately as equipment permits and investigation purposes require.	Learner contributes to systematic data collection, with regard to accuracy, reliability and the need to control a variable.
Evaluating data and communicating findings				
Learner reports on the group's procedure and the results obtained.	Learner relates observations and responses to the focus question.	Learner generalises in terms of a relevant aspect and describes how the data supports the generalisation.	Learner considers the extent to which the conclusions reached are reasonable answers to the focus question of the investigation.	Learner seeks patterns and trends in the data collected and generalises in terms of simple principles.



Learning Outcome 2: Constructing Science Knowledge

The learner will know and be able to interpret and apply scientific, technological and environmental knowledge.

Grade 4 Level	Grade 5 Level	Grade 6 Level
Recalling meaningful information when needed		
Learner, at the minimum, uses own most fluent language to name and describe objects, materials and organisms.	Learner, at the minimum, uses own most fluent language to name and describe features and properties of objects, materials and organisms.	Learner, at the minimum, describes the features which distinguish one category of thing from another.
Categorising information to reduce complexity and look for patterns		
Learner sorts objects and organisms by a visible property.	Learner creates own categories of objects and organisms, and explains own rule for categorising.	Learner categorises objects and organisms by two variables.
Interpreting information		
(There are no further Assessment Standards for this Learning Outcome in Grade 4.)	(There are no further Assessment Standards for this Learning Outcome in Grade 5.)	Learner, at the minimum, interprets information by using alternative forms of the same information.
Applying knowledge to problems that are not taught explicitly		
(There are no further Assessment Standards for this Learning Outcome in Grade 4.)	(There are no further Assessment Standards for this Learning Outcome in Grade 5.)	(There are no further Assessment Standards for this Learning Outcome in Grade 4.)

Grade 7 Level	Grade 8 Level	Grade 9 Level
Recalling meaningful information when needed		
Learner, at the minimum, recalls definitions and complex facts.	Learner, at the minimum, recalls procedures, processes and complex facts.	Learner, at the minimum, recalls principles, processes and models.
Categorising information to reduce complexity and look for patterns		
Learner compares features of different categories of objects, organisms and events.	Learner applies classification systems to familiar and unfamiliar objects, events, organisms and materials.	Learner applies multiple classifications to familiar and unfamiliar objects, events, organisms and materials.
Interpreting information		
Learner interprets information by identifying key ideas in text, finding patterns in recorded data, and making inferences from information in various forms such as pictures, diagrams and text.	Learner interprets information by translating tabulated data into graphs, by reading data off graphs, and by making predictions from patterns.	Learner interprets information by translating line graphs into text descriptions and vice versa, by extrapolating from patterns in tables and graphs to predict how one variable will change, and by identifying relationships between variables from tables and graphs of data, and by hypothesising possible relationships between variables.
Applying knowledge to problems that are not taught explicitly		
Learner applies conceptual knowledge by linking a taught concept to a variation of a familiar situation.	Learner applies conceptual knowledge to somewhat unfamiliar situations by referring to appropriate concepts and processes.	Learner applies principles and links relevant concepts to generate solutions to somewhat unfamiliar problems.

Learning Outcome 3: Science, Society and the Environment

The learner will be able to demonstrate an understading of the interrelationships between science and technology, society and the environment

Grade 4 Level	Grade 5 Level	Grade 6 Level
Understanding science and technology in the context of history and indigenous knowledge		
Learner describes how local indigenous cultures have used scientific principles and technological products for specific purposes.	Learner identifies ways in which products and technologies have been adapted from other times and cultures.	Learner describes similarities in problems and solutions in own and other societies in the present, the past and the possible future.
Understanding the impact of science and technology on the environment and on people's lives		
Learner identifies features of technological devices around him or her, and tells about their purpose and usefulness.	Learner identifies the positive and negative effects of scientific developments or technological products on the quality of people's lives and/or the environment.	Learner suggests ways to improve technological products or processes and to minimise negative effects on the environment.
Recognising bias in science and technology which impacts on people's lives		
Learner identifies difficulties some people may have in using technological devices.	Learner describes the impact that lack of access to technological products and services has on people.	Learner suggests how technological products and services can be made accessible to those presently excluded.

Grade 7 Level	Grade 8 Level	Grade 9 Level
Understanding science as a human endeavour in cultural contexts		
Learner compares differing interpretations of events.	Learner identifies ways in which people build confidence in their knowledge systems.	Learner recognises differences in explanations offered by the natural sciences and other systems of explanation.
Understanding sustainable use of the Earth's resources		
Learner analyses information about sustainable and unsustainable use of resources.	Learner identifies information required to make a judgement about resource use.	Learner responds appropriately to knowledge about the use of resources and environmental impacts.

CHAPTER 5
CORE KNOWLEDGE AND CONCEPTS

INTRODUCTION

As stated in Chapter 1, the Natural Sciences Learning Area comprises a wide variety of fields of inquiry. Because of this diversity, it is not possible to list all science knowledge under one heading. In this Revised National Curriculum Statement, the fields which scientists study have been grouped into four main content areas:

- *Life and Living* focuses on life processes and healthy living, on understanding balance and change in environments, and on the importance of biodiversity.
- *Energy and Change* focuses on how energy is transferred in physical and biological systems, and on the consequences that human needs and wants have for energy resources.
- *Planet Earth and Beyond* focuses on the structure of the planet and how the earth changes over time, on understanding why and how the weather changes, and on the earth as a small planet in a vast universe.
- *Matter and Materials* focuses on the properties and uses of materials, and on understanding their structure, changes and reactions in order to promote desired changes.

Several points should be noted about the core knowledge statements which comprise this Chapter.

- These core knowledge statements are neither Learning Outcome statements nor Assessment Standards.
- The statements are core, minimum knowledge for Learning Programmes in the Natural Sciences Learning Area. Learning Programmes must draw content from all four strands over a Phase.
- This core knowledge is applicable when doing all three Learning Outcomes. By Grade 9, every learner should be able to interpret and apply these concepts in both familiar and somewhat unfamiliar situations.
- The core knowledge statements may be clustered and taught in various sequences.
- The knowledge statements for the Intermediate and Senior Phases represent a notional 70% of the time in a Phase's Learning Programme. The other 30% of the time should be used to extend these minimum knowledge statements; alternatively, science content from contexts which are significant to the learners and the local community may be used. These contexts may be economic, environmental, social or health matters, for example.
- The core knowledge statements represent four major fields of scientific study, and these have been refined into sub-strands. Each sub-strand is summarised by a general proposition or unifying statement; the unifying statement could be explored at increasing depth in the General Education and Training Band of schooling, in Further Education and Training, and in Higher Education. The unifying statement also provides a broad statement under which further content which may be added in terms of the 30% time for local options.

CORE KNOWLEDGE AND CONCEPTS IN LIFE AND LIVING

Life Processes and Healthy Living	Interactions in Environments	Biodiversity, Change and Continuity
Unifying statement: Living things, including humans and invisibly small organisms, can be understood in terms of life processes, functional units and systems.	*Unifying statement: Organisms in ecosystems are dependent for their survival on the presence of abiotic factors and on their relationship with other organisms.*	*Unifying statement: The huge diversity of forms of life can be understood in terms of a history of change in environments and in characteristics of plants and animals throughout the world over millions of years.*
Foundation Phase		
❖ Many of our body parts correspond to parts of animals, such as limbs, heads, eyes, ears, feet, and in many cases animals use them for the same purposes we do. ❖ Animals and plants have needs similar needs to ours, for food, water and air.	❖ We depend on plants and animals for food, and we breed certain animals and grow certain plants as crops. ❖ We see cultural diversity in the kinds of food people like to eat. ❖ Some animals, like flies and ticks, carry germs which can make people sick.	❖ There is a large variety of plants and animals, which have interesting visible differences but also similarities, and they can be grouped by their similarities. ❖ Plants and animals change as they grow, and as the years pass, and as the seasons change.
Intermediate Phase		
❖ Green plants produce their own food and grow by using water and substances from the air and soil. Energy from light is needed to change these simple substances into food and plant material. Green plants are the only organisms that can produce food in their own bodies.	❖ Animals cannot make their own food, and so some animals eat plants for food while some animals eat other animals. All animals ultimately depend on green plants for their food. ❖ Ecosystems are self-contained areas where a wide variety of plant and animal species live and reproduce. They depend on each other and on the non-	❖ New plants can grow from certain parts of a parent plant. This is called vegetative reproduction and does not need seeds. The new plants have all the characteristics of the parent plant.

CHAPTER 5
CORE KNOWLEDGE AND CONCEPTS

INTRODUCTION

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- *Planet Earth and Beyond* focuses on the structure of the planet and how the earth changes over time, on understanding why and how the weather changes, and on the earth as a small planet in a vast universe.
- *Matter and Materials* focuses on the properties and uses of materials, and on understanding their structure, changes and reactions in order to promote desired changes.

Several points should be noted about the core knowledge statements which comprise this Chapter.

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- This core knowledge is applicable when doing all three Learning Outcomes. By Grade 9, every learner should be able to interpret and apply these concepts in both familiar and somewhat unfamiliar situations.
- The core knowledge statements may be clustered and taught in various sequences.
- The knowledge statements for the Intermediate and Senior Phases represent a notional 70% of the time in a Phase's Learning Programme. The other 30% of the time should be used to extend these minimum knowledge statements; alternatively, science content from contexts which are significant to the learners and the local community may be used. These contexts may be economic, environmental, social or health matters, for example.
- The core knowledge statements represent four major fields of scientific study, and these have been refined into sub-strands. Each sub-strand is summarised by a general proposition or unifying statement; the unifying statement could be explored at increasing depth in the General Education and Training Band of schooling, in Further Education and Training, and in Higher Education. The unifying statement also provides a broad statement under which further content which may be added in terms of the 30% time for local options.

CORE KNOWLEDGE AND CONCEPTS IN LIFE AND LIVING

Life Processes and Healthy Living	Interactions in Environments	Biodiversity, Change and Continuity
Unifying statement: Living things, including humans and invisibly small organisms, can be understood in terms of life processes, functional units and systems.	*Unifying statement: Organisms in ecosystems are dependent for their survival on the presence of abiotic factors and on their relationship with other organisms.*	*Unifying statement: The huge diversity of forms of life can be understood in terms of a history of change in environments and in characteristics of plants and animals throughout the world over millions of years.*
Foundation Phase		
❖ Many of our body parts correspond to parts of animals, such as limbs, heads, eyes, ears, feet, and in many cases animals use them for the same purposes we do. ❖ Animals and plants have needs similar needs to ours, for food, water and air.	❖ We depend on plants and animals for food, and we breed certain animals and grow certain plants as crops. ❖ We see cultural diversity in the kinds of food people like to eat. ❖ Some animals, like flies and ticks, carry germs which can make people sick.	❖ There is a large variety of plants and animals, which have interesting visible differences but also similarities, and they can be grouped by their similarities. ❖ Plants and animals change as they grow, and as the years pass, and as the seasons change.
Intermediate Phase		
❖ Green plants produce their own food and grow by using water and substances from the air and soil. Energy from light is needed to change these simple substances into food and plant material. Green plants are the only organisms that can produce food in their own bodies.	❖ Animals cannot make their own food, and so some animals eat plants for food while some animals eat other animals. All animals ultimately depend on green plants for their food. ❖ Ecosystems are self-contained areas where a wide variety of plant and animal species live and reproduce. They depend on each other and on the non-	❖ New plants can grow from certain parts of a parent plant. This is called vegetative reproduction and does not need seeds. The new plants have all the characteristics of the parent plant.

Life Processes and Healthy Living	Interactions in Environments	Biodiversity, Change and Continuity
❖ Living things need food for energy, to move, grow and to repair damage to their bodies ('tissues'). Animals including humans have digestive systems for getting nutrients from food. Humans need a balanced diet from certain groups of food to be healthy. ❖ All living things can respond to their environment in various ways; animals, including humans, have specialised sense organs. ❖ Living things can move themselves; animals, including humans, can move themselves from place to place. Many species of animals move themselves by means of muscles attached to some kind of skeleton, which is either inside or on the surface of the body.	living environment. The life and reproduction of all the organisms in an ecosystem depend on the continuing growth and reproduction of plants. ❖ Organisms' habitats are the places where they feed, hide, produce young and, in many cases, shelter the young until the young have a better chance of survival. Animal species live in their habitats in a variety of social patterns (such as being solitary, pairing for life, or living in packs, prides, herds, troops or colonies). ❖ Ecosystems depend on soil. Soil forms by natural processes from rock and dead plant and animal material, but it takes an extremely long time to form. Substances which plants take from the soil must be replaced to maintain fertility of the soil. *(Links with soil in Planet Earth and Beyond)* ❖ Water plays an important role in ecosystems, sustaining both plant and animal life. Industrial, agricultural and domestic activities may have a serious impact on the quality and quantity of water available in an area. *(Links with Planet Earth and Beyond)*	❖ Sexual reproduction is the process by which two individual plants or animals produce another generation of individuals. The next generation's individuals look like the parents but always have slight differences ('variation') from their parents and from each other. ❖ South Africa has a rich fossil record of animals and plants which lived many millions of years ago. Many of those animals and plants were different from the ones we see nowadays. Some plants and animals nowadays have strong similarities to fossils of ancient plants and animals. We infer from the fossil record and other geological observations that the diversity of living things, natural environments and climates were different in those long-ago times. *(Links with fossils in Planet Earth and Beyond)*

Life Processes and Healthy Living	Interactions in Environment	Biodiversity, Change and Continuity
Senior Phase		
❖ Humans go through physical changes as they age; puberty means that the body is ready for sexual reproduction. ❖ Human reproduction begins with the fusion of sex cells from mother and father, carrying the patterns for some characteristics of each. ❖ Conception is followed by a sequence of changes in the mother's body, and during this period the future health of the unborn child can be affected. ❖ Knowledge of how to prevent the transmission of sexually transmitted diseases, including the HIVirus, must be followed by behaviour choices. ❖ Green plants use energy from the sun, water and carbon dioxide from the air to make food by photosynthesis. This chemical reaction is central to the survival of all organisms living on earth. ❖ Animals, including humans, require protein, fat, carbohydrates, minerals, vitamins and water. Food taken in is absorbed into the body via the intestine. Surplus food is stored as fat or carbohydrate. ❖ Animals, including humans, have a circulatory system which includes the heart, veins, arteries and capillaries, and	❖ Human reproduction is more than conception and birth; it involves adults raising children, which requires judgement and values and usually depends on the behaviour of other people in a community and environment. ❖ Each species of animal has characteristic behaviours which enable it to feed, find a mate, breed, raise young, live in a population of the same species, or escape threats in its particular environment. These behaviours have arisen over long periods of time that the species population has been living in the same environment. ❖ All organisms have adaptations for survival in their habitats (such as adaptations for maintaining their water balance, obtaining and eating the kind of food they need, reproduction, protection or escape from predators.) ❖ An ecosystem maintains numerous food webs and competition for food among different individuals and populations. South Africa has certain ecosystems which have exceptional biodiversity. All uses of these areas must be based on principles of sustainable development	❖ Offspring of organisms differ in small ways from their parents and generally from each other. This is called variation in a species. ❖ Natural selection kills those individuals of a species which lack the characteristics that would have enabled them to survive and reproduce successfully in their environment. Individuals which have characteristics suited to the environment reproduce successfully and some of their offspring carry the successful characteristics. Natural selection is accelerated when the environment changes; this can lead to the extinction of species. ❖ Variations in human biological characteristics such as skin colour, height, and so on. have been used to categorise groups of people. These biological differences do not indicate differences in innate abilities of the groups concerned. Therefore, such categorisation of groups by biological differences is neither scientifically valid nor exact; it is a social construct. ❖ Biodiversity enables ecosystems to sustain life and recover from changes to the environment. Loss of

Life Processes and Healthy Living	Interactions in Environments	Biodiversity, Change and Continuity
which carries nutrients and oxygen to all parts of the body and removes waste products. Oxygen, which is provided by the breathing system, reacts with food substances to release energy. *(Links with Energy and Change)* • All living things, including humans, have means of eliminating waste products which are produced during life processes. Water plays an important role in this process. • Water makes up a large proportion of all living things, and their health depends on water passing through them in various ways, using structures (such as kidneys, skin or stomata) which can fulfil this function.	• Pollution interferes with natural processes that maintain the interdependencies and diversity of an ecosystem. • Many biological changes, including decomposition and recycling of matter in ecosystems and human diseases, are caused by invisibly small, quickly-reproducing organisms.	biodiversity seriously affects the capacity of ecosystems and the earth, to sustain life. Classification is a means to organise the great diversity of organisms and make them easier to study. The two main categories of animals are the vertebrates and invertebrates, and among vertebrates the five classes are amphibians, birds, fish, reptiles and mammals. • Human activities, such as the introduction of alien species, habitat destruction, population growth, pollution and over-consumption, result in the loss of biodiversity. This becomes evident when more species become endangered, or, ultimately, extinct. • Extinctions also occur through natural events. Mass extinctions have occurred in the past, suggesting that huge changes to environments have occurred. However, these changes occurred very slowly, compared to the fast rate at which humans can destroy plant and animal species. *(Links with Planet Earth and Beyond)* • The cell is the basic unit of most living things, and an organism may be formed from one or many cells. Cells themselves carry on life processes such as nutrition, respiration, excretion and reproduction, which sustain the life of the organism as a whole.

CORE KNOWLEDGE AND CONCEPTS IN ENERGY AND CHANGE

Energy Transfers and Systems	Energy and Development in South Africa
Unifying statement: Energy is transferred through biological or physical systems, from energy sources. With each energy transfer, some of the energy becomes less available for our use, and therefore we need to know how to control energy transfers.	*Unifying statement: Energy is available from a limited number of sources, and the sustainable development of countries in our region depends on the wise use of energy sources.*
Foundation Phase	
❖ When we say we feel 'full of energy', we mean we feel ready to move fast or do a lot of work.	❖ People who do not have enough food or the right kind food to eat, feel tired and lack energy.
Intermediate Phase	
❖ There are sources of energy in nature which can be used for doing useful work; examples are wind, the sun, fire, animals' muscles and falling water. Energy sources can be dangerous but can also be used in systems which people design, such as boats, windmills, carts, cookers and turbines. ❖ A system is made of two or more parts that work together or affect each other. Systems may be as simple as two grindstones that crush grain between them, or have several parts, like an electrical circuit, or have many parts, like an ecosystem. Systems transfer energy from one part of the system to other parts. ❖ We can design and make systems which store energy. Electric cells, stretched springs, food and chemicals which can react are examples of such systems. ❖ An electrical circuit is a system. It is a path of electrical components and conductors with no breaks in it, and an energy source to make electric charges flow around the conducting path. The energy source may be cells or the 'mains' electricity supply. The circuit transfers energy from the source to resistors such as bulbs, heating-wires, solenoids or motors in the circuit. *(Links with the Technology Learning Area)*	❖ Humans and animals get energy from eating plants and from eating animals that ate plants. The sun provides energy for plants to grow and produce food. *(Links with Life and Living)* ❖ Energy from electrical sources can be dangerous and so we need safety rules for using electricity.

Energy Transfers and Systems	Energy and Development in South Africa
❖ Whenever a substance changes by expanding, contracting, melting evaporating, condensing or solidifying, it means that the substance has gained or given away some energy. *(Links with Matter and Materials)* ❖ Sound transfers energy from a vibrating body to our ears. Vibrations travel through a medium, which may be a solid, a liquid or a gas. We hear a change in the rate of vibration as a change in pitch.	*(There are no further core knowledge statements for Energy and Development in South Africa in this Phase.)*
Senior Phase	
❖ Energy can be stored in a system as potential energy, either by the positions of the bulk parts of the system or by its particles (atoms and molecules) which have the potential to react with each other and release energy. Examples of potential energy are the stored energy of a compressed spring or the stored energy of particles which could react in a fuel-and-air mixture, or in the food and body of a living thing. ❖ Potential energy can be released as kinetic energy in the motion of parts of the system, either in the motion of bulk parts of the system or in the motion of particles of the system. Examples of the release of kinetic energy are the motion of a released spring or the faster motion of the particles of hot gases when a fuel-air mixture burns, or the body movement of humans and animals. Kinetic energy is transferred to parts within the system and energy is also transferred to the system's surroundings. When energy is transferred, it causes changes in the system and the system's surroundings. ❖ There is an unlimited number of systems which can be made to store or transfer energy. The possible systems include electrical, mechanical (including spring and friction systems), chemical, gravitational, nuclear, solar, biomass, optical (light), acoustical (sound) and thermal (heat) systems as well as human bodies and ecosystems.	❖ Energy sources such as wind, sun, and water in high dams are renewable. Fuels such as coal, gas and oil are not renewable energy sources, because they cannot be replaced. *(Links with Planet Earth and Beyond)* ❖ Development and relief of poverty depends on energy supplies, particularly electrical energy, and the systems to deliver the energy to where it is needed. ❖ Large-scale electricity supply depends on generation systems which use a few energy sources such as burning coal, nuclear reactions, burning gas and falling water. Use of any of these sources has environmental implications. For example, when coal is burned to generate electricity, gases are produced that affect the atmosphere and local and global environments. *(Links with Planet Earth and Beyond)*

Energy Transfers and Systems	Energy and development in South Africa
❖ All physical systems that people use (for example, appliances, vehicles and human bodies) waste some of the energy they receive, and the wasted energy goes to heat up the surroundings. When the energy has gone into heating the surroundings, we can no longer use that energy to do work for us. ❖ Hot objects transfer energy to colder objects, until the objects reach the same temperature. Hot objects transfer their energy, as heat, in three ways: by conduction, by convection and by radiation. These transfers may be useful or wasteful. Wasteful heat transfer can be controlled by reducing conduction, convection and radiation in a system. Similarly, useful heat transfer can be increased by improving conduction, convection and radiation in a system. ❖ All organisms in an ecosystem need energy from other parts of the ecosystem. Energy is transferred from part to part of an ecosystem and each part retains only a fraction of the energy it received. *(Links with Life and Living)* ❖ Light travels away from a light-giving body until it strikes an object. The object may then absorb the light, or refract it or reflect it. Light transfers energy to other objects. *(Links with Life and Living)* ❖ Objects can exert forces on each other, thereby forming a system which can store or transfer energy. They may do so by physical contact or by forces which act through a field. Field forces are the magnetic, electric and gravitational forces. All forces act in pairs, so that if body A exerts a force on body B, B exerts an equal and opposite force on A.	❖ Other electricity-generation systems have smaller environmental impact but may cost more in the short term. Better design of buildings and appliances, and better practices in using energy, can save costs to consumers and lessen the environmental impact of exploiting energy sources ❖ Many people in South Africa use wood for heating and cooking. Plants such as trees can be a renewable energy source if more trees are planted and the soil is managed well. *(Links with Planet Earth and Beyond)*

Energy Transfers and Systems	Energy and development in South Africa
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CORE KNOWLEDGE AND CONCEPTS IN THE PLANET EARTH AND BEYOND

Our Place in Space	Atmosphere and Weather	The Changing Earth
Unifying statement: Our planet is a small part of a vast solar system in an immense galaxy.	*Unifying statement: The atmosphere is a system which interacts with the land, lakes and oceans and which transfers energy and water from place to place.*	*Unifying statement: The Earth is composed of materials which are continually being changed by forces on and under the surface.*
Foundation Phase		
❖ Many different objects can be observed in the sky. Examples are birds, clouds, aeroplanes, the sun, stars, the moon, planets and satellites. All these objects have properties, locations and movements that can be investigated with a view to determining patterns, relationships and trends.	❖ Weather changes from day to day in ways that can be recorded and sometimes predicted. There are occasional unusual weather events like storms, floods or tornados which impact on people's lives.	❖ Soil and rocks vary in appearance and texture from place to place. By investigation, learners can find out that some soils erode more easily than others do, while some soil types support plant life better than others. They could investigate what some of the factors involved might be.
Intermediate Phase		
❖ Day and night may be explained by the rotation of the earth on its own axis as it circles the sun. ❖ The moon's apparent shape changes in a predictable way and these changes may be explained by its motion relative to the earth and sun. Many cultural traditions and special occasions are related to the shape or position of the moon.	❖ Weather may change from day to day. Weather can be described by measurable quantities, such as temperature, wind direction and speed, and precipitation. ❖ Other changes take longer to occur. An example of this type of medium-term change is annual seasonal changes, which may be described in terms of changes in rainfall, average wind direction, length of day or night and average maximum and minimum temperatures.	❖ Earth materials are solid rocks and soils, water, and the gases of the atmosphere. ❖ Erosion of the land creates the landforms that we see and also results in the deposition of rock particles that may be lithified to form sedimentary rocks. Erosion and deposition can be very slow and gradual or it can occur in short catastrophic events like floods.

Our Place in Space	Atmosphere and Weather	The Changing Earth
❖ The stars' apparent positions in relation to each other do not change, but the nightly position of the star pattern as a whole changes slowly over the course of a year. Many cultures recognise and name particular star patterns, and have used them for navigation or calendars.	❖ Water changes its form as it moves in a cycle between the hydrosphere, atmosphere and lithosphere in what is known as the 'water cycle'. ❖ Most of planet earth is covered by water in the oceans. A small portion of the planet is covered by land that is separated into continents. At the poles there are ice caps. Only a small amount of the water is available for living things on land to use and only a small portion of the land is easily habitable by humans.	❖ Rocks may be classified into igneous, sedimentary and metamorphic types. This classification is based on the origins and history of the rocks. ❖ Soil consists of weathered rocks and decomposed organic material from dead plants, animals, and bacteria. Soil forms by natural processes, but it takes an extremely long time to form. Soils have properties of colour and texture, capacity to retain water, and ability to support the growth of many kinds of plants, including those in our food supply. *(Links with Life and Living)* ❖ Fossils are the remains of life forms that have been preserved in stone. Fossils are evidence that life, climates and environments in the past were very different from those of today. *(Links with Life and Living)* ❖ The quality of water resources is determined by the quality of the catchment area. Proper care and management of catchment areas and water resources is essential, and factors affecting the quality of water resources and catchment areas may be investigated. *(Links with Life and Living)*

Our Place in Space	Atmosphere and Weather	The Changing Earth
Senior Phase		
❖ The earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects, such as asteroids and comets. The sun, an average star, is the central and largest body in the solar system. ❖ Most objects in the solar system are in regular and predictable motion. The motions of the earth and moon explain such phenomena as the day, the year, phases of the moon, and eclipses. ❖ Gravity is the force that keeps planets in orbit around the sun and governs the rest of the motion in the solar system. Gravity alone holds us to the earth's surface. ❖ The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle.	❖ The outer layers of the earth are the atmosphere, the hydrosphere and the lithosphere. We live in the biosphere, which is where all these layers interact to support life. ❖ Climate varies in different parts of the globe. It tends to be cold in the polar regions and hot in the tropics. Different types of plants and animals are adapted to living in different climatic regions. *(Links with Life and Living)* ❖ The atmosphere is a mixture of nitrogen and oxygen in fairly constant proportions, and small quantities of other gases that include water vapour. The atmosphere has different properties at different elevations. ❖ The atmosphere protects the earth from harmful radiation and from most objects from outer space that would otherwise strike the earth's surface. The atmosphere is the most important factor in keeping the earth's surface temperature from falling too low or rising too high to sustain life.	❖ The planet earth has a layered structure, with a lithosphere, a hot, convecting mantle and a dense, metallic core. ❖ Lithospheric plates larger than some continents constantly move at rates of centimetres per year, in response to movements in the mantle. Major geological events, such as earthquakes, volcanic eruptions and mountain building, result from these plate motions. ❖ Landforms are the result of a combination of constructive and destructive forces. Constructive forces include crustal deformation, volcanic eruption, and deposition of sediment, while destructive forces include weathering and erosion.

Our Place in Space	Atmosphere and Weather	The Changing Earth
❖ Space exploration programmes involve international collaboration in the use of earth-based telescopes (such as SALT in South Africa) and telescopes in orbit. Robotic spacecraft travel long distances to send back data about the planets and other bodies in our solar system, and research is being done on ways to send people to investigate the planet Mars.	❖ Human activities and natural events can slightly change the composition and temperature of the atmosphere. Some effects of these small changes may be changes in annual weather patterns and long-term changes in rainfall and climate.	❖ Many of the organisms in South Africa's fossil record cannot be easily classified into groups of organisms alive today, and some are found in places where present-day conditions would not be suitable for them. This is evidence that life and conditions on the surface of earth have changed through time. *(Links with Life and Living)* ❖ Fossil fuels such as coal, gas and oil are the remains of plants and animals that were buried and fossilised at high pressures. These fuels are not renewable in our lifetimes. *(Links with Energy and Change)* ❖ Mining is a major industry in South Africa, with local examples in all the nine provinces. It is important in terms of the supply of coal for energy, essential raw materials for other industries, employment and earnings for the country. A great number of other industries depend on the mining industry. Legislation controls mining, with regard to safety and environmental effects.

CORE KNOWLEDGE AND CONCEPTS IN MATTER AND MATERIALS

Properties and Uses of Materials	Structure, Reactions and Changes of Materials
Unifying statement: We can classify materials by their properties, in order to establish types and patterns. Properties determine the selection of materials for particular uses.	*Unifying statement: We can modify materials in ways we choose, through our understanding of their sub-structure.*
Foundation Phase	
❖ Materials have different properties such as texture, colour, strength and heaviness, and can be classified by these properties. We make things with materials which have the properties we want.	❖ Substances can be mixed and sometimes changes can be seen, such as the dissolving of a solid or new colours when food colourings/paints are mixed.
Intermediate Phase	
❖ Pure substances have melting temperatures and boiling temperatures which are characteristic for each substance, and help us to identify the substance. ❖ Materials are evaluated and classified by their properties (such as hardness, flexibility, thermal conductivity or insulation, electrical conductivity or insulation, whether they can be magnetised, solubility and rusting). ❖ Major classes of materials are metals, ceramics (including glasses) and polymers (including plastics and fibres). Composite materials combine the properties of two or more materials.	❖ Some changes to materials are temporary but other changes are permanent. ❖ Substances change when they receive or lose energy as heat. These changes include contraction and expansion, melting, evaporation, condensation and solidification. *(Links with Energy and Change)* ❖ The dissolving of a substance in a solvent depends on variables which affect the rate of dissolving.

Properties and Uses of Materials	Structure, Reactions and Changes of Materials
Senior Phase	
❖ Substances in different states ('phases') have distinct properties such as crystalline structures, or compressibility/incompressibility, or tendency to diffuse. ❖ Dark-coloured surfaces get hotter than light-coloured surfaces when exposed to radiating sources of energy like the sun. Dark-coloured objects radiate their energy as heat more readily than shiny light-coloured objects. *(Links with Energy and Change)* ❖ Some materials are magnetised by electric currents or magnets. Some materials can be electrically charged by rubbing them with a different material. *(Links with Energy and Change)* ❖ Some conductors and circuit components reduce the current in an electric circuit to a significant extent and are called resistors. Resistors can be selected or designed to control currents. ❖ A pure substance cannot be separated into different substances, while a mixture can be separated, usually by physical means. Differences in properties can be used to separate mixtures of different substances (by methods such as filtration, distillation, evaporation, chromatography or magnetism). *(Links with Matter and Materials)* ❖ Specific gases may be separated from the air or produced in reactions, and have many uses in industry and other sectors of the economy. Oxygen, hydrogen and carbon dioxide have characteristic properties and reactions by which we can identify them. ❖ Extracting useful materials from raw materials depends on chemical reactions and methods of separation. ❖ Raw materials, from which processed materials are made, must be mined, grown or imported from other countries. Raw materials that are mined are non-renewable and mining has environmental costs. Growing raw materials involves choices about the use of arable land and water catchment areas.	❖ A particle model of matter can explain physical changes of substances such as melting, evaporation, condensation, solidification, diffusion and heating by conduction. ❖ Many household substances are acidic or basic. Indicators are substances that react with acids and soluble bases to produce products that have distinctive colours. Acids and bases neutralise one another to form salts. Acids have characteristic reactions with metals, metal oxides, hydroxides and carbonates. ❖ Many chemical reactions need some energy to get started; many chemical reactions give off energy as they happen. ❖ Elements are made of just one kind of atom, whereas compounds are made of two or more kinds of atoms in fixed proportions. Elements may react to form compounds, and compounds may be decomposed into their elements. Energy input is needed to break a compound into its elements, whereas energy is given out when elements react to form a compound.

CORE KNOWLEDGE AND CONCEPTS IN MATTER AND MATERIALS

Properties and uses of materials	Structure, Reactions and Changes of Materials
(There are no further core knowledge statements for Matter and Materials in this Phase.)	❖ Oxygen has characteristic reactions with metals and non-metals, forming oxides. Some of these oxides dissolve in water to form acidic or alkaline solutions. Some metals react more readily with oxygen than other metals. Corrosion of iron is an economically important reaction which can be prevented through an understanding of the reactions between iron, water and oxygen. ❖ The reaction of oxygen with food releases energy in the cells of living things. *(Links with Life and Living)*